국제학석사학위논문

A study on comovements across national stock markets in Asia, Europe and U.S.

아시아, 유럽, 미국 주식시장의 동조화에 관한 연구

2012 년 6 월

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A study on comovements across national stock markets in Asia, Europe and U.S.

A thesis presented

by

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To

Graduate program in International Area Studies
In partial fulfillment of the requirements
For the degree of Master
In the subject of International Studies

Graduate School of International Studies
Seoul National University
Seoul, Korea
June, 2012

Abstract

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In old days, empirical results showed consistently low degree of correlation in returns across global stock markets. Interestingly, the correlation coefficients of returns across national stock market have been increasing lately with two reasons. Firstly, investors across the world tend to include foreign stocks in their portfolio holdings in pursuit of raising return and reducing risk. Governments opening up its domestic stock market to the globe with lesser restrictions are in support of this trend. Secondly, firms are becoming more globalized in terms of its sales, manufacturing and financing. Hence global firms and its stock price are more exposed to the global business cycle, causing national stock markets to move together.

The purpose of this paper is to observe the degree of influence that a stock market of one nation has on that of the other, and to reveal the existence of "comovement" across national stock markets. An appropriate stock market index is to be chosen to describe the fluctuation of a stock market. Such indices will be compared with one another with regression analysis, in pursuit of observing the comovement across national stock markets. Regression analysis is applied to measure the influence between stock markets.

Correlation analysis is used to examine the existence of comovement across national stock markets. The thesis also strives to answer whether the synchronization of global stock markets is a permanent phenomenon driven by fundamentals or a temporary one.

The thesis demonstrates that U.S. stock market has a significant influence on Asian stock markets, an Asian stock market has a significant influence on European stock markets and that European stock market has a significant impact on U.S. stock market. However, the influence does not work the other way around. This is simply due to the sequence of stock exchange business hours. In this thesis, test results and graphs shows existence of comovement across national stock market and that it's gradually increasing over time. Despite of continued fluctuation, correlation coefficients of returns on stock market index across the globe have definite upward trend.

In South Korea, domestic stock market opened its door to foreign investors in 1992. Since then, the number of stock transactions by foreign investors has been increasing.
As of now, it is known that around 30 percent of prevailing KOSPI stocks is owned by foreigner. Due to these facts, KOSPI's comovement with global stock markets has been increasing, as expected.

Keywords : *Comovement, Stock Market Index, Correlation, KOSPI, S&P 500, TOPIX, DAX*

학　번 : 2007−22413

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I. Introduction

One of the pronounced regularities in international stock markets has been that there is a low degree of correlation of returns across national stock markets. This empirical regularity has broken down in recent years. The correlation coefficients of returns across national stock market have been increasing lately. There are several plausible explanations for this. First, investors across the world are including foreign stocks in their portfolio holdings in pursuit of raising return and reducing risk. In addition, governments promote foreigners to invest in their domestic stocks by removing restrictions on trading. The connections among one nation's stock exchange with another are definitely strengthening. Portions of the listed foreign firms and of foreign investor's stock transactions have been increasing. Secondly, firms are becoming more globalized in terms of its sales, manufacturing and financing. As a result, global firms and its stock price are more exposed to the global business cycle, causing national stock markets to move together. In South Korea, the domestic stock exchange opened its door to foreign investors in 1992. Since then, the number of stock transactions by foreign investors has been increasing, and naturally, the ratio of foreigner's share on South Korean stocks has accumulated.

The purpose of this paper is to investigate the degree of influence that a stock market of one nation has on that of the other, and to reveal the existence of "comovement" across national stock markets. To analyze the impact of one nation's stock market on another and to reveal the comovements of stock markets, appropriate stock market indices are chosen to describe the behavior of each stock market. These representative indices are then compared with one another with regression and correlation analysis. Regression analysis is an appropriate method in measuring the influence of one nation's stock market on another, and correlation analysis is suitable in testing the existence of "comovement" across national stock markets. The thesis also seeks to investigate whether the rise in parallel movements across national stock markets is driven by fundamentals, in order to determine whether the phenomenon is permanent or temporary.

The thesis demonstrates that U.S. stock market has a significant influence on Asian stock markets, an Asian stock market has a significant influence on European stock markets and that European stock market has a significant impact on U.S. stock market. However, the logic does not apply the other way around. This is simply due to the sequence of stock exchange business hours. Stock exchanges open daily in order of U.S., Asia, European and back to U.S. Considering a long time lag between Asian stock market openings and previous day's European stock market closings, European stock markets having almost no influence on Asian stock market is plausible. However, previous day's U.S stock market closing does have a significant influence on European stock market opening price, proving the global significance of U.S. stock market.

Test results and graphs in this thesis shows that comovement across the globe has been increasing over time. Despite of continued fluctuation, correlation coefficients of returns on stock market index across the globe have definite upward trend.

Stock market comovement is sometimes confused with stock market integration. Stock market is formally defined 'integrated' when the Law of One Price, which states that assets generating identical cash flows command the same return, holds. Given the formal definition, stock market integration can be measured by comparing the returns of assets that are issued in different countries but generating identical cash flows. However, it is difficult to identify such assets in real world, and theoretical asset pricing models are difficult to estimate.

Many research paper claims that comovements among a group of countries' stock markets do exist with calculated correlation coefficient as supporting evidence. However, the correlation coefficients computed in papers often do not match because of different sample periods. Due to the varying results on correlation coefficient, there still lacks a confidence in calling the existence of comovement official. My thesis has collected a long period data to verity existence of comovement as a rising phenomenon, and to provide its direction, increasing or decreasing. There is a general consensus across the papers that U.S. stock market is considered as a global standard and hence possesses a global influence regardless of time lag. However, results on influence of non-U.S. countries' stock markets on U.S. market or on other country's stock market are still conflicting. This is also due to differing sample period. Most papers apply time-series analysis. Yoo and Kim(1997), Gil(2003) and Eun and Shim(1989) used an autoregressive model, and Hamao, Maulis and Ng(1990) used ARCH(autoregressive conditional heteroskedasticity) model. However, this paper does not intend to use time-series analysis for long period data usually does not meet the assumption and previous returns are insignificant in determining the validity of rising phenomenon.

Most of the statistical analysis has been conducted with Excel worksheet, regression analysis with statistical software R (http://www.r-project.org/).

II. Related Literature

Most of the related research papers show correlation coefficients among returns of national stock indices to describe the comovement. The following tables are excerpts from the papers:

<Table 2-1> Correlations (excerpt from Yoo and Kim (1997))

〈표 2.2〉 한 · 미 · 일 주간수익률간의 상관관계

자국통화 기준		KOSPI	NIKKEI	S&P 500
		전 체		
전 체	KOSPI			
	NIKKEI	0.125		
	S&P 500	0.109	0.381	

달러화 기준		KOSPI	NIKKEI	&P 500
		전 체		
전 체	KOSPI			
	NIKKEI	0.134		
	S&P 500	0.111	0.308	

Note) data: weekly returns, Jan.1985 ~ June 1996

<Table 2-2> Correlations (excerpt from Gil (2003))

<표 2> 한·미·일 3국 시장 지수 일일 수익률간 상관관계(1997.4.2~2000.12.26)

	KOSPI	KOSDAQ	NYSE	NASDAQ	NIKKEI	JASDAQ
KOSPI	1					
KOSDAQ	0.8669	1				
NYSE	0.3452	0.2652	1			
NASDAQ	0.5696	0.5834	0.8015	1		
NIKKEI	0.7060	0.7438	-0.1456	0.2192	1	
JASDAQ	0.7345	0.7627	0.6070	0.9179	0.4957	1

Note) data: daily returns, April 2, 1997 ~ Dec. 26, 2000

<Table 2-3> Correlations (excerpt from Karolyi and Stulz (1996))

	Daytime Returns				Overnight Returns			
Statistics	Japan ADRs	US Industry	US Size	Nikkei Futures	Japan ADRs	US Industry	US Size	Nikkei Futures
Mean returns (%)	0.0342	0.0449	0.0369	0.0535	−0.0553	0.0064	0.0123	−0.1142
Standard deviation	0.5400	0.8205	0.7338	0.8561	1.2633	0.4325	0.3726	1.6684
t-value (mean = 0)	1.90*	1.64*	1.51	1.28	−1.31	0.44	0.98	−1.40
Skewness	0.01	−0.32**	−0.58**	1.72**	0.08	−0.64**	−1.04**	−0.79**
Excess kurtosis	17.00**	4.95**	8.31**	23.23**	3.98**	9.46**	10.94**	6.07**
Q_k Box-Ljung	10.65*	10.41**	2.95	3.52	15.92**	8.96	12.13**	4.83
Q_k^2 Box-Ljung	5.69	49.44**	71.25**	5.31	45.65**	43.69**	35.59**	4.64
Cross-correlations:								
Japan ADR (OC)	1.000							
US industry (OC)	0.343	1.000						
US size (OC)	0.372	0.811	1.000					
Nikkei futures (OC)	0.537	0.538	0.562	1.000				
Japan ADR (CO)	0.039	−0.009	0.039	−0.011	1.000			
US industry (CO)	0.036	−0.039	−0.002	−0.047	0.427	1.000		
US size (CO)	0.042	−0.050	−0.005	−0.008	0.393	0.869	1.000	
Nikkei futures (CO)	0.084	−0.034	0.049	−0.190	0.662	0.414	0.415	1.000
With Instruments:								
NKOC	0.020	0.003	0.024	−0.085	0.594	0.341	0.322	0.785
NKCO	−0.019	0.009	0.009	−0.021	0.267	0.186	0.173	0.254
NKCO (t + 1)	0.452	0.328	0.349	0.392	0.265	0.218	0.196	0.336
NKVOL	−0.022	−0.022	−0.055	0.001	−0.166	−0.035	−0.048	−0.238
SPOC	0.379	0.848	0.880	0.653	0.034	−0.007	0.002	0.006
SPCO	0.110	0.000	0.071	0.003	0.411	0.828	0.819	0.478
SPVOL	−0.097	−0.113	−0.096	−0.049	0.038	−0.061	−0.008	−0.031
RFX	0.290	0.009	0.059	0.198	0.296	0.090	0.055	0.169
RTB	−0.053	0.029	−0.040	−0.074	0.030	−0.114	−0.132	0.099
RVW	0.385	0.740	0.799	0.577	0.252	0.435	0.437	0.253

Note) data: daily returns, May 31, 1988 ~ May 29, 1992

<Table 2-4> Correlations (excerpt from Eun and Shim (1989))

TABLE 2

The Correlation Matrix of Residual Returns[a]

	AU	CA	FR	GE	HK	JA	SW	UK	US
Australia (AU)	1.000	0.045	0.068	0.050	0.124	0.127	0.069	0.051	0.035
Canada (CA)		1.000	0.029	0.060	0.062	0.005	0.105	0.205	0.673
France (FR)			1.000	0.078	−0.006	0.095	0.114	0.086	0.022
Germany (GE)				1.000	0.086	0.149	0.279	0.136	0.053
Hong Kong (HK)					1.000	0.079	0.040	0.074	0.088
Japan (JA)						1.000	0.188	0.104	0.020
Switzerland (SW)							1.000	0 129	0.083
U.K. (UK)								1.000	0.176
U.S.A. (US)									1.000

[a] Each entry in the table represents the contemporaneous correlation coefficient of the residual returns between a pair of countries, net of expected returns that are estimated from the nine-market vector-autoregressive system using daily returns from the period 1980 1–1985.12.

Note) correlation among residual returns

data: daily returns, Dec 31, 1979 ~ Dec 20, 1985

The correlation coefficients shown in these papers vary. Take an example of correlation coefficient between U.S and Japan. Gil's calculation is -0.4156, Yoo and Kim's is 0.381. Eun and Shim's calculation is 0.020 which is between residual returns. It is surprising to observe varying correlation coefficients between the same pair of stock market index returns. Such difference can be explained by differing data periods being collected and analyzed. The difference actually implies the change in correlation coefficients over time. The fact that Yoo and Kim(1997) computed returns in weekly basis, while Gil(2003) and Eun and Shim(1989) computed in daily basis should be noted.

Returns of stock indices among neighboring countries showed strong correlation coefficients. For example, correlation coefficient between U.S. and Canada is 0.673. This is because a business hour of stock exchange is similar, which allows information to be quickly transmitted without a delay. It is also demonstrated that the same stock trading in different countries holds a significant correlation coefficient, but not quite high. Karolyi and Stulz(1996) studied on 8 Japanese firm traded on the American and New York Stock Exchanges as ADR(American Depository Receipts), and found that correlation coefficient between them are 0.3~0.4.

Some of the related papers also provide technical analysis that requires advanced statistical skills. Yoo and Kim(1997), Gil(2003) and Eun and Shim(1989) used an autoregressive model which can be roughly described as:

$$\text{KOSPI return}_t = \beta_o + \beta_1\cdot(\text{KOSPI return}_{t-1}) + \beta_2\cdot(\text{KOSPI return}_{t-2}) + ..$$

$+ \beta_j \cdot (\text{US return}_{t-1}) + \beta_k \cdot (\text{Japan return}_t) + \varepsilon_t$

$\text{Japan return}_t = \beta_o + \beta_1 \cdot (\text{Japan return}_{t-1}) + \beta_2 \cdot (\text{Japan return}_{t-2}) + ..$

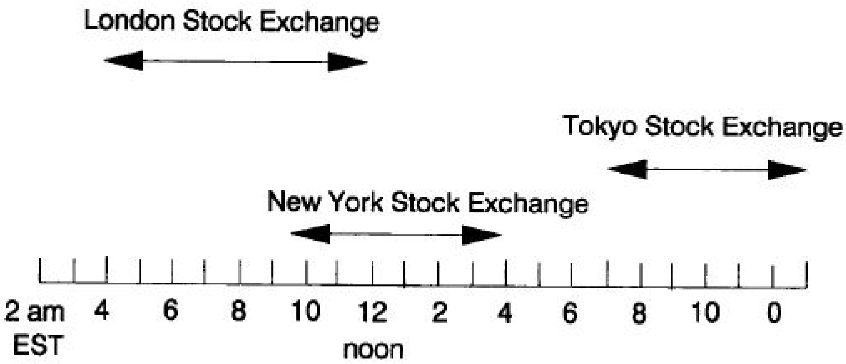
$+ \beta_j \cdot (\text{US return}_t) + \beta_k \cdot (\text{KOSPI return}_t) + \varepsilon_t$

$\text{US return}_t = \beta_o + \beta_1 \cdot (\text{US return}_{t-1}) + \beta_2 \cdot (\text{US return}_{t-2}) + ..$

$+ \beta_j \cdot (\text{KOSPI return}_t) + \beta_k \cdot (\text{Japan return}_t) + \varepsilon_t$

The papers did test $\begin{cases} \text{Ho: } \beta_j = 0 \\ \text{Ha: } \beta_j \neq 0 \end{cases}$ and $\begin{cases} \text{Ho: } \beta_k = 0 \\ \text{Ha: } \beta_k \neq 0 \end{cases}$. If the null hypothesis is rejected, it could be concluded that the independent variable has an influence on the dependent variable. Daily returns were tested in Gil(2003) and Eun and Shim(1989) and weekly returns were tested in Yoo and Kim(1997). However, the papers mentioned above have compared returns of the same time, which may undermine the empirical findings. To test whether U.S. stock market has an influence on Korea and Japan's stock markets, previous day's U.S. index return must be used to integrate the time delay. Hamao, Maulis and Ng(1990) and Karolyi and Stulz(1996) incorporated the difference in business hour of stock exchange among Asian stock markets, U.S. stock markets and European stock market. The following figure is an excerpt from Karolyi and Stulz(1996).

<Figure 2-1> Exchange trading hours (U.S., Japan, U.K.)



Note) excerpt from Hamao, Maulis and Ng(1990)

Hamao, Maulis and Ng(1990) used ARCH(autoregressive conditional heteroskedasticity) model to observe the effect of volatility of a stock market of one country to that of another. For example, the impact of volatility of U.S. market on volatility of Japan's stock market was measured by the following model:

Nikkei volatility of returns$_t$ = β_o + β_1·(Nikkei volatility$_{t-1}$) + β_2·(U.S. volatility$_{t-1}$) + ε_t

The papers did test $\begin{cases} Ho: \beta_2 = 0 \\ Ha: \beta_2 \neq 0 \end{cases}$. If the null hypothesis is rejected, it could be concluded that the volatility of U.S. stock market return has an influence on the volatility of Japanese market. They showed that volatility spillover occurred from U.S. to Japan, from U.K. to Japan, and from U.S. to U.K. However, no volatility spillover occurred from Japan to U.S. and from Japan to U.K. The result seems very dependent on the data period collected because they found that the spillover effect was not significant when the post-October

1987(Black Monday) period was removed from the sample.

Karolyi and Stulz(1996) used a different method. They started the idea that index return is composed of two factors: a global effect and the nation's relative competitiveness compared to other countries. The model can be roughly described as:

U.S. return_t = expected return + (global effect) + (U.S.'s relative competitiveness) + ε_t

They argued that a global effect increases the correlation coefficient between two countries' index returns, while a nation's relative competitiveness effect decreases it. They demonstrated that U.S. stock market has a strong influence on other countries' stock markets, whereas no other countries' stock markets have strong influence on U.S. stock market.

All the papers mentioned above showed that the comovement exists among some national stock market index returns in a specific period. Due to the varying results of computed correlation coefficients, however, it is insufficient to conclude that comovement is a permanent phenomenon. All the papers have shown the existence of comovement in their sample periods, but do not show the whether the comovement is permanent, and furthermore increasing or decreasing. This paper is to address this natural question: Does comovement exist in the long run and is it increasing or decreasing? To answer this question, a long period data is required to observe the trend of correlation.

All the papers mentioned above has also demonstrated that U.S. market has a significant influence on other countries' stock markets. However, results on non-U.S. stock markets' influence on U.S. stock market are conflicting. The conflict arises from differing data period used in analysis. This indicates that empirical findings are period-sensitive. For example, Gil(2003) demonstrated that Japan's stock market has an influence on U.S. market, while South Korea's stock market has no impact on U.S. market. The main reason for ineffectiveness of South Korea's stock market is best explained by inclusion of 1997 South Korean financial crisis. To fully verify the influence of South Korea's stock market on U.S. market, the period of 1997 South Korean financial crisis should be omitted or a period data should be long enough to be unbiased.

This thesis uses a long period data that avoids the issue of period-sensitivity. A long period data could resolve the issue of period-sensitivity, but it raises another potential issue. Covariance stationary condition, a basic assumption in autoregressive models may not be met if the data period is too long. However, there is no need to apply an autoregressive model since the coefficient of the lagged independent variables turns out to be not significantly different from zero. See the following AR(2) model based on the data collected in this thesis.

$\text{KOSPI return}_t = \beta_o + \beta_1 \cdot (\text{KOSPI return}_{t-1}) + \beta_2 \cdot (\text{US return}_{t-1}) + \varepsilon_t$

Regression results are in the following figure.

<Figure 2-2>

```
> summary(lms)

Call:
lm(formula = KOSPI ~ KOSPIt1 + SP500)

Residuals:
      Min        1Q    Median        3Q       Max
-0.111994 -0.008429 -0.000118  0.008482  0.123427

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0003848  0.0002214   1.738   0.0822 .
KOSPIt1     0.0161141  0.0124896   1.290   0.1970
SP500       0.3491503  0.0186591  18.712   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01699 on 5896 degrees of freedom
  (1930 observations deleted due to missingness)
Multiple R-squared: 0.05769,    Adjusted R-squared: 0.05737
F-statistic: 180.5 on 2 and 5896 DF,  p-value: < 2.2e-16
```

If we do test $\begin{cases} Ho: \beta_1 = 0 \\ Ha: \beta_1 \neq 0 \end{cases}$, we do reject the null hypothesis. This indicates that previous return has no influence on this period return. Therefore, KOSPI return_{t-1} can be removed and hence the AR(2) becomes a simple regression model.

III. Stock Market Indices

1. Stock Market Index

A stock market index is a method of measuring the performance of a stock market. Many indices are cited by news or financial service firms. These are used as benchmarks to measure the performance of portfolios such as mutual funds. A stock market index of a nation represents the performance of the stock market of the given nation—and by proxy, reflects investor sentiment on the state of its economy. These indices are composed of the stocks of large companies or all the companies listed on nation's largest stock exchanges.

Because the indices are intended to reflect the overall movements of a group of stocks, three factors are needed that are important when understanding an index intended to represent all the stocks listed in the whole stock market.

• Size of Sample

A sample is usually used to construct an index because there are too many stocks in the population and some stocks are not traded in large volumes. A small percentage of the total population will provide valid indications of the behavior of the total population if the sample is properly selected. In some cases, virtually all the stocks on an exchange or on a market are included, with a few deletions of unusual securities. The sample should be representative of the total population. The sample can be generated by completely random selection or by a non random selection technique designed to incorporate the important characteristics of the population. Finally, the source of the sample is important in case there are any differences between segments of the population, in which case samples from each segment are required.

• Weighting Sample Members

The second factor is the weight given to each member in the sample. Three principal weighting schemes are used for security-market indices: i) a price-weighted index, ii) a market-value-weighted index, and ii) an unweighted index, or what would be described as an equal-weighted index. These three weighting schemes will be explained later in this chapter.

• Computational Procedure

The final consideration is the computational procedure used. One alternative is to take a simple arithmetic mean of the various members in the index. Another is to compute an index and have all changes, whether in price or value, reported in terms of the basic index. Finally, some prefer using a geometric mean of the components rather than an arithmetic mean.

Dow-Jones Industrial Average (DJIA) and the S&P 500 Index are indices representing stocks listed in all the U.S. stock exchanges. Even though they are representative U.S. stock market indices, these indices experience different percentage changes. The reasons for some of the differences are obvious because they adopt different populations, different sizes of samples, different weighting schemes and different computational procedures.

1) Price-weighted Index

A price-weighted index is an arithmetic mean of current prices, which means that index movements are influenced by the differential prices of the components. Dow Jones Industrial Average (DJIA) is a well-known example. The DJIA is a price-weighted average of 30 large industrial stocks that are generally the leaders in their industry (blue chips). The DJIA is computed by totaling the current prices of the 30 stocks and dividing the sum by a divisor that has been adjusted to take account of stock splits and changes in the simple over time. The divisor is adjusted so the index value will be the same before and after the split. The equation is

$$DJIA = \sum_{i=1}^{30} P_{it} / D_{adj}$$

where:

$DJIA_t$ = the value of die DJIA On day t

P_{it} = the closing price of stock i on day t

D_{adj} = the adjusted divisor on day t

Because the index is price weighted, a high-priced stock carries more weight than a low-priced stock. The DJIA has been criticized on several counts. First, the sample used for the index is limited to 30 non randomly selected blue-chip stocks that cannot be representative of the thousands of U.S. stocks. Further, the stocks included are large, mature, blue-chip firms rather than typical companies.

Nikkei Stock Average Index is also a price-weighted index and an arithmetic mean of prices for 225 stocks on the First Section of the Tokyo Stock Exchange (TSE). It is also criticized because the 225 Stocks only comprise about 15 percent of all stocks on the First Section.

2) Value-weighted Index

A value-weighted index is generated by deriving the initial total market value of all stocks used in the index [Market Value = Number of Shares Outstanding X Current Market Price]. This initial figure is typically established as the base and assigned an index value (the most popular beginning index value is 100). Subsequently, a new market value is computed for all securities in the index, and the current market value is compared to the initial "base" market value to determine the percentage of change.

$Index_t = \sum P_t Q_t / P_b Q_b$ *Beginning index value

where:

$Index_t$=index value on day t

P_t=ending prices for stocks on day t

Q_t=number of outstanding or freely floating shares on day t

P_b=ending price for stocks on base day

Q_b=number of outstanding or freely floating shares on base day

In a value-weighted index, the importance of individual stocks in the sample depends on the market value of the stocks. Therefore, a specified percentage change in the value of a large company has a greater impact than a comparable percentage change for a small company. KOSPI, KOSPI200, KOSPI100 and TOPIX are good examples of value-weighted indices.

3) Unweighted Index

In an unweighted index, all stocks carry equal weight regardless of their price or market value. A $20 stock is as important as a $40 stock, and the total market value of the company is unimportant. Such an index can be used by individuals who randomly select stocks for their portfolio and invest the same dollar amount in each stock. The actual movements in the index are typically based on the arithmetic mean, or the geometric mean of percentage changes can be used.

2. Indices in This Thesis

The indices used in this thesis are as follows:

1) KOSPI, KOSPI200 and KOSPI100

The Korea Composite Stock Price Index or KOSPI (코스피지수) is the index of all common stocks traded on the Korea Stock Exchange. It is the representative stock market index of Korea, like the Dow Jones Industrial Average or S&P 500 in the U.S.

KOSPI was introduced in 1983 with the base value of 100 as of January 4, 1980. It is a value-weighted index. As of 2007, KOSPI's daily volume is hundreds of millions of shares or (trillions of won). KOSPI has over

700 components. Top 10 stocks include Samsung Electronics, POSCO, Hyundai Heavy Industries, Kookmin Bank, Korea Electric Power, Shinhan Financial Group, SK telecom, Woori Finance Holdings, LG Display and Hyundai Motor.

The KOSPI 200 index consists of 200 big companies of Korea Stock Exchange. The base value of 100 was set on January 3, 1990. It has over 70% market value of the KOSPI, and so moves along with the KOSPI index. KOSPI 200 is important because it's listed on futures and option markets and is one of the most actively traded indices in the world.

The KOSPI, KOSPI200 and KOSPI100 all are value-weighted indices, which is calculated as current market capitalization divided by base market capitalization (as of January 4, 1980).

2) S&P 500

Standard & Poor’s introduced its first stock index in 1923. Before 1957, its primary daily stock market index was the "S&P 90", a value-weighted index based on 90 stocks. The S&P 500 index in its present form began on March 4, 1957. The S&P 500 consists of 500 large capitalization stocks actively traded in the U.S. exchanges. The stocks included in the S&P 500 are those of large publicly held companies that trade on either of the two largest American stock market exchanges such as the New York Stock Exchange and the NASDAQ. The index also includes a few companies with headquarters in and/or incorporated in other countries.

After the Dow Jones Industrial Average, the S&P 500 is the most widely followed index of large-cap American stocks. Many mutual funds, exchange-traded funds, and other funds such as pension funds, are designed to track the performance of the S&P 500 index. Hundreds of billions of US dollars have been invested in this fashion. The index is the best known of the many indices owned and maintained by Standard & Poor's, a division of McGraw-Hill.

3) DJIA

The Dow Jones Industrial Average is a price-weighted index created by Wall Street Journal editor and Dow Jones & Company co-founder Charles Dow on May 26, 1896. It is now owned by the CME Group, which is the majority owner of Dow Jones Indices. The average is named after Dow and one of his business associates, statistician Edward Jones. The index consists of 30 large, publicly owned companies based in the U.S. The 30 companies include 3M, Alcoa, American Express, AT&T, Bank of America, Boeing, Caterpillar, Chevron Corporation, Cisco Systems, Coca-Cola, DuPont, Exxon Mobil, General Electric, Hewlett-Packard, The Home Depot, Intel, IBM, Johnson & Johnson, JP Morgan Chase, Kraft Foods, McDonald's, Merck, Microsoft, Pfizer, Procter & Gamble, Travelers, United Technologies Corporation, Verizon Communications, Wal-mart and Walt Disney.

4) Nikkei

The Nikkei 225 (日経平均株価 *Nikkei heikin kabuka*,), more commonly called the Nikkei is a price-weighted index for the Tokyo Stock Exchange (TSE). It has been calculated daily by the Nihon Keizai Shimbun (Nikkei) newspaper since 1950. Currently, the Nikkei is the most widely quoted average of Japanese equities, similar to the Dow Jones Industrial Average. The Nikkei index began to be calculated on September 7, 1950, retroactively calculated back to May 16, 1949.

5) TOPIX

Tokyo stock Price Index, commonly known as TOPIX, along with the Nikkei 225, is an important stock market index for the Tokyo Stock Exchange (TSE) in Japan, tracking all domestic companies of the exchange's First Section. It began to publish in 1969. It is calculated and published by the TSE. As of 1 February 2011, there are 1,669 companies listed on the First Section of the TSE. It is a value-weighted index.

6) Shanghai Index A, B

Shanghai index A consists of stocks that can be traded in Shanghai stock exchange restricted by domestic investors only. Shanghai index B consists of stocks that can be initially traded by foreigners in the exchange. Since 2001, Shanghai B shares are available to both domestic and foreign investors. And after Dec. 2002, foreign investors are now allowed (with limitations) to trade in A shares under the Qualified Foreign Institutional Investor program which was officially launched in 2003. There has been a plan to eventually merge the two types of shares in the future.

As of 2007, 850 stocks are constituted in Shanghai A index, while 54 stocks are listed in Shanghai B index. Shanghai A shares are priced in the Chinese currency yunan, while the B share stocks are generally quote in U.S. dollars.

7) Hangseng Index

The Hang Seng Index (abbreviated: HSI, Chinese: 恒生指數) is a value-weighted stock market index in Hong Kong. It is used to record changes of the largest companies of the Hong Kong stock market and is the main indicator of the overall market performance in Hong Kong. These 45 constituent companies represent about 60% of the capitalization of the Hong Kong Stock Exchange.

HSI was started on November 24, 1969, and is currently compiled and maintained by Hang Seng Indices Company Limited, which is a wholly owned subsidiary of Hang Seng Bank, one of the largest banks registered and listed in Hong Kong. When the Hang Seng Index was first published, its base of 100 points was set equivalent to the stocks' total value as of the market close on July 31, 1964.

8) STI

The FTSE Straits Times Index (STI) is a value-weighted stock market index that is regarded as the benchmark index for the Singapore stock market. It tracks the performance of the top 30 companies listed on the Singapore Exchange. It is jointly calculated by Singapore Press Holdings

(SPH), Singapore Exchange (SGX) and FTSE Group (FTSE).

9) DAX

The DAX (Deutscher Aktien Index, formerly Deutscher Aktien-Index (German stock index)) is a value-weighted index consisting of the 30 blue chip German companies trading on the Frankfurt Stock Exchange. The Base date for the DAX is 30 December, 1987 and it was started from a base value of 1,000.

10) CAC

The CAC 40 (French: CAC quarante or Cotation Assistée en Continu quarante) is a benchmark French stock market index. The value-weighted index consists of 40 largest companies on the Paris Bourse (now Euronext Paris). Its base value of 1,000 was set on 31 December 1987.

11) FTSE

The FTSE 100 Index, also called FTSE 100, FTSE, or, informally is a share index of the 100 most highly capitalized UK companies listed on the London Stock Exchange. The index is a value-weighted index, and is maintained by the FTSE Group, an independent company jointly owned by the Financial Times and the London Stock Exchange. Its name derives from the acronym of its two parent companies. The index began on 3 January 1984 with a base level of 1000. FTSE 100 companies represent about 81% of the market capitalization of the whole London Stock Exchange.

IV. Statistics of Stock Market Indices

1. Data Overview

An original data set used in this thesis consists of indices which represents national stock markets. The original data set is as follows:

-Korea)

KOSPI: 1985/1/4~2011/4/15

KOSPI200: 1990/1/4 ~ 2011/4/15

KOSPI100: 2000/3/2~2011/4/15

-U.S.A.)

S&P 500: 1981/4/15~2011/4/15

DJIA: 1981/4/15~2011/4/15

-Japan)

Nikkei: 1981/4/15~2011/4/15

TOPIX: 1981/4/15~2011/4/15

-China)

Shanghai A: 1992/1/2~2011/4/15

Shanghai B: 1992/2/21~2011/4/15

-Hong Kong)

Hangseng: 1985/1/2~2011/4/15

-U.K.)

FTSE 1985/1/2~2011/4/15

-Germany)

DAX 1985/1/2~2011/4/15

-France)

CAC 1987/7/9~2011/4/15

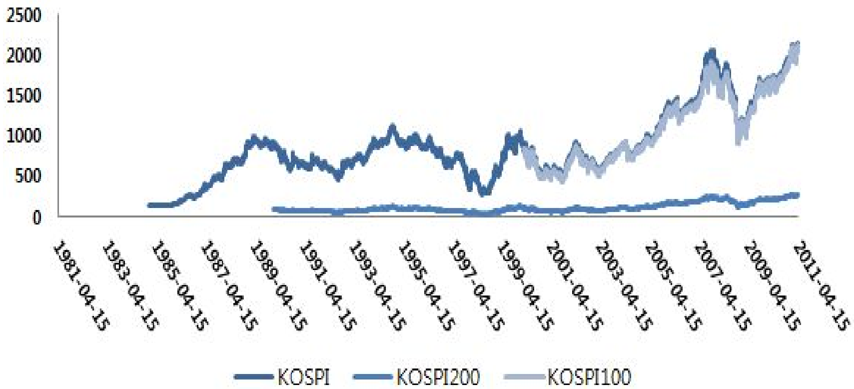
-Singapore)

STI 1999/8/31~2011/4/15

2. Trends of stock indices

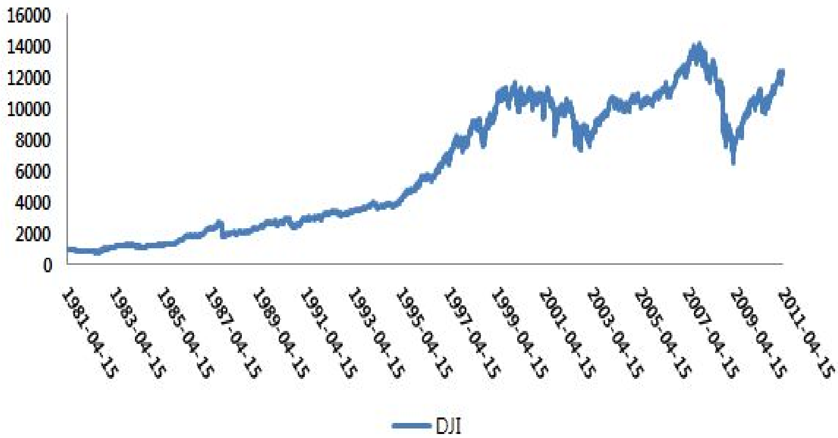
Trends of stock indices are depicted below.

• KOSPI, KOSPI200, KOSPI100



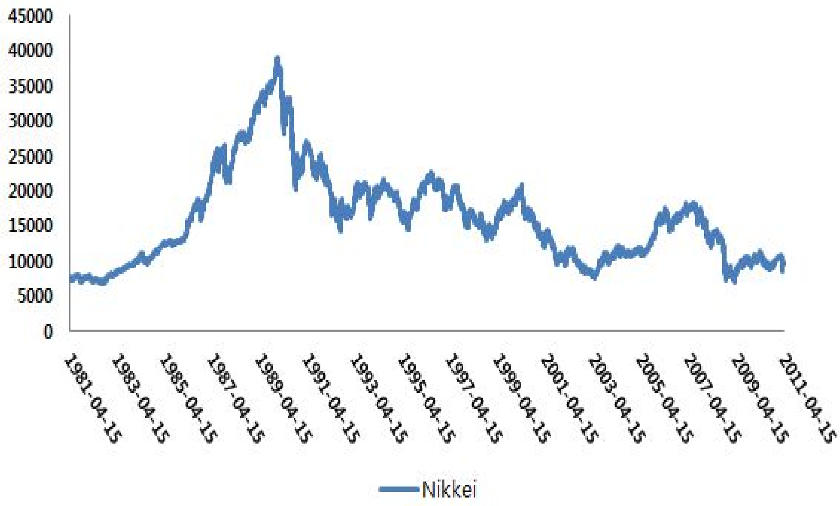
• S&P 500

• DJIA

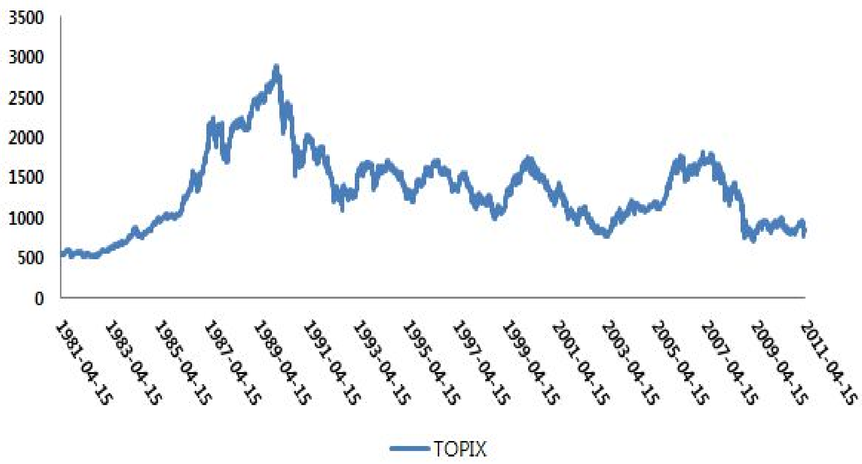


The S&P500 index and DJIA index reached high in March, 2000 for dot-com bubbles, and then lost in a tow-year bear market. In mid-2007, difficulties stemming from subprime mortgages began spreading to the finance sector, resulting in a bear market.

• Nikkei

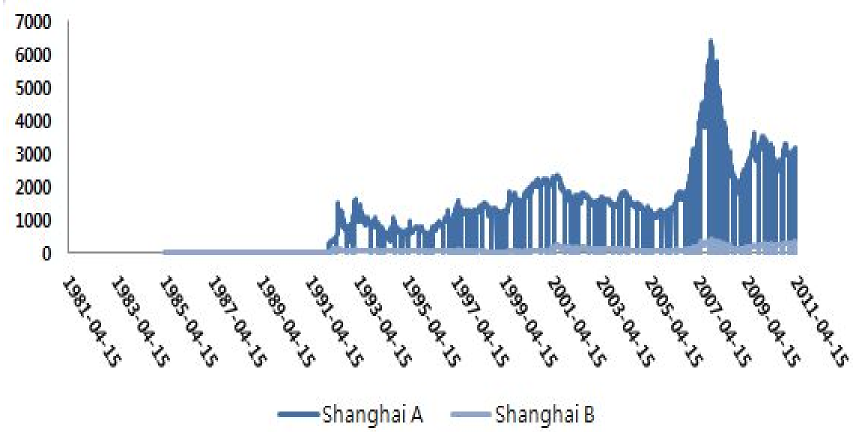


• TOPIX



The indices in Japan hit its all-time high in December, 1989, during the peak of the Japanese asset price bubble, when it had grown sixfold during the decade. Subsequently, it lost nearly all these gains.

• Shanghai A and Shanghai B



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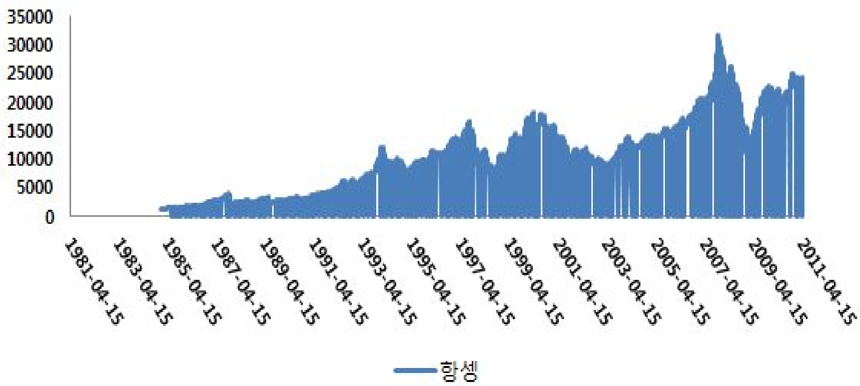
Shanghai A
Shanghai B

- HSI



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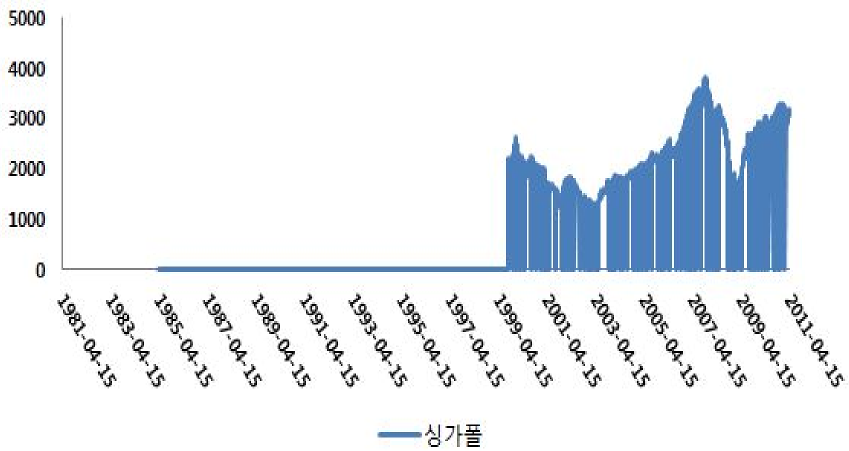
항셍

- STI



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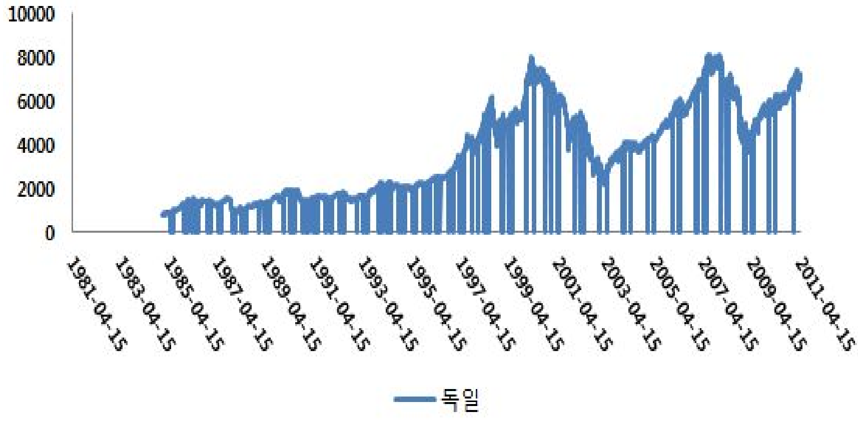
싱가폴

• DAX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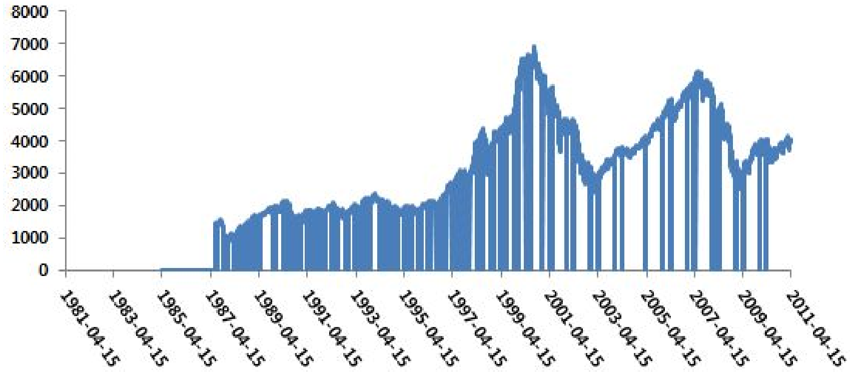
독일

• CAC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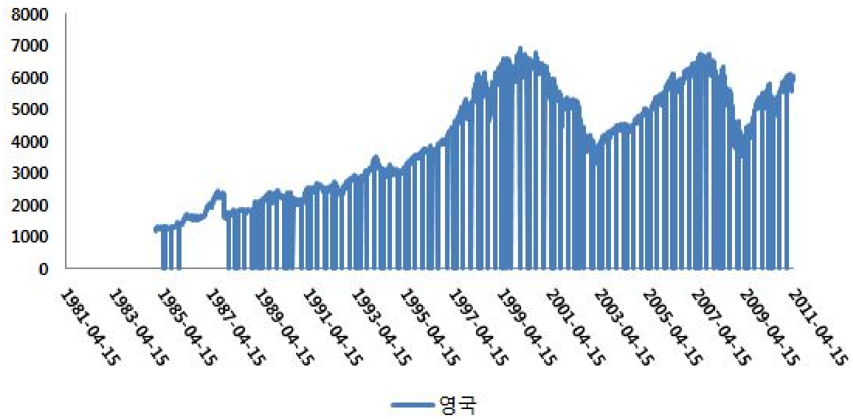
2007-04-15
2009-04-15
2011-04-15

• FTSE

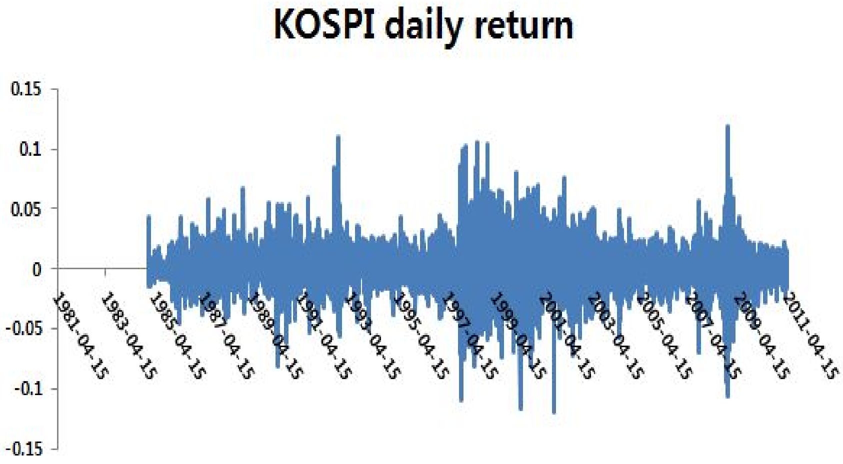


3. Definitions

Stock market index is more popular to the public than stock index return. However stock index returns are a better method of measuring performance of a stock market. Stock index return is calculated as:

$$\text{Stock index return}_t \quad = \frac{(\text{index}_t - \text{index}_{t-1})}{\text{index}_{t-1}}$$

In this thesis, stock index return is computed in a daily basis. Because KOSPI index is 241.71 on Oct. 20, 1986 and 241.17 on Oct. 21, 1986, for an example, the index return is -0.00236$\left(=\frac{(241.17-241.74)}{241.74}\right)$. The KOSPI index return trend is depicted as follows.



- average: An average of a data set is a measure of the center value of the data set. The formula for average is $\bar{x} = \frac{\sum x_i}{n}$. In this thesis, an average measures the expected return on a stock index.

- standard deviation: Standard deviation is a widely used measurement of variability of the data set. It shows how much dispersed the data are from the average (or the expected value). A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data are spread out over a large range of values. The standard deviation of a statistical population, data set, or probability distribution is the square root of its variance. That is,

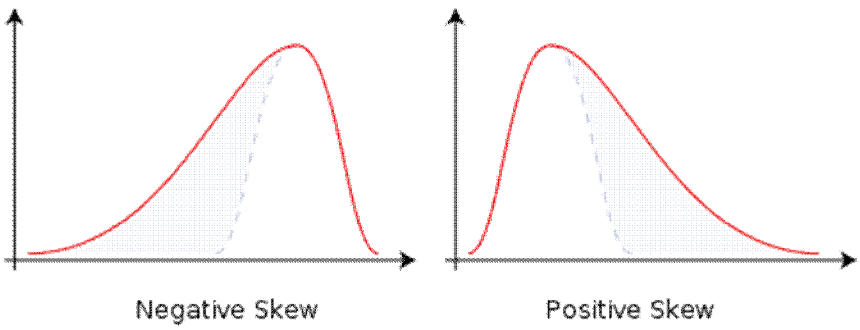
$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

In this thesis, standard deviation measures the degree of risk on a stock index.

- skewness: skewness is a measure the asymmetry of the probability distribution. The skewness value can be positive or negative. A skew is calculated as:

$$\frac{n}{(n-1)(n-2)}\sum\left(\frac{x_i-\bar{x}}{s}\right)^3$$

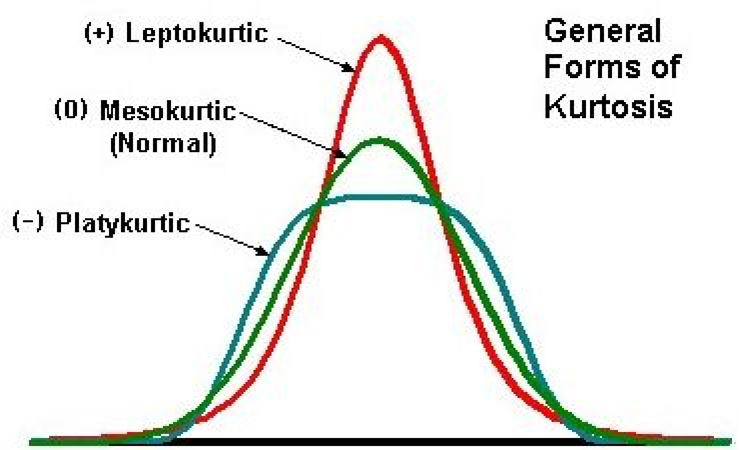
A negative skew indicates that the tail on the left side of the probability density function is thicker than the right side, whereas a positive skew indicates that the tail on the right side is thicker than the left side. A zero value indicates that the values are relatively evenly distributed on both sides of the mean, typically but not necessarily implying a symmetric distribution. However, a symmetric distribution has zero skew.



- kurtosis: Kurtosis (from the Greek word κυρτός, kyrtos or kurtos, meaning bulging) is a measure of the "peakedness" of a probability distribution of a real-valued random variable, although some sources are insistent that heavy tails, and not peakedness, is what is really being measured by kurtosis. Kurtosis and excess kurtosis are sometimes defined in differently. However, in this thesis kurtosis is defined as follows:

$$\left\{\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum\left(\frac{x_j-\bar{x}}{s}\right)^4\right\} -\frac{3(n-1)^2}{(n-2)(n-3)}$$

The following graph shows a normal distribution, leptokurtic(kurtosis>0) and plyakurtic(kurtosis<0).



- median: A median is the middle number of the group when they are ranked in order. (If there are an even number of numbers, the mean of the middle two is taken.)

- range

= maximum value – minimum value

4. Basis Statistics of Indices

Basic statistics

	US: S&P 500	US: DJIA	JAPAN: NIKKEI
average	0.000355	0.000388	0.000127

median	0.000215	0.000221	0
standard deviation	0.011256	0.011126	0.013796
variance	0.000127	0.000124	0.00019
kurtosis	22.61619	30.07666	9.407849
skewness	-0.79473	-1.01684	-0.08074
range	0.32047	0.336909	0.290512
minimum value	-0.20467	-0.22611	-0.14901
maximu value	0.1158	0.110803	0.141503
observations	7825	7731	7827

	JAPAN: TOPIX	KOREA: KOSPI	KOREA: KOSPI 200
average	0.000131	0.000546	0.000366
median	0	0	0
standard deviation	0.012237	0.017212	0.01892
variance	0.00015	0.000296	0.000358
kurtosis	10.38863	5.085521	4.49375
skewness	-0.14955	0.077958	0.160293
range	0.283526	0.239645	0.241928
minimum value	-0.14624	-0.12019	-0.11961
maximu value	0.137288	0.119457	0.122319
observations	7827	6855	5552

	KOREA: KOSPI 100	CHAINA: Shanghai A	CHAINA: Shanghai B
average	0.000483	0.000871	0.000427
median	0.000379	0.000623	-9.8E-05
standard deviation	0.01781	0.029974	0.022509
variance	0.000317	0.000898	0.000507
kurtosis	4.646392	416.3057	4.979516
skewness	-0.28149	12.21976	0.37034
range	0.241265	1.275109	0.276397

minimum value	-0.11894	-0.1683	-0.12817
maximu value	0.122324	1.106808	0.148229
observations	2901	4615	4570
	HONG KONG: HIS	U.K.:	GERMANY:
average	0.000567	0.000269	0.000373
median	0.000712	0.000508	0.00082
standard deviation	0.016573	0.01128	0.014413
variance	0.000275	0.000127	0.000208
kurtosis	14.13246	9.638589	6.156085
skewness	-0.27355	-0.32034	-0.1246
range	0.405691	0.220543	0.242103
minimum value	-0.21745	-0.12216	-0.12808
maximu value	0.188237	0.098388	0.11402
observations	6247	6518	6472
	FRANCE:	SINGAPORE:	MEAN in all
average	0.000189	1.05E-05	0.00034
median	0.000316	0.000409	0.000274
standard deviation	0.01405	0.012944	0.01494
variance	0.000197	0.000168	0.000263
kurtosis	5.688984	4.248414	36.52432
skewness	0.000513	-0.22227	0.637649
range	0.208168	0.161499	0.316251
minimum value	-0.09641	-0.08329	-0.13524
maximu value	0.111762	0.078213	0.18101
observations	5854	2822	5574.4

The mean daily return of 14 averages of all stock indices is 0.034%. Japanese index daily return is lower than the global mean due to sluggish economy since 1990. European index daily return is also lower than the global mean because of i) side effect of German unification, ii) crisis of subprime mortgages and iii) recent sovereign debt crisis. The daily return of Singapore

STI index is lower than the average because the data of STI index is collected after year 1999. U.S. index daily return is similar to the global mean. Overall, index return is higher in developing countries whereas that is lower in developed countries.

Variance, which represents variability of stock return, has a mean of 0.000263 in the whole world. It is has been presumed that variances of index return are higher in developing countries than in developed countries. The statistical results shown in this thesis demonstrate that the presumption is correct. The variances of index daily return in developing countries are 0.000296(KOSPI), 0.000358(KOSPI200), 0.000317(KOSPI100), 0.00089845(Shanghai A), 0.00050664(Shanghai B) and 0.000275(HSI), which is higher than the global average 0.000263. The variances in developed countries are 0.000127(S&P500), 0.000124(DJIA), 0.00019(Nikkei), 0.00015(TOPIX), 0.000127(U.K.), 0.000208(Germany) and 0.000197(France), which is lower than the global mean.

5. Test of Normality

Normality test is to used to determine whether a distribution of stock index return follows a normal distribution. An informal approach to testing normality is to compare a histogram of the sample data to a normal probability curve. Normality is presumed if the histogram is bell-shaped and resemble a normal distribution. Another informal test is to take a look at the values of kurtosis and skewness. Since a normal distribution has skewness of 0 and kurtosis of 0, the distribution is assumed to exhibit normality if skewness and kurtosis is near 0. In the basic statistics shows that mean of kurtosis is 36.524 which is far from 0, indicating the distribution exhibits non-normality. Even though excluding extreme large value of Shanghai A's kurtosis, the mean is 8.222 which still indicates non-normality.

A formal test, the Jarque-Bera test is a goodness-of-fit measure of departure from normality, based on the sample kurtosis and skewness. The test is named after Carlos Jarque and Anil K. The test statistic JB is defined as

$$JB = \frac{n}{6}\left(s^2 + \frac{k^2}{4}\right) \sim \chi_2^2$$

Where n=number of observations, s=skewness, k=kurtosis

The statistic JB has a chi-square distribution with two degrees of freedom and can be used to test the null hypothesis that the data are from a normal distribution. The null hypothesis of the skewness being zero and the kurtosis being 0, since samples from a normal distribution have an expected skewness of 0 and an expected kurtosis of 0. As the definition of JB shows, any deviation from this increases the JB statistic. The calculated JB statistics are:

<JB statistics>

	S&P500	DJI	NIKKEI	TOPIX	KOSPI	KOSPI200	KOSPI100
JB-statistic	167591.4	292728.3	28873.05	35225.76	7393.926	4695.272	2647.878

	Shanghai A	Shanghai B	HSI	U.K.	Germany	France	Singapore
JB-statistic	33441008.5	4825.95	52065.01	25342.22	10236.41	7894.2	2145.5

Assuming a significance level α=5%, the critical value of a chi-square distribution with two degrees of freedom is around 5.99, we must reject the null hypotheses of normality. Due to very large positive kurtosis and negative skewness (except Shanghai A), the distributions of index returns exhibit more frequent outliers and more frequent lower returns than higher returns.

V. Analyzing relationships among domestic indices

This section analyzes relationships among indices in a nation. To understand the relationships, we first compare the daily returns of indices in one nation. And then we calculate variability of index returns and find the trend of the variability.

We have collected 3 indices in Korea stock market, 2 indices in U.S. stock market, 2 indices in Japan stock market, and 2 indices in China stock market. The relationships are analyzed by correlation analysis. Through these analyses, we can also find out an index representing a national stock market.

1. Korea

The national stock market indices chosen in Korea are KOSPI, KOSPI200 and KOSPI100.

<Table 5-1> Correlations among index daily returns

	KOSPI	KOSPI200	KOSPI100
KOSPI	1		
KOSPI200	0.985	1	
KOSPI100	0.995	0.999	1

footnote) period

KOSPI: 85/1/6~2011/4/15

KOSPI200: 90/1/4~2011/4/15

KOSPI100: 2003/3/2~2011/4/15

Remarkably high correlation coefficients in the table above indicate that KOSPI, KOSPI200 and KOSPI100 have made movements in a very similar fashion. The high correlation coefficients are expected from the beginning because i) they are calculated in the same method, value-weighted scheme, ii) the constituents in KOPSI200 and KOSPI100 accounts for very large portions of the total market value of the KOSPI (200 constituents in KOSPI200 accounts for 70% market value of the KOSPI). Due to the high correlation coefficients, all three indices could be representative stock market indices of Korea. KOSPI will be used to compare with other foreign stock market indices because longer period data is available for KOSPI.

The following table shows correlation coefficients during different periods. It shows that the correlation coefficient between KOSPI and KOSPI200 has remained very high in any period.

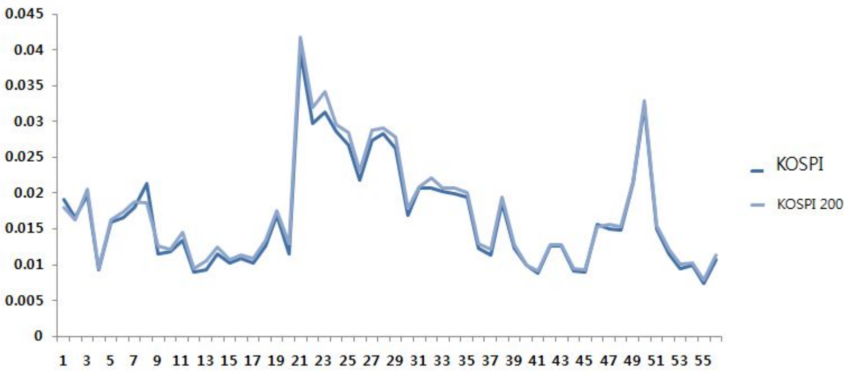
<Table 5-2> Correlation coefficient between KOSPI and KOSPI200 daily returns

Period	whole period	‘90s	2000/1~
correlation	0.985	0.974	0.997

footnote) period: 90/1/3~2011/4/15

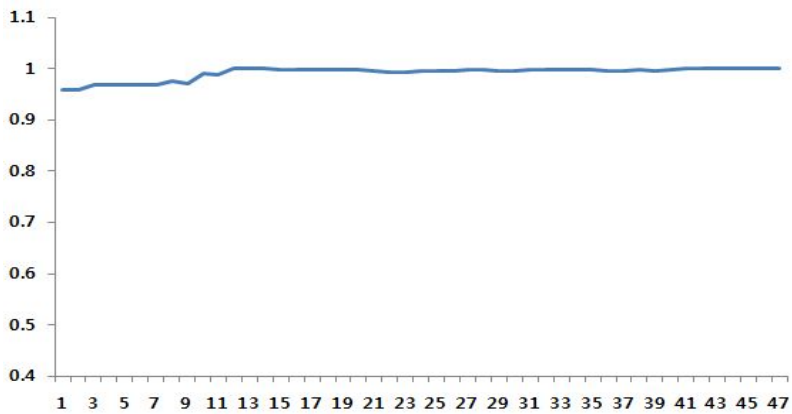
To measure variability of index returns, I calculate standard deviations on 100 daily returns. As in the table below, the daily returns of KOSPI and KOSPI200 have fluctuated in an almost identical pattern. The variability of KOSPI daily return is high whenever that of KOSPI200 daily return is high, and the variability of KOSPI daily return is low whenever that of KOSPI200 daily return is low.

<Figure 5-1> Standard deviations of KOSPI and KOSPI200 100 daily returns



This relationship is verified by calculating correlation coefficients between two standard deviations of KOSPI 100 daily returns and KOSPI200 100 daily returns. The correlation coefficient has been extremely high between two standard deviations, bounded below by 0.95, which is depicted in the figure below. This relationship is anticipated because i) the two indices are calculated in the same method, value-weighted scheme, ii) the constituents in KOPSI200 accounts for the major portions of the total market value of the KOSPI.

<Figure 5-2> Correlation between standard deviations of KOSPI and KOSPI200 100 daily returns



2. U.S.

The most popular indices in the U.S. are DJIA and S&P500. The correlation coefficient between S&P500 and DJIA may not be high because i) their calculation methods are different, S&P500 adopts a value-weighted scheme while DJIA adopts a price-weighted scheme and ii) the number of constituents are very different (DJIA consists of 30 stocks while S&P500 consists of 500 stocks).

<Table 5-3> Correlation between S&P500 and DJIA daily returns

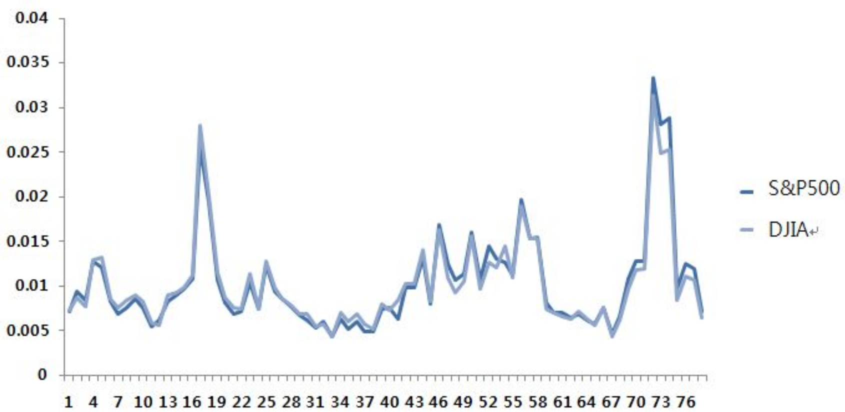
period	whole period	‘80s	‘90s	2000/1 ~
correlation	0.962	0.974	0.943	0.968

footnote) period: 81/4/5~2011/4/15

The table above demonstrates that correlation coefficients have been even even though two indices have distinctive features. This indicates that a stock price follows the stock market movements more than follows individual stock’s characteristics. High correlations also imply that any of two indices can represent U.S. stock market.

The 100-day standard deviation of index daily returns is computed to measure the variability of an index daily return. The following figure shows variability of S&P500 and DJIA daily returns. The movements of the two standard deviations are similar, but not as much as those of KOSPI and KOSPI200 daily returns.

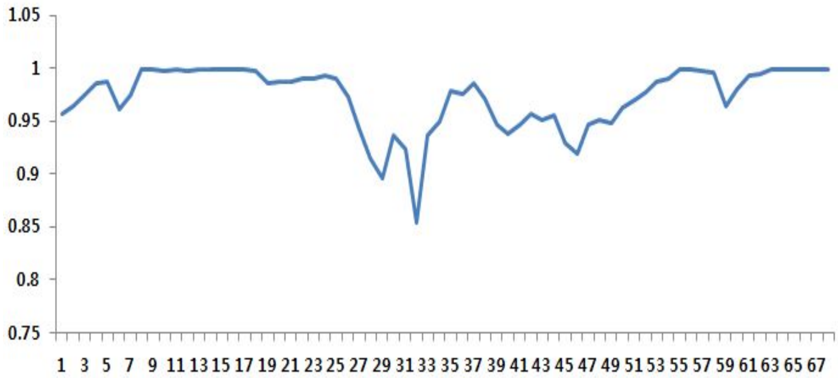
<Figure 5-3> Standard deviations of S&P500 and DJIA 100 daily returns



The figure below describes the relationship between standard deviations of S&P500 and DJIA 100 daily returns. The correlation coefficient has been high in the whole period. It has dropped record low approximately 0.85 around 1990. However, it is not as high as that of two Korean indices- KOSPI and KOSPI200, because i) the two indices are calculated in the different weighting schemes, ii) the constituents in DJIA accounts for a small portion of the total market value of the S&P500.

<Figure 5-4> Correlation between standard deviations of S&P500 and DJIA

daily returns



3. Japan

The two most popular stock market indices are dealt with in this thesis—Nikkei and TOPIX. Nikkei index is a price-weighted index just like DJIA. TOPIX is a value-weighted index like S&P500, but the former is a composite index. Despite of different weighting schemes of Nikkei and TOPIX, their performances are similar, which indicates that a stock price follows the stock market movements rather than follows individual stock's characteristics. In the table below, the correlation coefficients are 0.885 in '80s, 0.903 in '90s, and 0.959 in 2000s. It shows that the correlation coefficient between TOPIX daily return and DJIA daily return is bigger in recent years.

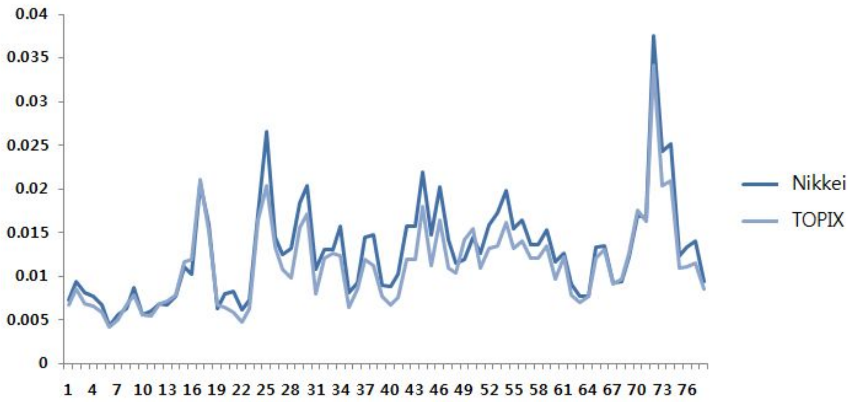
<Table 5-4> Correlations between TOPIX and Nikkei daily returns

period	whole period	'80s	'90s	2000/1 ~
correlation	0.929	0.885	0.903	0.959

footnote) period: 81/4/5~2011/4/15

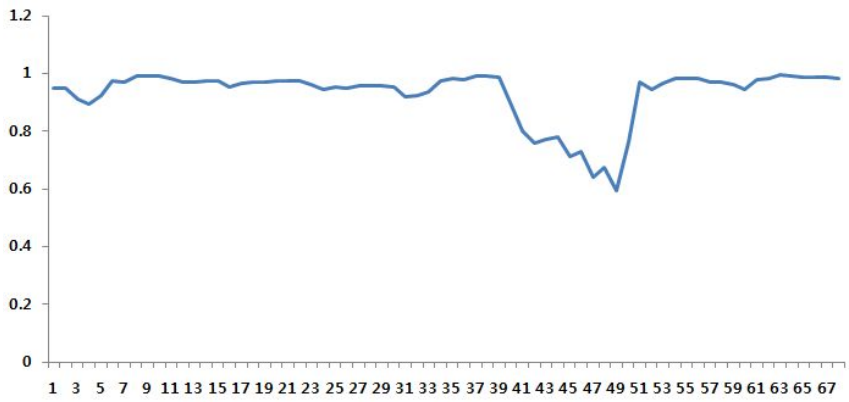
The 100-day standard deviation of index daily returns is computed to measure the variability of an index daily return. The following figure shows variability of Nikkei and TOPIX daily returns. They have fluctuated in a similar manner, but have bigger gaps than U.S. and Korean national indices.

<Figure 5-5> Standard deviations of Nikkei and TOPIX daily returns



Correlation coefficients between Nikkei and TOPIX are computed to find out the relationship between Nikkei and TOPIX daily returns. As in the figure below, the correlation coefficient has remained high during the whole period. The record low was around 0.6. The correlation coefficient is not as high as that of two Korean indices-KOSPI and KOSPI200, because the two indices are calculated in the different schemes-TOPIX is value-weighted while Nikkei is value-weighted. It is also not as high as that of the two U.S. indices because TOPIX is a composite index while S&P500 and DJIA do not include medium or small companies..

<Figure 5-6> Correlation between standard deviations of Nikkei and TOPIX 100 daily returns



4. China

Stock listed in Shanghai stock exchange which was established in 1990 has increased ever since. The stocks listed are categorized into two groups. One group is called Shanghai A stocks that can be initially traded by domestic investors only. The other group is called Shanghai B stocks which can be initially traded by foreigners only. The table below shows very low correlation coefficient, 0.198, between Shanghai A index daily return and Shanghai B index return in '90s. This is due to i) different investment styles between domestic investors and foreign investors, and ii) Shanghai A and Shanghai B consist of different stocks. The correlation coefficient went up to around 0.7 in 2000s, but not still as high as that of other countries.

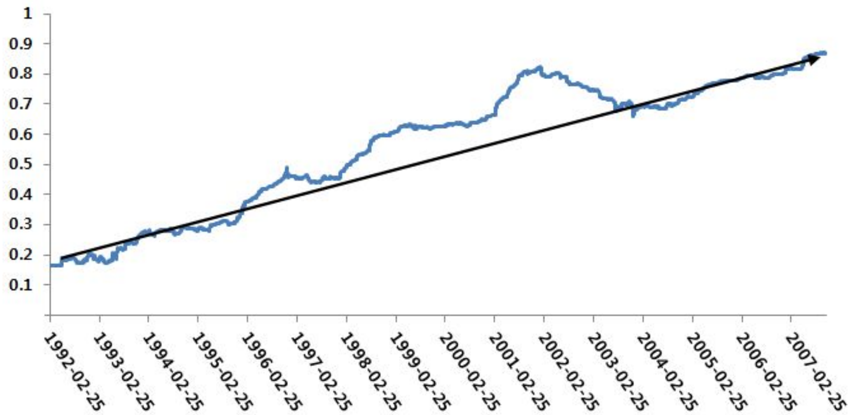
<Table 5-5> Correlation coefficients between Shanghai A and Shanghai B index daily returns

기간	전체	'90s	2000/1~
correlation	0.350	0.198	0.726

footnote) periods: 92/2/24~2011/4/15

The graph below shows trend of correlation coefficient between Shanghai A and Shanghai B index daily returns. To see the trend, I calculate correlation coefficient in 900-daily returns. As you see in the graph below, the correlation coefficient is getting bigger over time. The linear arrow line shows the linear trend, heading upward.

<Figure 5-7> Trend of correlation coefficients between Shanghai A and Shanghai B index daily returns

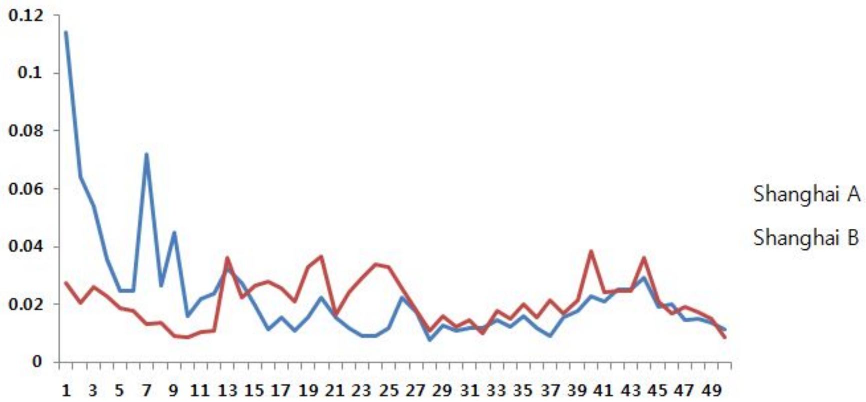


footnote) '1992-02-25' indicates starting date.

Shanghai A stocks have been gradually made available allowed to foreign investors since 2002 and Shanghai B stocks are available to domestic investors since 2001. Thanks to the government's ongoing plans to merge Shanghai A stocks with Shanghai B stocks, performances of the two indices are becoming similar. This is why the correlation coefficient gets larger with time.

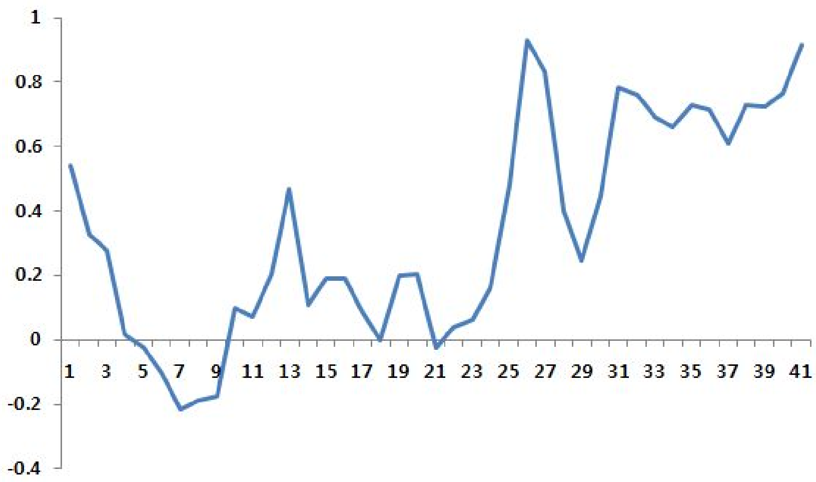
100-day standard deviation of index daily return is computed to measure the variability of an index daily return. The figure below displays variability of Shanghai A and Shanghai B daily returns. Their behaviors are very different in early years, and are getting more similar since 2001.

<Figure 5-8> Standard deviations of Shanghai A and Shanghai B 100 daily returns



Correlation coefficients are used to figure out the relationship between variability of the two indices. As in the figure below, there were no relationship between variability of Shanghai A and Shanghai B in early years. This is due to i) it was the first time for domestic investors to be exposed to stock market, which led irrational behavior in investing stocks, and ii) Shanghai A and Shanghai B consist of different stocks. Because Chinese government is merging the two indices, the variability seems to be getting more similar over time.

<Figure 5-9> Correlation between standard deviations of Shanghai A and Shanghai B 100 daily returns



5. Summary

I examined possible connections among domestic stock market indices. A study on behavior as well as variability of returns is conducted. Analysis shows that Shanghai A and Shanghai B indices do not have enough relationship due to the reasons explained above. Except Chinese indices, domestic stock market indices exhibit strong relationships. Irrespective of weighting schemes, index returns fluctuate in an almost identical manner. The variability of index returns shows a relationship among domestic stock indices, but not as strong as behavior of index returns. The relationship on variability depends on i) weighting scheme and ii) constituents. If the weighting schemes are the same, there is a strong relationship on variability. And if constituents of one stock index account for a large portion on the market value of another stock index, there is also a strong relationship on variability.

VI. Analyzing Relationships among National Stock Market Indices in a Given Continent

This chapter studies on the relationship among national stock index returns in a given continent. Owing to globalization by companies in sales and financing, and governments' lifting on foreigners' investment on domestic stocks, it is expected that the stock markets shows closer comovement. To see whether stock market comovement is proceeding, I examine the relationship among national representative stock index returns. As representatives of national stock market indices, KOSPI for Korea stock market index, TOPIX for Japanese stock market index, HSI for Hong Kong stock market index. Both Shanghai A and Shanghai B in China are taken into account as representatives of Chinese stock market index, because I cannot pick one by distinctive differences between two indices.

1. Comovement among Stock Markets in Asia

<Table 6-1> Correlation coefficients among representative indices in Asia

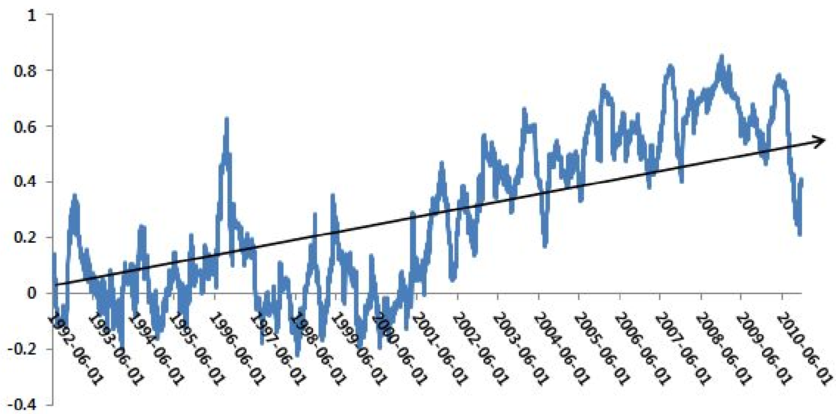
	TOPIX	KOSPI	Shanghai A	Shanghai B
TOPIX	1.000			
KOSPI	0.314	1.000		
Shanghai A	0.072	0.041	1.000	
Shanghai B	0.104	0.086	0.350	1.000
HSI	0.413	0.327	0.113	0.253

As in the table above, there are not strong relationships among stock market index returns across countries in Asia. There are low correlation coefficients of Shanghai A(B) with other nation's stock market index, which implies that Shanghai A(B) are not yet integrated with other nation's stock market owing to Chinese government restrictions on Chinese stock markets. That the correlation coefficients, at least 0.3, among Korea stock market, Japanese stock market and Hong Kong stock market reveals proceeded comovement of those national stock markets.

Stock market comovement between Korea and other Asian countries is studied through graphs without rigorous statistical tests. Linear arrows reflect a trend between national stock markets. All the graphs below describes that stock market comovement makes progress between Korea stock market and any other Asian stock markets. Chinese stock market also reveals comovement with Korea stock market, even though the level of comovement is still low.

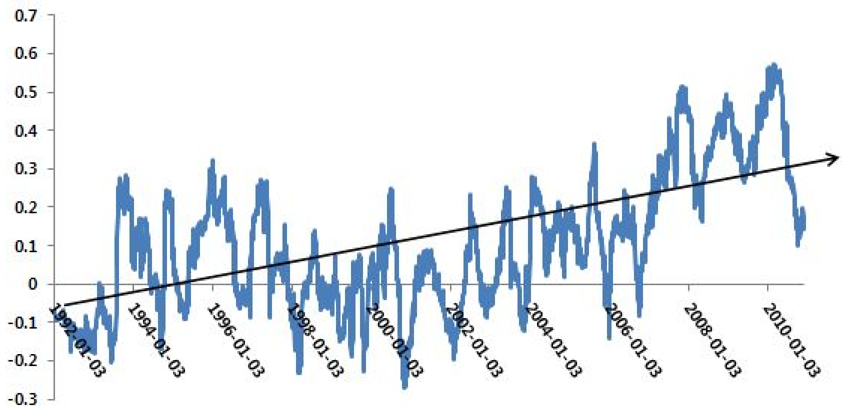
Korea and Japan

<Figure 6-1> Correlation coefficient between KOSPI and TOPIX 100 daily returns



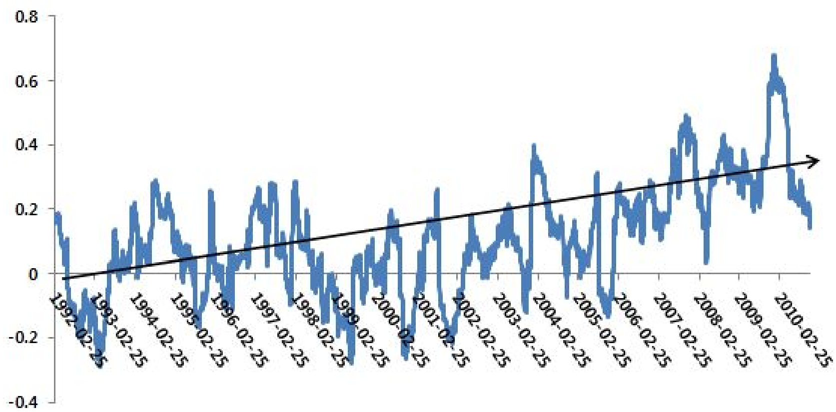
Korea and Shanghai A

<Figure 6-2> Correlation coefficient between KOSPI and Shanghai A 100 daily returns



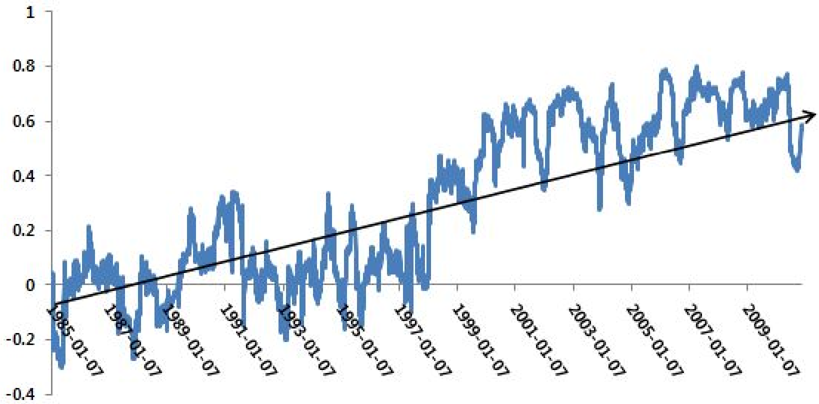
Korea and Shanghai B

<Figure 6-3> Correlation coefficient between KOSPI and Shanghai B 100 daily returns



Korea and Hong Kong

<Figure 6-4> Correlation coefficient between KOSPI and HSI 100 daily returns



2. Comovement among Stock Markets in Europe

DAX in Germany, CAC in France and FTSE in U.K. are selected to see whether European stock markets show comovement. The following coefficient table indicates strong integration among three different countries' stock market returns, which is stronger than in Asia. The correlation coefficient in Europe shows at least 0.679 which is much higher the highest correlation coefficient in Asia, 0.413. The introduction of Euro in 1994 could also increase dependence among European countries, which also induced rapid stock market comovement.

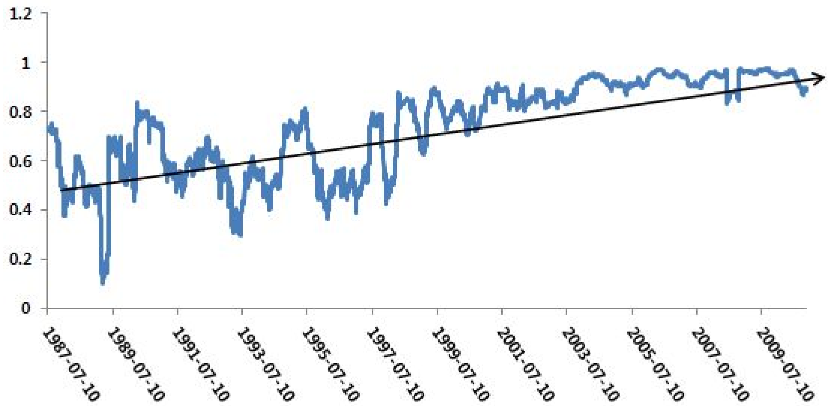
<Table 6-2> Correlations among 3 stock market index returns

	DAX (Germany)	CAC (France)	FTSE (U.K.)
DAX (Germany)	1.000		
CAC (France)	0.790	1.000	
FTSE (U.K.)	0.679	0.791	1.000

The following figures demonstrate that stock market comovement across European countries grows stronger. A linear arrow in each graph reflects a trend of stock markets comovement.

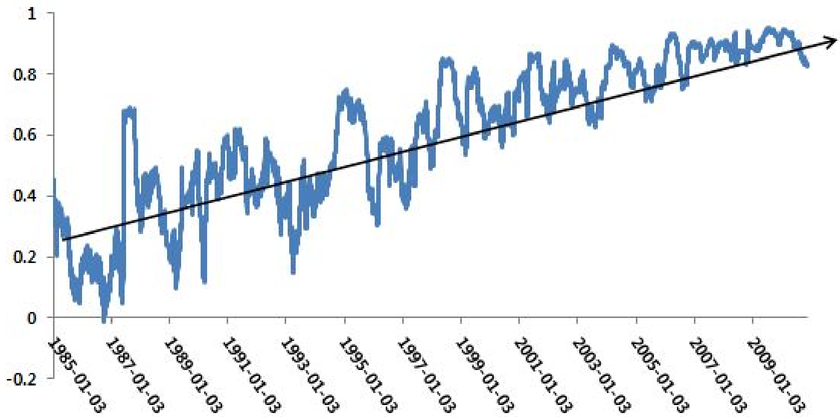
Germany and France

<Figure 6-5> Correlation coefficient between DAX and CAC 100 daily returns



Germany and U.K.

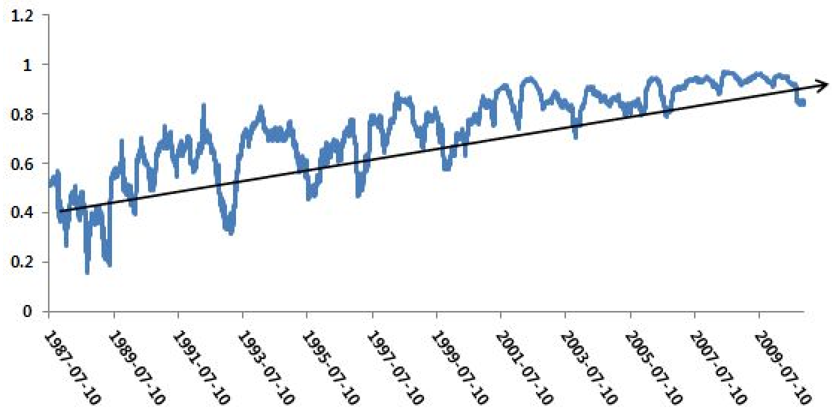
<Figure 6-6> Correlation coefficient between DAX and FTSE 100 daily returns



France and U.K.

<Figure 6-7> Correlation coefficient between CAC and FTSE 100 daily

returns



3. Summary

The results show that all the national stock markets in Asia and those in Europe reveal comovement. Even Chinese stock markets are emerging comovement with other Asian national stock markets thanks to government's deregulation on stock exchange. The studies also demonstrate that national stock markets in Europe reveal comovement much stronger than those in Asia.

VII. Analyzing Relationships among National Stock Market Indices in a Given Continent

This chapter strives to figure out whether one market has an influence on other markets. It has been claimed that U.S. stock market affects South Korea's stock market, but not the other way around. The thesis will test the validity of this statement. Naturally, another question comes up, "What about the influence of Asian stock market on European markets and vice versa?", "What about the influence of European stock market on U.S. stock market and vice versa?". This chapter provides simple graphical demonstrations together with rigorous proofs.

To observe whether one stock market affects the other market, time difference among the stock exchanges should be understood. If the time is 24:00(midnight) in Seoul, South Korea, it is

24:00 in Tokyo,

23:00 in Shanghai, Hong Kong and Singapore

17:00 in Berlin, Paris (summer time)

16:00 in London (summer time)

11:00 in New York (summer time)

To test the influence of South Korea's stock market on U.S. stock market, KOSPI return and S&P500 return on the same day must be analyzed. However, to test the influence of U.S. market on South Korea's stock market, KOSPI return and previous day's S&P500 return must be analyzed. The same logic applies in the analysis of the relationship between South Korea's stock market and European stock market. If I want to test the influence of South Korea's stock market on European stock market, KOSPI return and European stock index return on the same day must be compared. Whereas, to test the influence of European stock market on South Korea's stock market, KOSPI return and a previous day's European stock index return must be analyzed.

1. The Influence of Asian Stock Markets on U.S. Stock Market

Asian stock market return and S&P500 return is to be compared. The returns being compared must be on the same day to test the influence of Asian stock market on U.S. stock market. The data for returns is collected on a daily basis to best reflect the early adapting nature of stock market. A regression model must be used to observe the influence of Asian stock market on U.S. stock market.

The regression model is as follows:

$$\text{S\&P500 } return_t = \beta_0 + \beta_1 \cdot ((\text{Asia's stock market index return}_t) + \varepsilon.$$

And the null hypothesis and alternative hypothesis are as follows:

$$\begin{cases} Ho: \beta_1 \leq 0 \\ Ha: \beta_1 > 0 \end{cases}$$

The null hypothesis implies that the Asian stock market has no or negative influence on U.S. stock market, while the alternative hypothesis implies that the former has a positive influence on the latter. If t-value of the slope coefficient is greater than 1.645, the null hypothesis is rejected, implying the positive influence of Asian stock market on U.S. stock market. The following six figures show the result of a regression analysis.

<Figure 7-1> Results of Regressing S&P500 Returns on KOSPI Returns on a Same Day basis

```
> lms <- lm(SP500 ~ KOSPI)
> summary(lms)

Call:
lm(formula = SP500 ~ KOSPI)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.205341 -0.005077  0.000203  0.005424  0.112860 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.0003369  0.0001498   2.250   0.0245 *  
KOSPI       0.0686682  0.0084435   8.133 5.03e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.01181 on 6218 degrees of freedom
  (1608 observations deleted due to missingness)
Multiple R-squared: 0.01053,    Adjusted R-squared: 0.01037 
F-statistic: 66.14 on 1 and 6218 DF,  p-value: 5.026e-16 
```

<Figure 7-2> Results of Regressing S&P500 Returns on TOPIX Returns on a Same Day basis

```
> lms <- lm(SP500 ~ TOPIX)
> summary(lms)

Call:
lm(formula = SP500 ~ TOPIX)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.202449 -0.005073  0.000121  0.005404  0.102360 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.0002865  0.0001335   2.146   0.0319 *  
TOPIX       0.1041809  0.0105853   9.842   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.0113 on 7162 degrees of freedom
  (664 observations deleted due to missingness)
Multiple R-squared: 0.01334,    Adjusted R-squared: 0.01321 
F-statistic: 96.87 on 1 and 7162 DF,  p-value: < 2.2e-16 
```

<Figure 7-3> Results of Regressing S&P500 Returns on HSI Returns on a Same Day basis

```
> lms <- lm(SP500 ~ HSI)
> summary(lms)

Call:
lm(formula = SP500 ~ HSI)

Residuals:
      Min        1Q    Median        3Q       Max
-0.191618 -0.005188  0.000133  0.005508  0.103376

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0002124  0.0001473   1.442    0.149
HSI         0.1192465  0.0088938  13.408   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01149 on 6084 degrees of freedom
  (1742 observations deleted due to missingness)
Multiple R-squared: 0.0287,     Adjusted R-squared: 0.02854
F-statistic: 179.8 on 1 and 6084 DF,  p-value: < 2.2e-16
```

<Figure 7-4> Results of Regressing S&P500 Returns on STI Returns on a Same Day basis

```
> lms <- lm(SP500 ~ STI)
> summary(lms)

Call:
lm(formula = SP500 ~ STI)

Residuals:
      Min        1Q    Median        3Q       Max
-0.083885 -0.006420  0.000257  0.006244  0.100823

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -5.645e-05  2.528e-04  -0.223    0.823
STI          2.288e-01  1.957e-02  11.690   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01325 on 2745 degrees of freedom
  (5081 observations deleted due to missingness)
Multiple R-squared: 0.04742,    Adjusted R-squared: 0.04708
F-statistic: 136.7 on 1 and 2745 DF,  p-value: < 2.2e-16
```

<Figure 7-5> Results of Regressing S&P500 Returns on Shanghai A Returns on a Same Day basis

```
Call:
lm(formula = SP500 ~ ShangA)

Residuals:
      Min        1Q    Median        3Q       Max
-0.090612 -0.005137  0.000266  0.005398  0.115560

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.0002571  0.0001764   1.457    0.145
ShangA      -0.0004611  0.0058424  -0.079    0.937

Residual standard error: 0.01178 on 4464 degrees of freedom
  (3362 observations deleted due to missingness)
Multiple R-squared: 1.395e-06,  Adjusted R-squared: -0.0002226
F-statistic: 0.006228 on 1 and 4464 DF,  p-value: 0.9371
```

<Figure 7-6> Results of Regressing S&P500 Returns on Shanghai B Returns on a Same Day basis

```
> lms <- lm(SP500 ~ ShangB)
> summary(lms)

Call:
lm(formula = SP500 ~ ShangB)

Residuals:
      Min        1Q    Median        3Q       Max
-0.090537 -0.005111  0.000259  0.005431  0.115304

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0002747  0.0001787   1.537    0.124
ShangB      0.0052031  0.0079050   0.658    0.510

Residual standard error: 0.01184 on 4390 degrees of freedom
  (3436 observations deleted due to missingness)
Multiple R-squared: 9.868e-05,  Adjusted R-squared: -0.0001291
F-statistic: 0.4332 on 1 and 4390 DF,  p-value: 0.5104
```

From the six figures above, the t-value for KOSPI, TOPIX, HIS(Hong Kong), STI(Singapore), Shanghai A and Shanghai B are 8.133, 9.842, 13.408, 11.690, -0.079 and 0.658, respectively. Thus, the null hypothesis is rejected. In other words, the result claims that the stock markets of South Korea, Japan, Hong Kong and that of Singapore have a positive influence on U.S. stock market. However, China's stock market does not have positive influence on U.S. stock market. The analysis with Ho: $\beta_1 = 0$ & Ha: $\beta_1 \neq 0$ on influence of China's stock market on U.S. market still fails to reject the null hypothesis, suggesting independence of U.S. market from China's stock market result. This conclusion may be contrary to the fact that China's economy has a big impact on U.S. economy. The plausible explanations for such result are i) numerous government restrictions on trading in China, ii) irrational investing behavior in China's stock market and iii) long time lag between two markets.

<Table 7-1> Correlations between S&P500 and Asian Stock Market Index Returns on a Same Day basis

	TOPIX	KOSPI	Shanghai A	Shanghai B	HSI	STI
correlation	0.110	0.0099	-0.001	0.010	0.167	0.214

As in the table above, there are low correlation coefficients between S&P500 and Asian stock market index on daily returns. In particular, the correlation coefficients between S&P500 and Shanghai A (B) and KOSPI returns are low. Therefore, the further analysis on existence of significant correlation coefficient is necessary. The null hypothesis and alternative hypothesis for this test are as follows:

$$\begin{cases} H_o: \rho = 0 \\ H_a: \rho \neq 0 \end{cases}, \quad \text{where } \rho \text{ is population correlation coefficient}$$

The test statistic follows a t-distribution with n-2 degrees of freedom.

$$t = \frac{\gamma\sqrt{n-2}}{\sqrt{1-\gamma^2}} \sim t_{n-2} \qquad (6.1)$$

where γ is sample correlation coefficient

The calculated test statistics are:

<Table 7-2> Calculated Test Statistics

	TOPIX	KOSPI	Shanghai A	Shanghai B	HSI	STI
t-statistic	9.588	7.139	-0.079	0.656	13.543	11.189

The critical value for this test is around $\pm$1.96. The null hypothesis (Ho:$\rho = 0$) is rejected if the absolute value of test statistics is greater than 1.96, and not rejected otherwise. Based on this decision rule, TOPIX, KOSPI, HIS(Hong Kong) and STI(Singapore) do have an influence on U.S. stock market. The test statistics for Shanghai A and Shanghai B are below 1.96, which implies that these index returns have no correlation with U.S. stock market index return.

2. The Influence of U.S. Stock Market on Asian Stock Market

To test the influence of U.S. stock market on Asian stock market, return on Asian stock market index and return on a previous day's U.S market must be compared. The regression model is as follows:

$$\text{An Asian stock market index return}_t = \beta_0 + \beta_1 \cdot S\&P500\ return_{t-1} + \varepsilon.$$

And the null hypothesis and alternative hypothesis is as follows:

$$\begin{cases} Ho: \beta_1 \leq 0 \\ Ha: \beta_1 > 0 \end{cases}$$

The null hypothesis implies that U.S. stock market has no or negative influence on the Asian stock market, while the alternative hypothesis implies that the former has a positive influence on the latter. If t-value of the slope coefficient is greater than 1.645, the null hypothesis is rejected, implying the positive influence of U.S. stock market on Asian stock market. The following six figures show the result of a regression analysis.

<Figure 7-7> Results of Regressing KOSPI Returns on Previous Day's S&P500 Returns

```
> lms <- lm(KOSPI ~ SP500)
> summary(lms)

Call:
lm(formula = KOSPI ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max
-0.111524 -0.008565 -0.000135  0.008601  0.123034

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0004395  0.0002192   2.005    0.045 *
SP500       0.3625345  0.0185295  19.565   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01723 on 6187 degrees of freedom
  (1640 observations deleted due to missingness)
Multiple R-squared: 0.05827,    Adjusted R-squared: 0.05811
F-statistic: 382.8 on 1 and 6187 DF,  p-value: < 2.2e-16
```

<Figure 7-8> Results of Regressing TOPIX Returns on Previous Day's S&P500 Returns

```
> lms <- lm(TOPIX ~ SP500)
> summary(lms)

Call:
lm(formula = TOPIX ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.092004 -0.005959 -0.000009  0.005834  0.088166 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 2.249e-05  1.358e-04   0.166    0.868    
SP500       4.538e-01  1.181e-02  38.425   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.01148 on 7155 degrees of freedom
  (672 observations deleted due to missingness)
Multiple R-squared: 0.1711,     Adjusted R-squared: 0.1709 
F-statistic:  1477 on 1 and 7155 DF,  p-value: < 2.2e-16 
```

<Figure 7-9> Results of Regressing HSI Returns on Previous Day's S&P500 Returns

```
> lms <- lm(HSI ~ SP500)
> summary(lms)

Call:
lm(formula = HSI ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.223564 -0.007088 -0.000130  0.007495  0.161344 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.0004001  0.0001987   2.013   0.0441 *  
SP500       0.5179258  0.0173874  29.787   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.0155 on 6090 degrees of freedom
  (1737 observations deleted due to missingness)
Multiple R-squared: 0.1272,     Adjusted R-squared: 0.127 
F-statistic: 887.3 on 1 and 6090 DF,  p-value: < 2.2e-16 
```

<Figure 7-10> Results of Regressing STI Returns on Previous Day's S&P500 Returns

```
> lms <- lm(STI ~ SP500)
> summary(lms)

Call:
lm(formula = STI ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.087746 -0.006221  0.000155  0.006196  0.081954 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 9.084e-05  2.297e-04   0.396    0.692    
SP500       3.458e-01  1.682e-02  20.559   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.01204 on 2745 degrees of freedom
  (5082 observations deleted due to missingness)
Multiple R-squared: 0.1334,     Adjusted R-squared: 0.1331 
F-statistic: 422.7 on 1 and 2745 DF,  p-value: < 2.2e-16
```

<Figure 7-11> Results of Regressing Shanghai A Returns on Previous Day's S&P500 Returns

```
> lms <- lm(ShangA ~ SP500)
> summary(lms)

Call:
lm(formula = ShangA ~ SP500)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.17025 -0.00989 -0.00042  0.00856  1.10618 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)   
(Intercept) 0.0009121  0.0004499   2.027   0.0427 * 
SP500       0.1208458  0.0380397   3.177   0.0015 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.03006 on 4464 degrees of freedom
  (3363 observations deleted due to missingness)
Multiple R-squared: 0.002256,   Adjusted R-squared: 0.002032 
F-statistic: 10.09 on 1 and 4464 DF,  p-value: 0.001499
```

<Figure 7-12> Results of Regressing Shanghai B Returns on Previous Day's S&P500 Returns

```
> lms <- lm(ShangB ~ SP500)
> summary(lms)

Call:
lm(formula = ShangB ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max
-0.129060 -0.009705 -0.000827  0.008868  0.148904

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0005540  0.0003372   1.643      0.1
SP500       0.1829714  0.0284076   6.441 1.32e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02234 on 4391 degrees of freedom
  (3436 observations deleted due to missingness)
Multiple R-squared: 0.009359,   Adjusted R-squared: 0.009134
F-statistic: 41.49 on 1 and 4391 DF,  p-value: 1.315e-10

> |
```

From the six figures above, the t-values for KOSPI, TOPIX, HSI(Hong Kong), STI(Singapore), Shanghai A and Shanghai B are 19.565, 38.425, 29.787, 20.559, 3.177 and 6.441, respectively. Thus, the null hypothesis is rejected. In other words, the result claims that the stock market of U.S has a significant influence on all Asian stock market. Even China's stock markets are directly influenced by U.S. stock market, which may feel contrary to the results found in <Figure 7-5> and <Figure 7-6> in which China's stock markets had no influence on the U.S. stock market. The simple explanation is as follows. Since China's stock market opens immediately after the U.S. stock market, the latter can directly influence on the former. However, the long time delay between China's stock market close and U.S. stock market opening and many other factors will neutralize the influence of China's stock market on U.S. stock market.

<Table 7-3> Correlations between a Previous Day's S&P500 Returns and Asian Stock Market Index Returns

	TOPIX	KOSPI	Shanghai A	Shanghai B	HSI	STI
correlation	0.398	0.231	0.047	0.095	0.353	0.360

All the correlation coefficients seem to be positive and relatively large except with Shanghai A and Shanghai B. A previous day's S&P500 return reveals higher correlation coefficient with TOPIX (or Hong Kong or Singapore) than with KOSPI because firms listed in TOPIX (or Hong Kong or Singapore) are more globalized and lesser government restrictions are imposed on investing in TOPIX stocks than in KOSPI. Higher correlation coefficient of Shanghai B than that of Shanghai A reflects the relatively heavy restrictions imposed on Shanghai A stocks. Since the correlation coefficients of Shanghai A and Shanghai B are not large enough, the significance of the correlation coefficients should be tested formally. The null hypothesis and alternative hypothesis are as follows:

$$\begin{cases} H_o: \rho = 0 \\ H_a: \rho \neq 0 \end{cases}, \quad \text{where } \rho \text{ is population correlation coefficient}$$

The test statistic follows a t-distribution with n-2 degrees of freedom.

$$t = \frac{\gamma\sqrt{n-2}}{\sqrt{1-\gamma^2}} \sim t_{n-2},$$

where γ is sample correlation coefficient

The test statistics calculated are:

<Table 7-4> Calculated Test Statistics

	TOPIX	KOSPI	Shanghai A	Shanghai B	HSI	STI
t-statistic	37.589	17.084	3.188	6.376	30.138	19.665

The critical value is ± 1.96 at $\alpha = 5\%$, with the null hypothesis being that S&P500 daily return has no influence on TOPIX, KOSPI, Shanghai A, Shanghai B, HIS and STI.

Based on the statistical results, it is concluded that U.S stock market has a significant influence on all the Asian stock index return. From <Table 7-2>, some of Asian stock index return had influences on U.S. stock market. Combining these results, another question arises, 'which influence is more significant?' To answer this question, correlation coefficients should be compared. The following table combines two correlation coefficient tables <Table 7-1> and <Table 7-3>.

<Table 7-5> Correlations: U.S.->Asia vs. Asia->U.S.

influence	TOPIX	KOSPI	Shanghai A	Shanghai B	HSI	STI
U.S.->Asia	0.398	0.231	0.047	0.095	0.353	0.360
Asia->U.S.	0.110	0.0099	-0.001	0.010	0.167	02.14

In the table above, 'U.S. -> Asia' uses a previous day's S&P500 stock market index return while 'Asia -> U.S' uses S&P500 stock market index return on the same day. All the correlation coefficients in the former appear to be higher than the latter, 0.398>0.110, 0.231>0.0099, 0.047>-0.001, 0.095>0.010, 0.353>0.167, and 0.363>0.214. This allows us to conclude that U.S. stock market has a stronger influence on Asian stock market than the other way around.

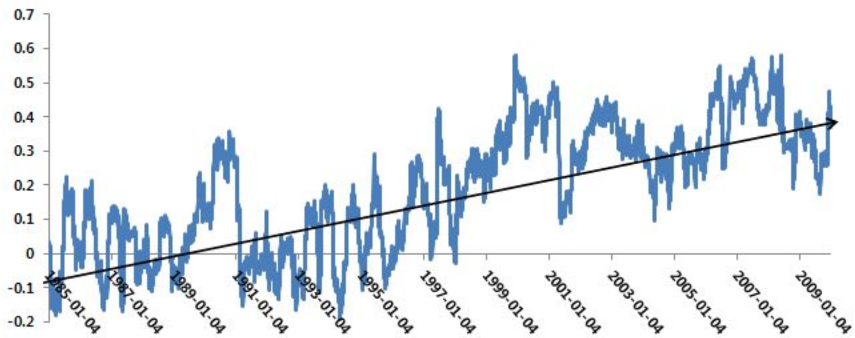
3. The Existence of Comovement between U.S. Stock Market and Asian Stock Market

The mathematical proof of an increase in comovement between U.S. and Asian stock market is difficult to establish. Instead, graphical demonstrations will provide a rough understanding of behavior of stock market comovement. 100-daily index returns are collected in order to calculate correlation coefficients between U.S. stock market return and South Korea's stock market return. Since U.S. stock market has a stronger influence on Asian stock markets than vice versa, the previous day's S&P500 return data is used.

1) Comovement between U.S. Stock Market and South Korea's Stock Market

As seen in the figure below, correlation coefficient between a previous day's S&P500 return and KOSPI return has been increasing, indicating an increase in comovement between U.S. stock market and South Korea's stock market. South Korea's stock market opening its door to foreign investors in 1992, deregulation on stock exchange and globalization of firms had helped two countries' stock markets to move together. The linear arrow in the graph indicates a linear trend, with which stronger comovement is expected in the future.

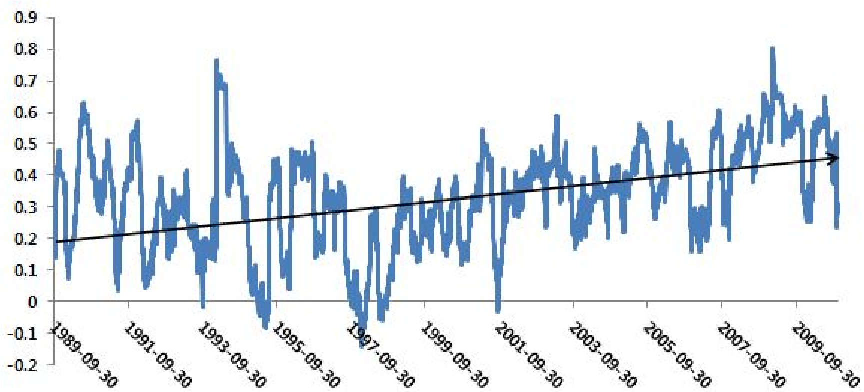
<Figure 7-13> Correlation between a Previous Day's S&P500 and KOSPI Returns



2) Comovement between U.S. Stock Market and Japan's Stock Market

Correlation coefficient between a previous day's S&P500 return and TOPIX return is also increasing in general as shown in the figure below, as expected.

<Figure 7-14> Correlation between a Previous Day's S&P500 and TOPIX Returns

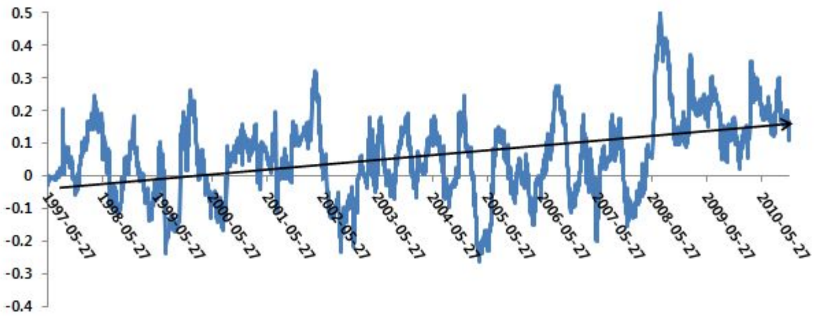


3) Comovement beteween U.S. Stock Market and China's Stock Market

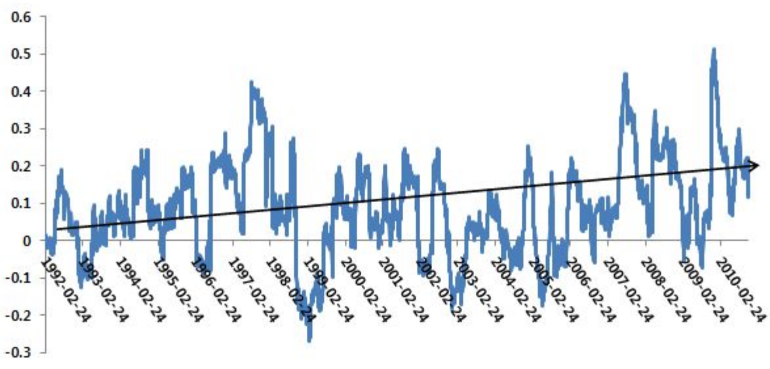
Although the correlation coefficient of a previous day's S&P500

return with Shanghai A (B) index return is not significantly high, there still is a strong evidence that it is increasing. The following two figures demonstrate that correlation coefficient of a previous day's S&P500 return with Shanghai A (B) index return is lower than 0.2 even in recent years, but there is a definite upward trend depicted by a linear arrow.

<Figure 7-15> Correlation between a Previous Day's S&P500 and Shanghai A Returns



<Figure 7-16> Correlation between a Previous Day's S&P500 and Shanghai B Returns



4. The Influence of Asian Stock Market on European Stock Market

To analyze the impact of Asian stock market on European stock market, stock market index returns on the same day must be compared. Regression models must be used to observe the influence of Asian stock market on European stock market. Since DAX (German stock market index), FTSE (U.K. stock market index) index), CAC (French stock market index), KOSPI, TOPIX, Shanghai A, Shanghai B, HSI and STI are to be examined, regression analysis must be used 18 times. To simplify the analysis CAC, Shanghai A, Shanghai B, HSI and STI will be excluded.

$$\text{An European stock market index } return_t = \beta_o + \beta_1 \cdot (\text{An Asian stock market index return}_t) + \varepsilon$$

And the null hypothesis and alternative hypothesis is as follows:

$$\begin{cases} Ho: \beta_1 \leq 0 \\ Ha: \beta_1 > 0 \end{cases}$$

The null hypothesis implies that the Asian stock market has no or negative influence on European stock market, while the alternative hypothesis implies that the former has a positive influence on the latter. If t-value of the slope coefficient is greater than 1.645, the null hypothesis is rejected, implying the positive influence of Asian stock market on European stock market. The following figures show the result of a regression analysis.

<Figure 7-17> Results of Regressing DAX Returns on KOSPI Returns on a

Same Day basis

```
> lms <- lm(Germany ~ KOSPI)
> summary(lms)

Call:
lm(formula = Germany ~ KOSPI)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.128656 -0.007114  0.000434  0.007474  0.108250 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.0002501  0.0001823   1.372     0.17    
KOSPI       0.1513348  0.0102171  14.812   <2e-16 ***
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' $

Residual standard error: 0.01426 on 6121 degrees of freedom
  (1705 observations deleted due to missingness)
Multiple R-squared: 0.0346,     Adjusted R-squared: 0.03444 
F-statistic: 219.4 on 1 and 6121 DF,  p-value: < 2.2e-16
```

<Figure 7-18> Results of Regressing FTSE Returns on KOSPI Returns on a Same Day basis

```
> lms <- lm(UK ~ KOSPI)
> summary(lms)

Call:
lm(formula = UK ~ KOSPI)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.119249 -0.005706  0.000250  0.006087  0.102571 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.0001797  0.0001421   1.264    0.206    
KOSPI       0.1303746  0.0079786  16.341   <2e-16 ***
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' $

Residual standard error: 0.01112 on 6123 degrees of freedom
  (1703 observations deleted due to missingness)
Multiple R-squared: 0.04179,    Adjusted R-squared: 0.04163 
F-statistic:   267 on 1 and 6123 DF,  p-value: < 2.2e-16
```

<Figure 7-19> Results of Regressing DAX Returns on TOPIX Returns on a Same Day basis

```
> lms <- lm(Germany ~ TOPIX)
> summary(lms)

Call:
lm(formula = Germany ~ TOPIX)

Residuals:
      Min        1Q    Median        3Q       Max
-0.123525 -0.007029  0.000358  0.007296  0.098319

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0002941  0.0001766   1.665    0.096 .
TOPIX       0.2812377  0.0132278  21.261   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' $

Residual standard error: 0.01385 on 6143 degrees of freedom
  (1683 observations deleted due to missingness)
Multiple R-squared: 0.06854,    Adjusted R-squared: 0.06839
F-statistic:   452 on 1 and 6143 DF,  p-value: < 2.2e-16
```

<Figure 7-20> Results of Regressing FTSE Returns on TOPIX Returns on a Same Day basis

```
> lms <- lm(UK ~ TOPIX)
> summary(lms)

Call:
lm(formula = UK ~ TOPIX)

Residuals:
      Min        1Q    Median        3Q       Max
-0.102704 -0.005661  0.000231  0.005918  0.076604

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0002110  0.0001363   1.549    0.121
TOPIX       0.2468095  0.0102394  24.104   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' $

Residual standard error: 0.01071 on 6181 degrees of freedom
  (1645 observations deleted due to missingness)
Multiple R-squared: 0.08592,    Adjusted R-squared: 0.08577
F-statistic:   581 on 1 and 6181 DF,  p-value: < 2.2e-16
```

From the four figures above, the t-values are 14.812, 16.341, 21.261, 24.104, consecutively. The result supports the claim that South Korea and Japan's stock markets have positive influences on German and U.K.'s stock markets. When analyzed, Shanghai A and Shanghai B also have positive influences on these European stock markets. The correlation matrix is computed in the table below. The table shows the correlation coefficients between three Asian stock market indices and three European stock market indices.

<Table 7-6> Correlation Matrix of Index Returns on a Same Day basis

Index	DAX(Germany)	CAC(France)	FTSE(U.K.)
KOSPI	0.182	0.193	0.199
TOPIX	0.254	0.266	0.283
HSI	0.337	0.319	0.316

All the correlation coefficients are positive and relatively large, which supports the claim that KOSPI, TOPIX and HSI have positive correlations with three European stock market indices. To obtain statistical proof, test statistics are calculated with the following formula.

$$t = \frac{\gamma\sqrt{n-2}}{\sqrt{1-\gamma^2}} \sim t_{n-2}$$

where γ is sample correlation coefficient

The calculated test statistics are:

<Table 7-7> Calculated Statistics between Asian and European Stock Markets

Index	DAX(Germany)	CAC(France)	FTSE(U.K.)
KOSPI	13.345	14.148	14.668
TOPIX	18.910	19.908	21.274
HSI	25.844	24.239	24.034

footnote) use n=5,200 because number of observations are at least 5,200

Since the critical value is 1.96, all the null hypothesis is rejected. In other words, KOPSI (TOPIX or HSI) daily returns have no correlation with DAX (CAC or FTSE) daily returns. The test result above concludes that all three Asian stock market index-KOSPI, TOPIX and HSI- are correlated with all European stock index return-DAX, CAC and FTSE.

The interesting features found in <Table 7-7> are that i) the correlation coefficients of an Asian stock market index returns are almost identical across European stock markets, and ii) the correlation coefficients of HSI is bigger than those of TOPIX, which are also bigger than those of KOSPI. The reason for i) is due to high integration of European stock market, and the reason for ii) is due to the high level of deregulation and portions of listed foreign stocks.

5. The Influence of European Stock Market on Asian Stock Market

Regression models will be used to observe the influence of European stock market on Asian stock market. To calculate the impact of European stock market on Asian stock markets, a previous day's European stock market returns must be used. To avoid tedious similar regression analyses, analysis on the influence of two of the European stock markets on two Asian stock markets has been conducted. The regression model is as follows:

$$\text{An Asian stock market index return}_t = \beta_o + \beta_1 \cdot (\text{An European stock market index } return_{t-1}) + \varepsilon$$

And the null hypothesis and alternative hypothesis are as follows:

$$\begin{cases} Ho: \beta_1 \le 0 \\ Ha: \beta_1 > 0 \end{cases}$$

<Figure 7-21> Results of Regressing KOSPI Returns on a Previous Day's DAX Returns

```
> lms <- lm(KOSPI ~ Germany)
> summary(lms)

Call:
lm(formula = KOSPI ~ Germany)

Residuals:
      Min        1Q    Median        3Q       Max
-0.120578 -0.008528  0.000080  0.008479  0.119213

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.0005618  0.0002280   2.465   0.0137 *
Germany     -0.0130335  0.0157608  -0.827   0.4083
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01782 on 6115 degrees of freedom
  (1712 observations deleted due to missingness)
Multiple R-squared: 0.0001118,  Adjusted R-squared: -5.169e-05
F-statistic: 0.6839 on 1 and 6115 DF,  p-value: 0.4083
```

<Figure 7-22> Results of Regressing TOPIX Returns on a Previous Day's DAX Returns

```
> lms <- lm(TOPIX ~ Germany)
> summary(lms)

Call:
lm(formula = TOPIX ~ Germany)

Residuals:
      Min        1Q    Median        3Q       Max
-0.142706 -0.006476  0.000052  0.006682  0.133362

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.479e-05  1.694e-04   0.087     0.93
Germany     -6.024e-02  1.169e-02  -5.152 2.65e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01327 on 6142 degrees of freedom
  (1685 observations deleted due to missingness)
Multiple R-squared: 0.004304,   Adjusted R-squared: 0.004142
F-statistic: 26.55 on 1 and 6142 DF,  p-value: 2.651e-07
```

<Figure 7-23> Results of Regressing KOSPI Returns on a Previous Day's

FTSE Returns

```
> lms <- lm(KOSPI ~ UK)
> summary(lms)

Call:
lm(formula = KOSPI ~ UK)

Residuals:
      Min        1Q    Median        3Q       Max
-0.120014 -0.008541  0.000040  0.008532  0.120054

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.0005500  0.0002277   2.416  0.01573 *
UK          -0.0574382  0.0201382  -2.852  0.00436 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01782 on 6131 degrees of freedom
  (1696 observations deleted due to missingness)
Multiple R-squared: 0.001325,   Adjusted R-squared: 0.001162
F-statistic: 8.135 on 1 and 6131 DF,  p-value: 0.004356
```

<Figure 7-24> Results of Regressing TOPIX Returns on a Previous Day' FTSE Returns

```
> lms <- lm(TOPIX ~ UK)
> summary(lms)

Call:
lm(formula = TOPIX ~ UK)

Residuals:
      Min        1Q    Median        3Q       Max
-0.138302 -0.006424  0.000029  0.006616  0.130020

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.638e-05  1.686e-04   0.216    0.829
UK          -1.010e-01  1.486e-02  -6.795 1.18e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01326 on 6188 degrees of freedom
  (1639 observations deleted due to missingness)
Multiple R-squared: 0.007407,   Adjusted R-squared: 0.007246
F-statistic: 46.18 on 1 and 6188 DF,  p-value: 1.183e-11
```

As mentioned above, the critical value is 1.645. The t-values for the slope coefficients in the four figures above are -0.827, -5.152, -2.852 and -6.795, none of which is greater than 1.645. Based on these results, no European stock market index returns have statistically significant influence on KOSPI and TOPIX returns. This is simply due to the long time delay between

European stock market close and Asian stock market open. During the time lag, numerous other factors neutralize the consequence of European stock market close. The correlation matrix between three Asian index returns and a previous day's European index returns is shown in the table below.

<Table 7-8> Correlation Matrix of Index Returns on a Previous Day's European Stock Market Returns

Index	KOSPI	TOPIX	HSI
DAX (Germany)	-0.010	-0.064	-0.019
CAC (France)	-0.018	-0.060	-0.013
FTSE (U.K.)	-0.035	-0.084	-0.012

All the correlation coefficients are negative, which may lead to a conclusion that European stock market indices have negative correlation with Asian stock markets. However, all the correlation coefficients are close to zero, which implies no significant correlation between a previous day's European stock index returns and Asian stock index returns. To test the validity of this argument, the null hypothesis and alternative hypothesis are set as follows:

$\begin{cases} H_o: \rho = 0 \\ H_a: \rho \neq 0 \end{cases}$, where ρ is population correlation coefficient

The test statistics are calculated with the following formula.

$$t = \frac{\gamma\sqrt{n-2}}{\sqrt{1-\gamma^2}} \sim t_{n-2}$$

where γ is sample correlation coefficient

The calculated test statistics are:

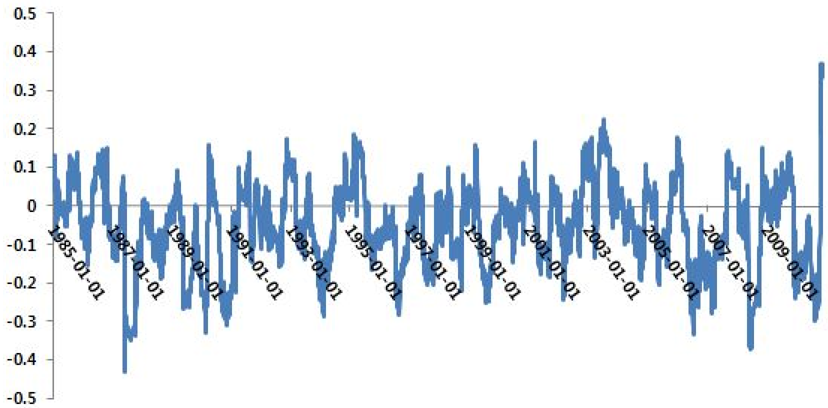
<Table 7-9> Calculated Statistics

Index	DAX(Germany)	CAC(France)	FTSE(U.K.)
KOSPI	-0.744	-1.299	-2.552
TOPIX	-4.639	-4.325	-6.089
HSI	-1.384	-0.935	-0.858

footnote) use n=5,200 because number of observations are at least 5,200

Since the critical value is around $\pm$1.96 given $\alpha = 5\%$, the null hypothesis is rejected if the absolute value of test statistics is less than 1.96. Based on this rule, European stock market index returns have no positive correlations with three Asian stock market index returns. Results also suggest that there are negative correlations between three European stock index returns and TOPIX returns. The following <Figure 7-25> shows the trend of 100-daily return correlations between TOPIX returns and a previous day's DAX returns. Although the figure indicates that the average correlation is negative, there exists some fluctuation of positive and negative correlation depending on certain periods. Hence the correlation between TOPIX and a previous day's DAX returns is inconclusive.

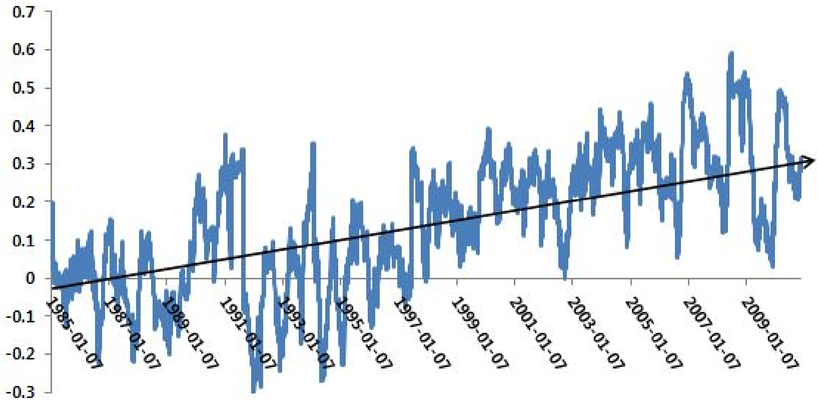
<Figure 7-25> Correlations between TOPIX Returns and a Previous Day's DAX Returns



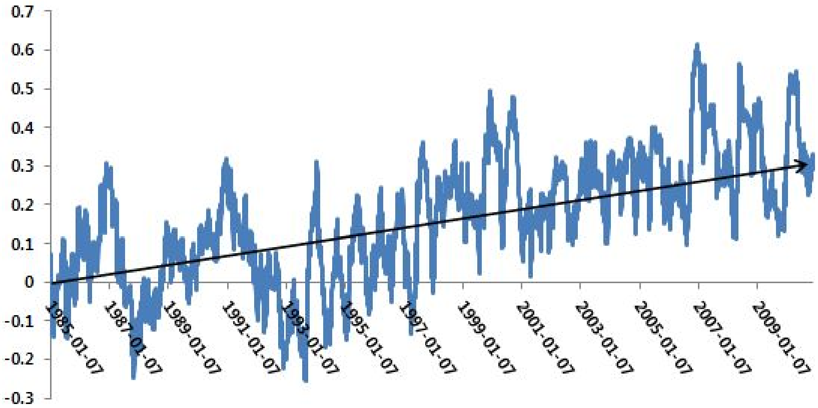
6. The Existence of Comovement between Asian Stock Market and European Stock Market

The following two figures demonstrate increasing behavior of comovement between South Korea's stock market and European stock markets. The daily return data on the same day are used, and correlation coefficients are calculated based on 100 daily returns. These two figures indicate that comovement between South Korea's stock market and European stock markets has been increasing. The same result appears between other Asian stock markets and European stock markets.

<Figure 7-26> Correlation between KOSPI and DAC (Germany) on a Same Day basis



<Figure 7-27> Correlation between KOSPI and FTSE (U.K.) on a Same Day basis



7. The Influence of European Stock Market on U.S. Stock Market

To investigate the influence of European stock market on U.S. stock market, the daily returns used must be on a same day basis. The regression model is as follows:

$$\text{S\&P500 } return_t = \beta_0 + \beta_1 \cdot \text{European stock index } return_t + \varepsilon.$$

And the null hypothesis and alternative hypothesis is as follows:

$$\begin{cases} Ho: \beta_1 \leq 0 \\ Ha: \beta_1 > 0 \end{cases}$$

As mentioned above, the critical value for $\alpha = 5\%$ is 1.645. The two regression results are as follows.

<Figure 7-28> Results of Regressing S&P500 Returns on DAX Returns on a Same Day basis

```
> lms <- lm(SP500 ~ Germany)
> summary(lms)

Call:
lm(formula = SP500 ~ Germany)

Residuals:
      Min        1Q    Median        3Q       Max
-0.168748 -0.005231  0.000132  0.005330  0.081892

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0002115  0.0001317   1.606    0.108
Germany     0.3849463  0.0091312  42.157   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01045 on 6301 degrees of freedom
  (1525 observations deleted due to missingness)
Multiple R-squared:  0.22,      Adjusted R-squared: 0.2199
F-statistic:  1777 on 1 and 6301 DF,  p-value: < 2.2e-16
```

<Figure 7-29> Results of Regressing S&P500 Returns on FTSE Returns on a Same Day basis

```
> lms <- lm(SP500 ~ UK)
> summary(lms)

Call:
lm(formula = SP500 ~ UK)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.151808 -0.004969  0.000167  0.005117  0.112911 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.0002578  0.0001295   1.991   0.0465 *  
UK          0.4898804  0.0114797  42.673   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01032 on 6352 degrees of freedom
  (1474 observations deleted due to missingness)
Multiple R-squared: 0.2228,     Adjusted R-squared: 0.2227 
F-statistic:  1821 on 1 and 6352 DF,  p-value: < 2.2e-16
```

Two regression results show very high t-values. This implies that European stock markets have strong influences on U.S. stock market. Correlation coefficients between S&P500 daily returns and European stock market returns are in the table below.

<Table 7-10> Correlation between S&P500 and European Stock Market Returns on a Same Day basis

	DAX (Germany)	CAC (France)	FTSE (U.K.)
correlation	0.463	0.474	0.465

As seen in the table above, the correlation coefficients are large enough to conclude that all three European stock market have correlations with returns on U.S. stock market. Owing to high correlation coefficients, we do not need formal statistical test.

8. The Influence of U.S. Stock Market on European Stock Market

To observe the influence of U.S. stock market on European stock market, a previous day's S&P500 daily returns must be used. The regression model is as follows:

$$\text{European stock index } return_t = \beta_0 + \beta_1 \cdot S\&P500\ return_{t-1} + \varepsilon$$

And the null hypothesis and alternative hypothesis is as follows:

$$\begin{cases} Ho: \beta_1 \leq 0 \\ Ha: \beta_1 > 0 \end{cases}$$

As mentioned above, the critical value for $\alpha = 5\%$ is 1.645. The two regression results are as follows.

<Figure 7-30> Results of Regressing DAX Returns on a Previous Day's S&P500 Returns

```
> lms <- lm(Germany ~ SP500)
> summary(lms)

Call:
lm(formula = Germany ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max
-0.110092 -0.006936  0.000219  0.007245  0.121976

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0002803  0.0001763    1.59    0.112
SP500       0.2986898  0.0148356   20.13   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01398 on 6298 degrees of freedom
  (1529 observations deleted due to missingness)
Multiple R-squared: 0.06047,    Adjusted R-squared: 0.06032
F-statistic: 405.3 on 1 and 6298 DF,  p-value: < 2.2e-16
```

<Figure 7-31> Results of Regressing FTSE Returns on a Previous Day's S&P500 Returns

```
> lms <- lm(UK ~ SP500)
> summary(lms)

Call:
lm(formula = UK ~ SP500)

Residuals:
      Min        1Q    Median        3Q       Max
-0.093993 -0.005632  0.000079  0.005832  0.085761

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0001846  0.0001355   1.362    0.173
SP500       0.2834134  0.0114763  24.696   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01079 on 6352 degrees of freedom
  (1475 observations deleted due to missingness)
Multiple R-squared: 0.0876,     Adjusted R-squared: 0.08746
F-statistic: 609.9 on 1 and 6352 DF,  p-value: < 2.2e-16
```

The t-values are 20.13 and 24.696, which leads to the rejection of null hypothesis. This indicates that a previous day's S&P500 returns have positive influences on European stock markets returns. The calculated correlation coefficients between S&P500 daily return and European stock market return are in the table below.

<Table 7-11> Correlation between a Previous Day's S&P500 and European Stock Market Returns

	DAX (Germany)	CAC (France)	FTSE (U.K.)
correlation	0.243	0.262	0.293

Test statistics are calculated for formal statistical testing in the table below. Since all three test statistics are greater than 1.96, it is concluded that a previous day's U.S. stock market has positive correlations with all three European stock markets.

<Table 7-12> Calculated Test Statistics

	DAX (Germany)	CAC (France)	FTSE (U.K.)
correlation	17.695	19.208	21.630

footnote) use n=5,200 because number of observations are at least 5,200

The following table combines <Table 7-10> and <Table 7-11>. As in the table below, 0.463>0.243, 0.474>0.262, 0.465>0.293, European stock market returns have larger correlations with on-the-same-day U.S. stock market returns than with a previous day's U.S. stock market returns. This is due to time lags between European and U.S. stock exchange business hours. U.S. stock exchanges open immediately after the closing of European stock exchanges. However, European stock exchanges open around nine hours after the closing of U.S. major stock exchanges. During this nine hours, information other than U.S. stock market close has been collected and transmitted to European stock markets, which neutralizes the effects of U.S. stock market close.

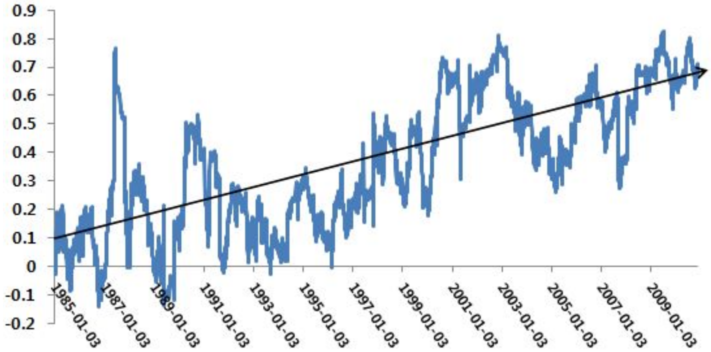
<Table 7-13> Comparison of Correlation Coefficients

	DAX (Germany)	CAC (France)	FTSE (U.K.)
Europe->U.S.	0.463	0.474	0.465
U.S.->Europe	0.243	0.262	0.293

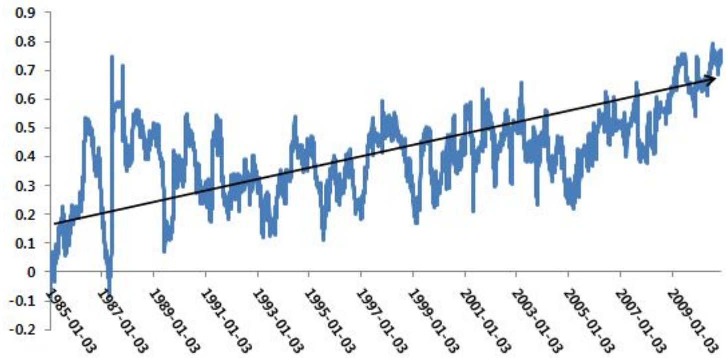
9. The Existence of Comovement between European Stock Market and U.S. Stock Market

The following two figures clearly demonstrate that European stock market and U.S. stock market moves together and that the trend is upward.

<Figure 7-32> Correlation between DAX (Germany) and S&P500 on a Same Day basis



<Figure 7-33> Correlation between FTSE (U.K.) and S&P500 on a Same Day basis



10. Summary

It has been demonstrated that U.S. stock market has a significant influence on Asian stock markets, while Asian stock markets have relatively smaller impact or no impact on U.S. stock market. It is also shown that influences of Asian stock markets on European stock markets are quite significant, but influences of European stock markets on Asian stock markets are insignificant. European stock markets appear to have significant impact on U.S. stock markets, and vice versa, while the influence of European stock markets on U.S. stock market is more significant than the other way around. It is also shown that stock market comovement among all the countries has been increasing over time. In other words, the phenomenon of synchronization across global stock markets movement is a permanent one.

VIII. Conclusion

This thesis is to study about the effect of one nation's stock market on other nations' stock markets, and to figure out whether or not stock markets reveal comovement across national stock markets. Regression analysis is used to analyze the impact of one nation's stock market on another, while correlation analysis is utilized to see if comovements exist among national stock markets.

It is conjectured that correlations of returns across national stock markets have been increasing in recent years. This is because i) investors are now trying to include foreign stocks in their portfolio holdings for both raising return and reducing risk, ii) governments facilitate foreigners to invest domestic stocks by removing restrictions on trading, and iii) firms are more globalized in their sales, manufacturing and financing. The thesis is not the first paper to address this conjecture. Most related papers also show that comovements exist in some countries' stock markets. Most of the papers suggested correlation coefficients to show comovements. However, the correlation coefficients and regression results are very different across papers, even leading to contradictory results. It becomes suspicious whether comovements are consistent or increasing (decreasing) in the long run.

Because the different results came out mainly due to different sample periods, it may be concluded that degree of comovements and effect among national stock markets is time-dependent. To this resolve time-dependency, long period data is used to verify the effect of one nation's stock market on other nations' stock markets in the long run, and whether comovements are constant and increasing/decreasing. Through rigorous analysis I found that comovements among all the national stock markets have been increasing over time. Correlation coefficients among all national stock market index returns have definite upward trends in spite of continued fluctuations. The thesis also demonstrates that the effect of one national stock market on another is in the direction of the U.S. stock exchange → Asian stock exchanges → European stock exchanges → the U.S. stock exchanges. This is due to sequence of stock exchange business hours. However, the effects of the other way around are not significant. It is found that U.S. stock market also has an influence on European stock market due to large proportion of U.S. economy in the world economy.

The thesis also showed that i) variety of index return are higher in developing countries than in developed countries and ii) all nations' stock returns exhibit very large kurtosis and negative skewness, which negate normality of stock returns.

Even though this thesis has some contributions, some developments should be made in the future. Data used in this paper are time-series, a thorough study is needed if regression analysis is enough without time-series analysis. Second, daily returns used in this thesis may not enough to calculate the effect of other countries' stock market on domestic stock market. Because the effect of U.S. stock market reflects only on opening prices of Korea's exchange, not until closing hours. Third, trend of increasing comovements is not mathematically proven. The thesis shows the trend graphically, which is not formally proven. It is better to find statistical tools to prove the trend.

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국문초록

국가간의 주식시장 수익률의 상관관계가 국내 시장간의 상관관계보다 훨씬 낮은 것으로 나타난 것은 하나의 현상이었다. 이런 현상은 최근 급격히 바뀌고 있다. 국가간 주식시장 수익률이 상관계수가 최근 들어 급격히 상승하고 있기 때문이다. 첫 번째 이유는 해외투자자들이 수익률을 높이면서 위험을 축소시키기 위해 국내 주식을 매입하고 있고, 정부 또한 해외투자자들에 대한 규제를 축소시켜 자국 주식을 매입할 수 있도록 도와주고 있기 때문이다. 두 번째 이유는 기업들이 영업, 생산, 재무 면에서 글로벌화되고 있기 때문에 기업들은 과거보다 외국의 경기변동에 민감하게 되고 주식시장은 국가 간에 동조화 현상을 보이게 된다.

본 논문은 한 나라의 주식시장이 다른 나라의 주식시장에 영향을 미치는지를 파악하고, 국가간의 주식시장이 동조화 현상을 보이고 있는지 확인한다. 우선 국가의 주식시장을 대변할 수 있는 주가지수를 찾은 다음, 이들에 대한 회귀분석을 통해 국가간 영향력을 분석하고, 이들의 비교를 통해 국가간 동조화 현상이 보이는지를 파악한다. 국가간 주식시장의 영향력이 존재하는가를 분석하는 수단은 회귀분석이며, 동조화의 여부와 그 정도를 분석하는 최적의 수단은 상관분석이다. 또한 본 논문은 국가간 주식시장의 동조화 현상은 단기적인지 지속적인 것인지 알아본다.

본 논문에서 수집된 자료를 근거로 판단한 결과, 미국의 주

식시장은 아시아 주식시장에, 아시아 주식시장은 유럽 주식시장에, 유럽 주식시장은 미국 주식시장에 영향을 주는 것으로 파악되었다. 그러나 그 반대 영향은 상대적으로 약한 것으로 나타났다. 그 이유는 주식시장이 열리는 시간적 차이 때문인 것으로 파악된다. 또한 주식시장의 동조화는 전세계적인 현상이며 지속적으로 심화되고 있음이 드러났다. 국가간 주가지수 수익률의 상관계수는 명확하게 상승하는 추세를 보이고 있기 때문이다.

대한민국은 1992년 주식시장을 해외투자자에게 개방하였다. 국내 주식시장에서 외국인의 거래 비중이 높아짐에 따라 국내 기업주식의 외국인 소유 비율이 지속적으로 증가하고 있다. 현재 코스피시장에 상장된 주식의 30% 가량이 외국인이 보유하고 있는 실정이다. 이런 요인들로 인해 외국 주식시장과의 동조화 현상은 심화되고 있다.

주요어 : 동조화 현상, 주가지수, 상관관계, KOSPI, S&P500, TOPIX, DAX

송민영 2007-22413