Emerging Stock Markets in the Pacific Basin: An Empirical Analysis with Particular Reference to the Korean Stock Market

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Submitted for the Degree of Ph.D.
School of Oriental and African Studies
University of London

2001

Abstract

This thesis investigates emerging stock markets in the Pacific Basin with particular reference to the Korean stock market, which is representative of typical, fast-growing emerging markets. Using a broader range of econometric models, the short-run and long-run behaviour of stock prices, the impact of changes of a price limit system, and derivatives trading on the stock market are investigated.

In the first two chapters, recent performance of emerging stock markets in the Pacific Basin and the development of the Korean stock market are examined. Chaper 3 investigates the behaviour of Korean stock market volatility is investigated. The results find that the GARCH(1,1)-AR(1) and the GARCH(1,1)-MA(1) seemed to be the best fit models among the Autoregressive Conditional Heteroscedasticity (ARCH) class models. The nexus between Korean stock market returns and macroeconomic variables is investigated in Chapter 5. The evidence suggests that changes in the exports/imports ratio is the most important determinant in forecasting the variance of stock returns in the Korean export-oriented economy. Chapter 6 provides tests of long-run equilibrium among Pacific-Basin stock markets for a period spanning the Asian financial market crises. Using unit root tests, which allow for a possible crash, the results find that four of the series are trend stationary. Among the remaining I(1) series, little evidence of cointegration is found. In Chapter 7, the consequences of price limits for weak-form efficiency is investigated for the first time. The evidence suggests that the stock market as a whole approaches a random walk as price limits are relaxed. Chapter 8 investigates the impact on the spot market of trading in KOSPI 200 futures. Empirical results show that futures trading increases the speed at which information is impounded into spot market prices. The lead-lag relation is asymmetric with stronger evidence that the stock index futures market leads the spot market.

Acknowledgements

I owe a special debt to Dr Graham Smith, my supervisor, in conducting this research. I have benefited greatly from his encouragement and suggestions at every stage, although any remaining shortcomings of the thesis belong to me. His practical but generous nature allowed me the freedom I needed to enjoy the entire research process, while encouraging me to focus on the task at hand. Data provided by Korea Stock Exchange in the early stage was crucial to the progress of the research and I am very grateful for their generosity.

My dearest thanks go to my family for their unquestioning support. My husband, Jin-Kyoo has shared ups and downs of my research during our life in London. Our two children, Yoo-Min and Jung-Hoon, were always a joy which provided the source of our energies, and I dedicate this thesis to them.

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List of Abbreviations

ADB	Asian Development Bank
FIBV	Federation Internationale des Bourses de Valeurs (International Stock Exchange Federation)
FSC	Financial Supervisory Commission
FSS	Financial Supervisory Service
IBRD	International Bank for Reconstruction and Development
IMF	International Monetary Fund
KATS	Korea Stock Exchange Automated Trading System
KEPCO	Korea Electric Power Corporation
KIC	Korea Investment Corporation
KIT	Korea International Trust
KOSCOM	Korea Securities Computer Corporation
KOSDAQ	Korea Securities Dealers Association Quotation Stock Market
KOSPI	Korea Stock Price Index
KSD	Korea Securities Depository
KSDA	Korea Stock Exchange Automated Trading System
KSE	Korea Stock Exchange
KT	Korea Trust (KT)
MOF	Ministry of Finance
MOFE	Ministry of Finance and Economy
OECD	Organisation for Economic Co-operation and Development
POSCO	Pohang Iron & Steel Company
SMATS	Stock Exchange Automated Trading System

1 Introduction

This thesis investigates the Korean stock market, which is one of the emerging stock markets in the Pacific Basin, using financial econometrics techniques. Other emerging markets in this region, for instance Indonesia, Malaysia, the Philippines, Thailand, Taiwan, are also analysed in some of the chapters. However, the main focus of the research is on the stock market in Korea. Investigating the Korean stock market is particularly interesting for several reasons. First, the Korean stock market is representative of a typical emerging market. It is relatively small compared to major markets but the stock market in Korea has been growing fast in terms of market capitalisation, trading volume and number of listed companies on the stock exchange since the 1980s. Secondly, it used to be one of the most restricted and controlled markets among emerging markets. However, it has experienced fast changes and has matured qualitatively since its opening-up to foreign investors in January 1992. Thirdly, with a price limit system and the introduction of derivative securities trading, there are interesting features in the Korean market that are present in some but not all. Finally, little research has been carried out on the market opening-up and recent developments in the Korean stock market. Therefore, a closer examination of this market is useful in its own right and may also help as to understand particular aspects of other emerging stock markets, especially in the Pacific Basin.

Although the literature on developed stock markets is extensive much less empirical evidence exists for emerging stock markets and only a few studies have focused on the stock market in Korea. In this thesis, the short-run and long-run behaviour of stock returns in Korea and impact of derivatives trading on the stock market as well as its historical development are investigated using a broader range of econometric models, including variance ratio test, Autoregressive Conditional Heteroscedasticity (ARCH), cointegration tests, innovation accounting analysis and tests of causality models. Although the last four decades are covered, the main focus is drawn on internationalisation of the stock market in the 1980s and opening of the stock market to foreign investors in the 1990s. In particular, in some of the chapters the data series are divided into two subperiods, pre- and post-opening periods, for a closer examination of the consequence of stock market opening to foreign investors in 1992.

The outline of the remainder of this thesis is as follows.

Chapter 2 reviews emerging stock markets in the Pacific Basin. Although growing speed of emerging stock markets has been slow since several main crashes, i.e., the Mexican crisis in 1994/5 and the Asian financial market crashes in 1997, growth in overall stock market performance has been dramatic, especially in those countries where experienced rapid economic growth as well as in countries that government have embarked on liberalisation measures. In this context, examining emerging stock markets in the Pacific Basin is of interest for examination. In fact, the term, 'emerging stock market' has been used without being known its precise meaning, despite the fact that it is no longer to be new one. Therefore, this chapter aims to define the term, 'emerging stock market' and outline the nature and recent performance of emerging markets in particular focusing on those in the Pacific Basin.

Chapter 3 examines a comprehensive review of the different aspects of the Korean stock market including its historical development and main features. The main focus is on how the Korean stock market has been developed and liberalised since its first opening in the 1950s. This chapter aims to provide some background to understanding changes in the trading system, relevant regulation system and the liberalisation program in a historical context. Also, the recent development of the market including the introduction of derivative securities trading and cyber on-line stock trading as well as the Korean financial market crisis in 1997 are noted. Although there have been some studies about the Korean stock market, most of the studies have concentrated on comparative analysis with other markets rather than examining the Korean stock market in depth. Little work has been done on the historical background including the stock market opening-up and recent development. Therefore, this chapter aims to fill this gap by examining the Korean stock market in a comprehensive way especially focusing on its liberalisation and recent development of the market. We also describe impact of the Korean financial market crisis in 1997.

In Chapter 4, the empirical distribution of Korean stock market returns is analysed and the best-fit models for the distribution of the stock market returns among a family of Autoregressive Conditional Heteroscedasticity (ARCH) and Generalised ARCH models are investigated. Very few studies have compared these methods empirically. For this reason it is of interest to apply each of the techniques studied previously to our data set, with the aim of investigating the different implications each might have for the predictability of volatility.

Chapter 5 investigates the nexus between Korean stock market returns and macroeconomic variables for the period from January 1987 to June 1997. The main purpose of this chapter is to explore whether changes in macroeconomic variables contain important information for stock market participants in Korea. The chapter analyses the effects of changes in major macroeconomic variables on stock market returns in Korea using cross correlation analysis and a multivariate vector autoregression (VAR) framework together with innovation accounting procedures to assess the economic implications of the model.

In particular, our macroeconomic variables including the current account balance, money supply, interest rates and exchange rates, and stock price series are analysed dividing into two subperiods, pre-opening (from January 1987 until the end of 1991) and post-opening (from the early of 1992). While most economic variables included in the analysis have been used in different forms in stock price analysis the effects of changes in macroeconomic variables on stock returns before and after stock market opening-up in Korea has not been analysed empirically. This chapter also aims to evaluate the usefulness of the relationships between macroeconomic variables and stock returns as a forecasting tool in the implementation of investment strategies.

Chapter 6 provides tests of long-run equilibrium among Pacific Basin stock markets over the period starting in March 1988 and ending in April 2000, a period spanning the Asian financial market crises. Total returns indices, which include dividends, paid and reinvested, are used. This chapter re-examines the question of the interdependence of Pacific Basin equity markets. It extends the previous literature in five principal ways. First, a larger set of stock markets is considered; eleven Pacific Basin markets are examined. Second, both developed and emerging markets are included together with those of the UK and the US. Third, data on total returns, which includes dividends paid and reinvested is used, since these are what matter to international investors. Fourth, a common currency, the US$, is used. Previous results of work in local currency and in a common currency differ. Where exchange rates change significantly it would seem important not to ignore currency risk by using equity prices denominated in local currency. Fifth, the data span the period of Asian financial market crises. Consequently unit root tests are used which allow for a possible crash and tests of cointegration are carried out for two periods: the first period ends immediately before Black Wednesday on the Bangkok stock exchange, the start of the Asian crisis, and the entire sample ends in April 2000. Therefore, preliminary results of the consequences of the Asian crisis for long-run equilibria between stock markets in the region are reported.

Chapter 7 provides tests of whether stock prices in Korea follow a random walk under price limits over the period from March 1988 to December 1998. During this time there are five regimes of daily price limits. A sample of 55 actively traded stocks, selected to cover a wide range of industries and with a marked number of limit moves, is used to test the random walk hypothesis under each price limit regime. Whilst there have been numerous studies of the efficient markets hypothesis, none of them has investigated the consequences of price limits for weak-form efficiency. Since the price limits in the Korea Stock Exchange have been modified several times as the bands have widened, the random walk hypothesis is tested under the different regimes of price limits. This chapter differs from previous studies in several ways. First, the multiple variance ratio (MVR) test developed by Chow and Denning (1993) is used to examine whether prices of individual stocks follow a random walk process under price limits. Secondly, the data cover a longer time span-over ten years of daily observations. In order to avoid the problem of missing observations some of which are associated with price limits, all six trading days in the week are included in the data. Thirdly, the effects of the relaxation of price limits are considered: as price limits are relaxed do some equity prices follow a random walk process? Finally, the impact of the Korean financial crisis on the weak-form efficiency of the stock market is noted.

In Chapter 8, the impact on the spot market of trading in stock index futures in Korea is investigated. Stock index futures are perceived as one of the most successful financial innovations of the 1980s and much of the futures trading in emerging markets is a relatively recent phenomenon. Although Korea is one of the fastest growing emerging markets, it was not until 3 May 1996 that a futures contract based on the Korea Stock Price Index 200 (KOSPI 200) was introduced on the Korea Stock Exchange (KSE). Trading in these stock index futures has grown remarkably. In the two and a half years following their introduction, trading activity expanded almost 1,300% in value terms and 2,500% in terms of trading volume.

While the impact of derivative trading on spot price volatility has been widely investigated for developed markets, there is very little work, which investigates the impact of stock index futures trading in emerging markets. This chapter contributes to the sparse literature; it is the first to examine the impact on the Korean spot market of trading in futures. Data are used from the start of futures trading on 3 May 1996 to the end of December 1998, for cointegration tests, estimation of error correction models, Granger tests of causality and examination of the lead-lag relationship. This chapter differs from previous studies, which use closing prices for futures and spot prices, by using data with matched closing times. This is desirable because in Korea, trading in index futures and trading in stocks finish at different times. By using matched closing times, we avoid comparing nonsynchronous closing prices of the spot index and futures contracts, which might lead to a significant source of error.

2 A Review of Emerging Stock Markets in the Pacific Basin

2.1 Introduction

Interest in emerging markets has developed since the first half of the 1980s as both academia and international investors became increasingly aware of the very rapid economic growth rates of some developing countries. In particular, academic studies that specifically examine emerging stock markets are merely a recent trend. To sum up the findings of the recent literature, emerging stock markets are typically, but not always, associated with the following characteristics

- higher returns but a higher degree of volatility than developed markets;
- thin trading activity;
- increasing interest by international investors but some barriers for foreign investors;
- a transparency problem due to lack of corporate information and a nonstandarised accounting system;
- unstable political environment.

However, despite apparent strong interest, relatively little is known about emerging stock markets. Although emerging stock markets' growth has been slow following several main crashes, e.g. the Mexican crisis in 1994/5 and the Asian financial market crises in 1997, overall stock market performance has been dramatic, especially in those countries which experienced rapid economic growth and those where government has embarked on liberalisation measures. These particular characteristics stimulate interest in examining emerging stock markets in the Pacific Basin. Frequently, the term, 'emerging stock market' is generally used without its precise meaning being stated. The main purposes of this chapter are (i) to define the term 'emerging stock market' and (ii) outline the nature and recent performance of emerging markets in the Pacific Basin.

The rest of this chapter is organised as follows. The next section presents a brief review of existing literature on the different ways in which the term 'emerging markets' is defined. Section 2.3 focuses on the recent development and market performance of six emerging and five developed markets in the Pacific Basin. The impact of the Asian financial crisis on the emerging stock markets in this region is also noted. Section 2.4 provides a brief conclusion.

2.2 What is an Emerging Stock Market?

The term 'emerging stock markets' most often is intended to mean stock markets based in developing economies. Even with this simple definition, emerging stock markets vary tremendously in size, liquidity, and sophistication. Initially the phrase '*emerging markets*' was coined by Antonie W. van Agtmael, who was an official of International Finance Corporation (IFC) in 1981. Since then the phrase has caught on, although this phrase has different meanings for different people.

One of the earliest attempts to classify emerging markets into homogeneous groupings was made by Errunza (1983). While this classification affords no definition, it does provide a guide as to the financial markets that the term, 'emerging markets' may embrace. Errunza suggested that the term subsumes three general categories of financial market, although these are by no means mutually exclusive. The first category includes the old-established markets, many of which have been in place for over a century. For example, the first attempt to establish a stock market in Caracas, Venezuela, took place as early as 1805, when a group of businessmen founded the Commerce Exchange. Indeed, many markets in the Latin America date back to the 1800s. The second category includes those markets that owe their growth and development to special situations. For example, active government support, turmoil in the Middle East and OPEC money are three factors largely responsible for the growth in size and sophistication of the Jordanian market. The final category includes new markets which have been organised to foster economic growth. An example of such a market is Korea, which has grown over the ten years from the beginning of the 1980s to the start of the 1990s from being a small market, largely unknown to international institutional investors, to become one of the worlds leading emerging markets. For example, by 1994 Korea had attracted 4.6% of total net assets invested in emerging markets, and approximately 10% of the total number of funds that invested in emerging markets. This classification highlights the fact that the definition of an emerging market is not solely a question of age or size.

The IFC definition is one of the most frequently adopted, but it has changed in recent years. Before 1997: "an emerging stock market is one in an economy with GNP per capita not exceeding the threshold adopted by the World Bank for classification as 'high income' (for instance, US$ 9,386 in 1995 and US$ 9,656 in 1997), i.e., if a country was eligible to borrow from the World Bank, its stock market was said to be emerging." In 1997: " The term 'emerging market' can imply that a process of change is underway, with stock markets growing in size and sophistication, in contrast to markets that are small and stagnant. The term can also refer to any market in a developing economy, with the implication that all have the potential for development. A stock market might then be said to be 'emerging' if it meets at least one of two general criteria: (i) an Emerging Economy criterion, and (ii) a Developing Stock Market Criterion." The least liquid emerging markets are known as '*frontier markets*.' The most recent definition: "IFC classifies a stock market as 'emerging' if it meets at least one of two general criteria: (i) it is located in a low- or middle-income economy as determined by the World Bank and (ii) its investable market capitalisation is low relative to its most recent GDP figure." This definition takes into account both economic and stock market criteria. There are also many qualitative features to be considered. For example, operational efficiency of stock markets, quality of market regulation, supervision and enforcement, transparency, and level of accounting standards are all important features. However, a significant problem arises when emerging markets are defined on the basis of GNP per capita. This aggregate measure does not show the degree of income inequality in society. Data on GNP per capita give a distorted picture of the level of well-being of the general population in countries where oil output is very large, such as Kuwait and Saudi Arabia.

Other literature adopts a variety of definitions. Keppler and Lechner (1997, p. 9) argued that, although no uniform definition currently exists for the term 'emerging markets,' usually emerging markets are understood as 'rapidly growing markets' or 'stock markets in newly industrialised countries,' In general emerging markets are not referred to as 'developing countries' or as 'third-world countries' because these terms usually evoke images of extreme poverty, starvation, debt crises, hyper-inflation, corruption, and political instability—images that no linger truly characterise a majority of the emerging markets. For example, while Wilcox (1992) followed the definition by the IFC, Divecha, Drach and Stefek (1992) defined emerging stock markets more narrowly compared to the IFC's definition. They classified an emerging stock market as one which securities trade in a public market that is not a developed stock market (as defined by countries covered within the Morgan Stanley Capital International Indices or Financial Times Indices). Also it is of interest to global institutional investors and has a reliable source of data. On the other hand, Price (1994) intuitively defined emerging markets to include countries experiencing or having the potential for high economic growth but facing substantial political, economic, and/or market-specific risks. In terms of market returns, investors can be well rewarded for taking the risk.

Kuczynski (1994) argued that the emerging market phenomenon is a sequential one that began in the first half of the 1980s as investors, both portfolio and direct investors, became increasingly aware of the very rapid economic growth rates of countries such as the four Asian dragons. He indicated that the term 'emerging markets' is by its nature general and applies to a very diverse and changing cast of countries but argues that the term is not necessarily tied to stock markets, that is, it is simply a reflection of the pace of the economy. Usually the term refers to stock markets that are developing from an incipient stage toward a more modern and eventually more mature stage. In addition, Hale (1994) claimed that the term 'emerging market' is itself a transitional concept and likely to disappear sometime during the next decade. Instead, investors will probably use concepts such as "high growth-middle income," "high income-mature," or "low growth-low income" to categorise global stock markets. Glen and Pinto (1994) stated that growth in emerging stock market prices has been dramatic, especially in those countries where governments have embarked on liberalisation measures, as well as in countries that have experienced rapid economic growth. Furthermore, Clemente (1994) argued that emerging markets are far from being a homogeneous group, and wide variations in structure, behaviour and performance can be observed.

Apart from the variety of definitions, the category of emerging stock markets is also very broad. Stock markets currently classified as emerging include (i) some of the largest and most liquid markets in the world, (ii) several long-established markets where trading still takes place over tea, and (iii) many markets where the latest technology has been installed to expedite trading, settlement, market supervision, and information dissemination. As the end of 1996, based on the criterion of a GNP per capita that did not exceed the World Bank's threshold for being a high income country, there are approximately 170 countries around the world that meet definition of emerging markets. However, only seventy-nine of these countries have functioning securities exchanges whereas twenty-three national markets are defined as developed markets.[1] In 1993, the IFC introduced IFC Investable indexes, which were designed specifically to be benchmarks for international portfolio managers. Among the seventy-nine markets mentioned above, however, only thirty-one markets met the minimum technical requirement of having a functioning, regulated securities exchange with an appropriate minimum market capitalisation. Also, in these thirty-one markets, foreign investors are permitted to make direct purchases of shares. For this reason, these markets are all included in the IFC Investable (IFCI) Composite index. For example, Asian emerging stock market group in the IFCI Composite index includes large, well-developed stock markets in Korea, Malaysia, Taiwan; increasingly active, fast-growing markets in Indonesia, the Philippines and Thailand; embryonic markets both large, in China and India, and small, in Pakistan and Sri Lanka. Among the NIEs

[1] According to the IFC, developed markets include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, the UK, the US.

(Newly Industrialising Economies), however, Singapore and Hong Kong, whose growth rates have been considerably high for decades and its values of GNP per capita reached to US$26,910 and US$24,260 as the end of 1996, respectively, can no longer be refereed to as emerging markets in any sense although they retain political risks characteristic of emerging markets.

The definition of emerging markets according to GNP per capita is only one of several ways of identifying attractive, rapidly growing markets around the world that enjoy a certain level of political stability. Another important requirement is that the market should possess a regulated and functioning securities exchange, or be in the process of developing one. Further, the shares traded on the exchange must be available for purchase by foreign investors, even if subject to certain restrictions, and the repatriation of dividend and interest income, capital gains, and the originally invested capital must be largely free and unrestricted.

2.3 Performance of Emerging Stock Markets in the Pacific Basin

In spite of the fact that emerging stock markets can be found in various regions such as Eastern Europe, the Middle East, Africa, Latin America and the Pacific Basin, it is obvious that stock markets in the Pacific Basin have become widely recognised as the most dynamic ones. These markets have undertaken substantial financial reform which includes removing barriers to domestic and international capital inflows and stock market liberalisation. In particular, they have been in a difficult situation so that the speed of development seems to have slowed down since the Asian financial market crises. However, it is worthwhile to include them since they have grown remarkably and have relative large stock markets compared to the rest of the emerging markets, although the speed of development has been slow in the late of the 1990s due to the East and Southeast Asian financial market crisis. In this section, we focus on six emerging markets in the Pacific Basin— Korea, Malaysia, Taiwan, Indonesia, the Philippines and Thailand, together with five developed markets— Hong Kong, Singapore, Japan, Australia and New Zealand since (i) these developed markets are located in the same region and (ii) stock market linkages within the region are discussed in Chapter 6 of this thesis, comparison is useful. Although China is one of the fast growing emerging markets in the region appropriate data for empirical analysis are only available from the early 1990s. For this reason, China is excluded from this empirical analysis.

Emerging markets in the Pacific Basin have grown remarkably in size in recent years owing not only to quantitative growth but also to market developments including liberalisation and deregulation. At the end of 1996, emerging stock markets were located in countries having 84% of the world's population but only 19% of its GNP and 9% of the world total market capitalisation (see Figure 2.1 through 2.3). At the end of the year, the total market capitalisation of all emerging markets amounted to US$2,230 billion. This total includes not only the markets comprising the IFCI Composite Index but also smaller markets that meet the definition of emerging markets but whose securities exchanges do not yet satisfy the criteria for admission to the IFCI Composite Index. In 1996, the total of six emerging stock markets' GNP accounts for 22.9% of the total emerging markets' GNP although it accounts 4% of the world GNP. For instance, by 1998, three emerging markets, Korea, Taiwan and Malaysia had larger capitalisation than the smallest Pacific Basin developed markets, New Zealand and Singapore.

Liquidity is also an important attribute of stock market development because theoretically liquid markets improve the allocation of capital and enhance prospects of long-term economic growth. Although many theoretical definitions of liquidity have been suggested by academia, investors and analysts generally use the term refer to the ability to buy and sell stocks easily. Since adequate liquidity allows investors to alter their portfolios quickly and cheaply, it makes investment less risky and facilitates longer-term, more profitable investments. However, excessively high and excessively low turnovers are both matters of concern for investors. Excessively high turnover implies immature markets and/or speculative market conditions. On the contrary, excessively low turnover may prevent alternations of investors' portfolios effectively. Market liquidity, measured by turnover ratio, also varies widely, particularly among emerging markets. With the exception of Taiwan and Korea, the emerging markets in the Pacific Basin tended to have, in general, lower turnover ratios than those of the developed markets. As shown in Table 2.1, Taiwan and Korea were two of the most liquid emerging markets in the world in 1996, and ranked 2nd and 7th, respectively. In 1998, Taiwan became the most liquid market in the world and Korea ranked 5th among the FIBV member exchanges. With the turnover ratio of 29.8%, Malaysia ranked 14th in 1996, but the turnover ratio halved to 29.8% in 1998. By the measure, the Philippines is perhaps the least liquid among emerging markets in the Pacific Basin (see also section 6.3 of Chapter 6 for further details).

Although many emerging markets are small, some of them contain a large number of listed companies. With more than 600 listed companies, for instance, Korea and Malaysia ranked 11th and 15th among 55 FIBV (Federation Internationale des Bourses de Valeurs) member exchanges in 1996, and ranked 5th and 8th among emerging stock markets, respectively. Whereas the stock exchanges in Thailand, Taiwan, Indonesia and the Philippines had a relatively small number of listed companies (see Figure 2.5). According to the IFC, in terms of total trading value, in 1996 Korea with US$177 billion trading value became the 3rd largest emerging stock markets in terms of trading value after Taiwan (US$470 billion) and China (US$256 billion) and followed by Malaysia (US$174 billion). In 1997, Korea ranked 4th largest emerging market even during the financial market crisis period. Up until the end of 1996 the Korean stock market was the 5th largest emerging market in terms of total market capitalisation whereas it ranked 19th in the world. Due to the outbreak of the Korean financial market crisis in the second half of 1997, however, its world ranking plummeted to 33rd, and it became the 13th largest emerging market at the year-end.

Most of the emerging markets in the Pacific Basin suffered a sharp downfall in their stock price indices during the 1997 Asian financial market crises. However, the Taiwanese market performance was rather surprising because its stock market index increased by 18% compared to the year before, whereas the declines in stock market indices in other countries in this region range from as little as 37% (Indonesia) to as much as 55% (Thailand) in US dollar terms. During the period from the second half of 1997 to the first half of 1998, most of the emerging markets in the region, which have suffered in a great deal from the Asian financial market crashes, seemed to recover rapidly except the Taiwanese market, which fell by 21% at the end of 1998 compared to the year before (see Table 2.1).

The market capitalisation of the six emerging markets has risen tremendously over the period from 1986 to 1996. Indeed, in 1996 the trading value of Taiwan (US$470 billion), Korea (US$177 billion) and Malaysia (US$173 billion) was greater than that of Australia (US$145 billion), New Zealand (US$9.8 billion), Singapore (US$42 billion) and Hong Kong (US$166 billion). Over the same period, the total capitalisation of the six emerging markets in the Pacific Basin increased twenty seven-fold from US$36.7 billion to US$991 billion. This suggests that the six emerging markets' share of world market capitalisation increased to 4.9% in 1996 from 0.8% in 1985 whereas the developed markets' share rather decreased in terms of percentage (see Figure 2.3).

As illustrated in Figure 2.4, excluding Indonesia, the five emerging markets' total annual trading value of US$12 billion represented only a 0.7 percent share of the world's total annual trading value of US$1,645 billion in 1985. In 1996, however, the six emerging markets' share accounted for 6.8% of the world's total trading value. For the period from 1985 to 1996, including Indonesia the six emerging markets' total annual trading value increased seventy seven-fold from US$12 billion to US$923 billion. Over the same period, the developed markets' trading volume increased only seven-fold from US$1,600 billion to US$12,011 billion.

In Table 2.2, the degree of market concentration in 1998 of the six emerging and selected developed markets is presented. In some markets, a few companies dominate the market. It is often said that high concentration is not desirable because it may adversely affect the liquidity of the market. To measure the degree of market concentration, both the shares of market capitalisation and trading value accounted for by the top 5 percent of the listed companies are computed. In terms of market concentration measured by capitalisation, the stock markets of Korea and Indonesia are relatively more concentrated among the emerging markets in the Pacific Basin, whereas Taiwan is the least concentrated market in the region. This might be explained by the fact that Taiwan is a small/medium size enterprise dominated economy whereas the Korean stock market is dominated by the large, well-known industrial corporations and family-owned conglomerates, the so-called '*Chaebol,*' which have an important place in its economy.[2] When market concentration is measured in terms of trading value, however, Indonesia and Malaysia are relatively more concentrated emerging markets in the region. The top 5 percent of listed companies account for approximately 60% of the domestic market capitalisation and trading value. Among developed market, Australia and Hong Kong have very high concentration.

2.4 Concluding Remark

As the emerging markets have grown rapidly, on average, a great deal of attention has been turned to them by investors and academia alike. Nevertheless, little is known about what an emerging market means. In this chapter, the various definitions of what constitutes an emerging stock market have been discussed and a brief review of the nature and recent performance of emerging markets in the Pacific Basin have been presented. The definition of emerging markets varies considerably across the literature surveyed. Nevertheless, six emerging stock markets (Korea, Taiwan, Malaysia, Indonesia, the Philippines and Thailand), which will be focused in Chapter 6 in this thesis, meet the various classifications without much argument.

Emerging markets in the Pacific Basin have grown remarkable in size in recent years. In particular, the growth of the stock market in Korea has been dramatic. As the end of 1996, with more than 700 listed companies, Korea ranked 11th among 55 FIBV member exchanges and ranked 5th among 79 functioning emerging stock markets in

[2] The *Chaebol*, which consist of large numbers of subsidiaries, are usually controlled by extended families. The *Chaebol*'s influence on the country's economy has been enormous. For example, in 1996, the 50 largest *Chaebols* had sales accounting for as much as 97 percent of Korea's GDP. Although the impact of the *Chaebol* on the country economy has been criticised and forced their reforms because they were widely blamed for the country's financial crisis in late 1997. Nevertheless, the *Chaebol* are still considered to be the main driving force of the Korean economy.

the world.[3] The Korean stock market became one of the most liquid emerging markets in the world and ranked 3rd and 5th among emerging markets in terms of total trading value and market capitalisation, respectively. The speed of quantitative growth of the emerging markets including Korea in the Pacific Basin has been slow due to the Asian financial market crisis; however, their qualitative developments through liberalisation, deregulation, and changes in investment environment are expected to be accelerated.

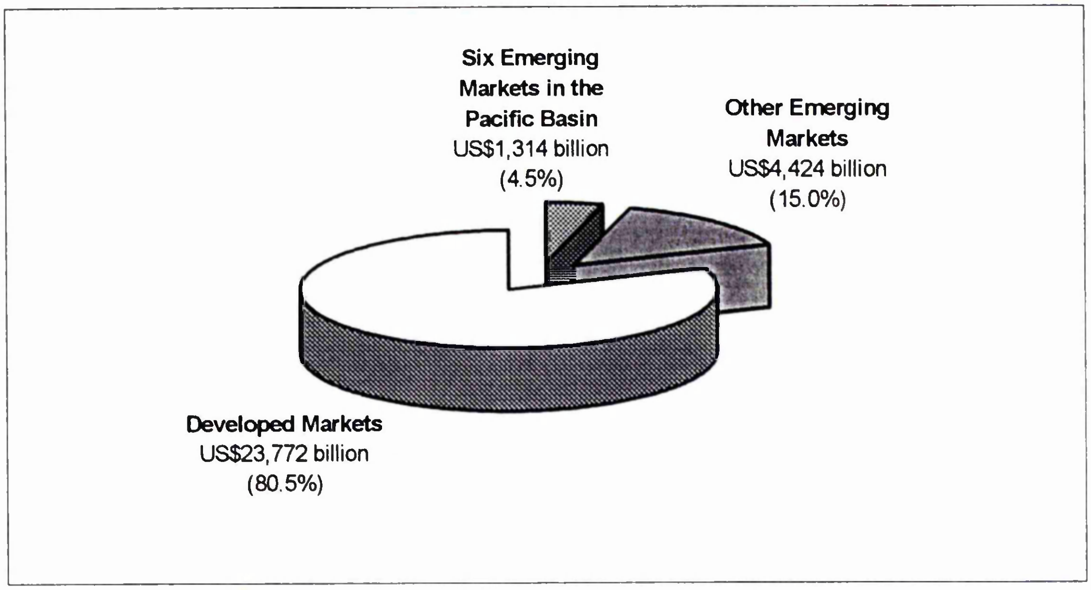
[3] As the end of 1996, only 79 countries have functioning securities exchanges among 170 countries around world that meet definition of emerging markets by the IFC.

Table 2.1 Comparison of World Stock Exchanges

Stock Exchange	Number of Listed Companies		Total Trading Value (US$ million)		Market Capitalisation (US$ million)		Turnover Ratio (%)		% Change of Stock Index	
	1996	1998	1996	1998	1996	1998	1996	1998	1997/ 1996	1998/ 1997
New York	2,476 (3)	2,669 (3)	4,063,655 (1)	7,317,949 (1)	6,841,988 (1)	10,271,900 (1)	59.1 (16)	69.9 (16)	30.3	16.6
NASDAQ	5,556 (1)	5,068 (1)	3,301,776 (2)	5,518,946 (2)	1,511,824 (5)	2,527,970 (2)	237.8 (1)	257.7 (2)	21.6	39.6
Vancouver	1,323 (7)	1,433 (6)	221,216 (10)	331,848 (11)	486,978 (8)	543,394 (11)	101.9 (9)	46.3 (34)	13.3	-3.2
Germany	1,971 (4)	3,525 (2)	811,626 (5)	1,491,796 (4)	664,913 (6)	1,093,962 (6)	129.3 (4)	137.9 (8)	44.9	16.3
Italy	248 (34)	243 (38)	102,568 (18)	486,507 (9)	256,595 (16)	569,732 (10)	43.3 (26)	102.3 (9)	58.2	41
London	2,494 (2)	2,423 (4)	1,413,236 (3)	2,887,990 (3)	1,642,582 (4)	2,372,738 (5)	40.5 (29)	47.0 (33)	24.7	14.5
Paris	897 (10)	1,097 (10)	282,014 (8)	587,854 (8)	586,963 (7)	991,484 (7)	173.2 (3)	228.5 (4)	24.5	28.5
Brussels	269 (30)	268 (32)	25,415 (33)	60,928 (24)	119,125 (23)	245,657 (18)	20.3 (43)	27.8 (41)	36.2	43.5
Johannesburg	626 (14)	668 (15)	26,998 (31)	56,941 (26)	239,579 (19)	150,670 (21)	10.3 (47)	27.0 (42)	-6.8	-12.4
Australian	1,190 (9)	1,222 (9)	146,236 (15)	161,001 (17)	311,865 (13)	328,929 (15)	51.4 (20)	52.7 (30)	7.9	7.5
Hong Kong	583 (16)	680 (14)	166,429 (14)	206,153 (15)	449,219 (9)	343,566 (14)	44.3 (25)	61.9 (24)	-19.2	-18.3
Jakarta	252 (31)	287 (28)	32,452 (29)	10,637 (42)	90,857 (27)	22,078 (41)	40.7 (27)	56.8 (28)	-37	-0.9
Korea	760 (11)	748 (11)	177,506 (13)	145,061 (19)	139,122 (22)	114,593 (23)	103.8 (7)	207.0 (5)	-42.2	49.5
Kuala Lumpur	618 (15)	731 (12)	178,011 (12)	26,840 (36)	306,165 (14)	95,560 (26)	65.5 (14)	29.8 (40)	-52.2	-1.4
New Zealand	175 (42)	183 (45)	10,139 (38)	14,274 (41)	36,879 (34)	24,458 (40)	27.9 (39)	48.0 (32)	2.9	-3.3
Philippine	216 (39)	221 (42)	25,509 (32)	10,148 (43)	80,464 (28)	34,911 (37)	34.2 (36)	32.2 (38)	-41	5.3
Singapore	296 (26)	349 (26)	255 (22)	58,510 (25)	153,107 (21)	96,473 (25)	39.3 (30)	63.9 (23)	-20.6	-10.2
Taiwan	382 (22)	437 (21)	478,356 (6)	895,958 (5)	273,776 (15)	260,498 (17)	208.0 (2)	314.1 (1)	18.1	-21.6
Thailand	454 (20)	418 (23)	45,398 (23)	20,976 (38)	95,901 (26)	34,118 (38)	38.9 (31)	68.8 (17)	-55.2	-4.5
Tokyo	1,833 (5)	1,890 (5)	938,822 (4)	750,825 (6)	3,011,161 (2)	2,439,549 (3)	27.1 (41)	34.1 (36)	-20.1	-7.5

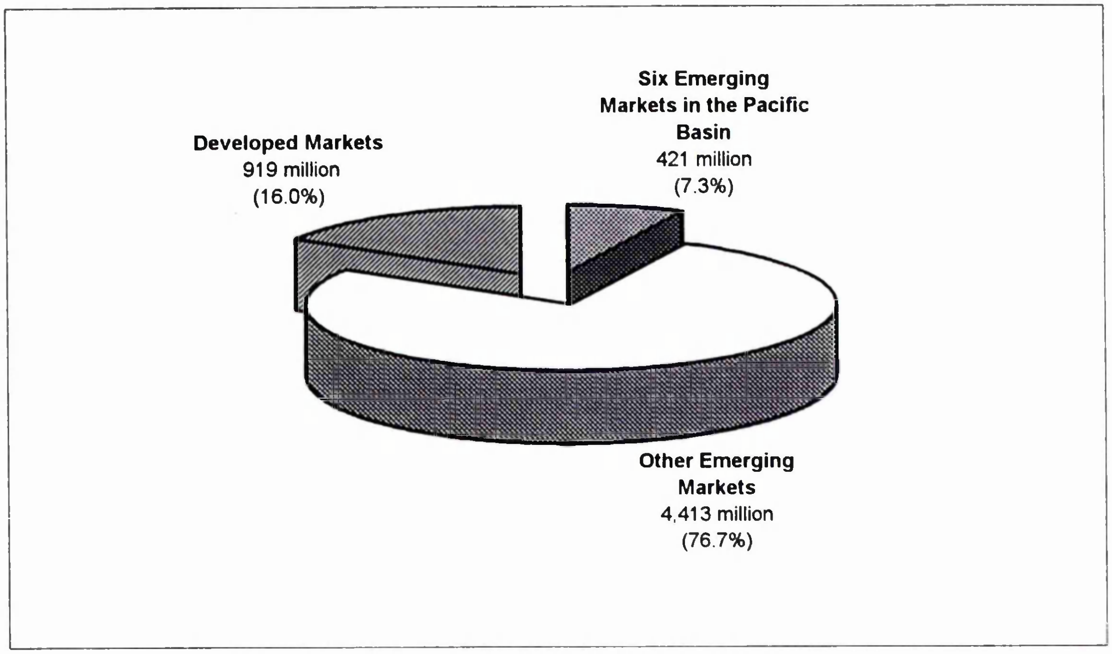
Source: Federation Internationale des Bourses de Valeurs (FIBV).
Ranks are provided in parentheses.
Number of listed companies includes domestic and foreign companies but excludes investment funds.

Figure 2.1 Emerging Markets' Share of World GNP, 1996



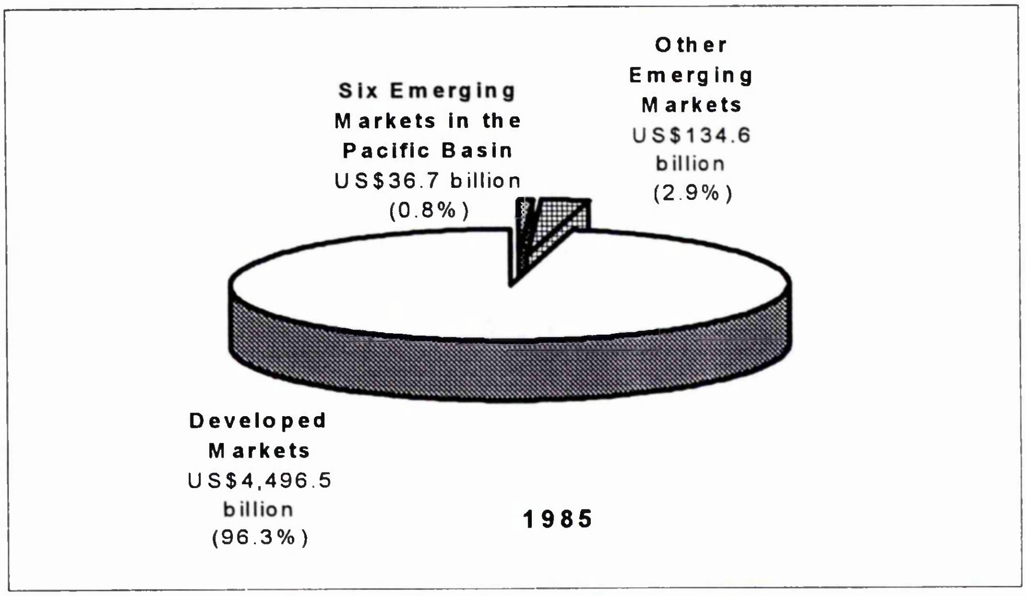
Source: International Finance Corporation, *Emerging Stock Markets Factbook*, 1998; *Taiwan Statistical Data Book*, 1998.

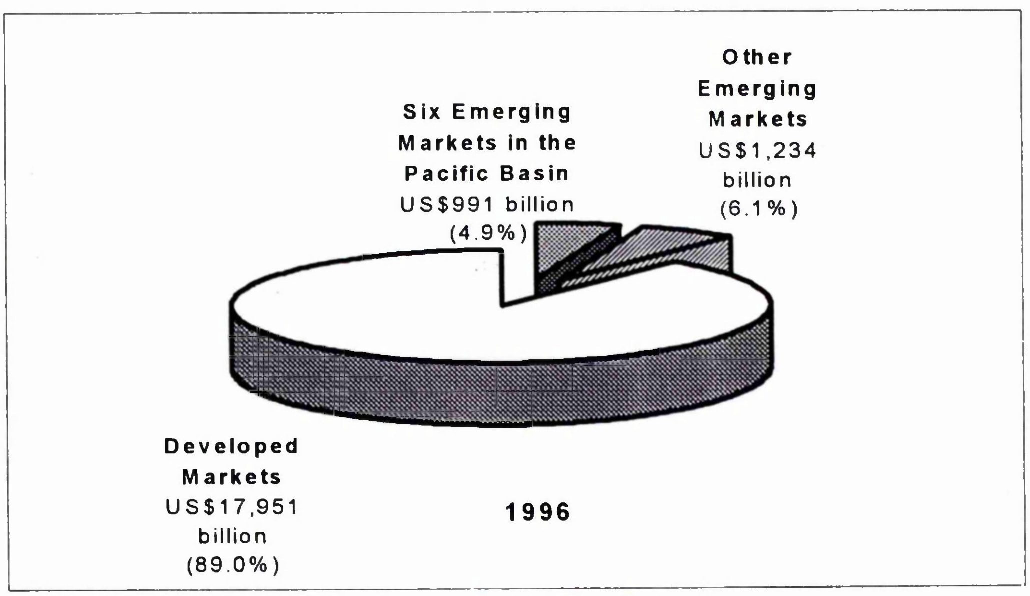
Figure 2.2 Emerging Markets' Share of World Population, 1996



Source: International Finance Corporation, *Emerging Stock Markets Factbook*, 1998; *Taiwan Statistical Data Book*, 1998.

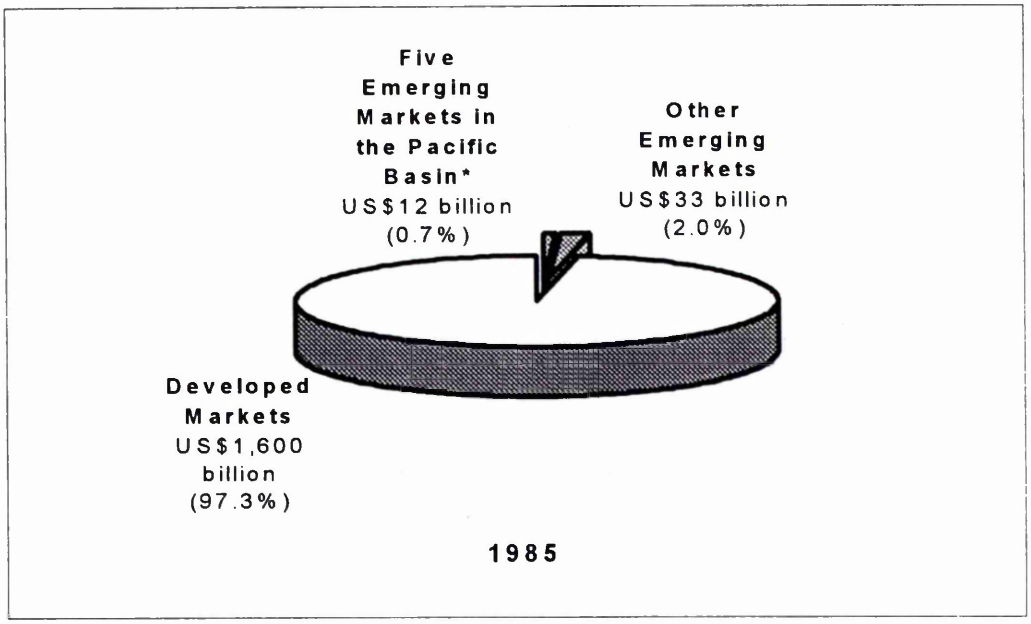
Figure 2.3 Emerging Markets' Share of World Market Capitalisation in 1985 and 1996



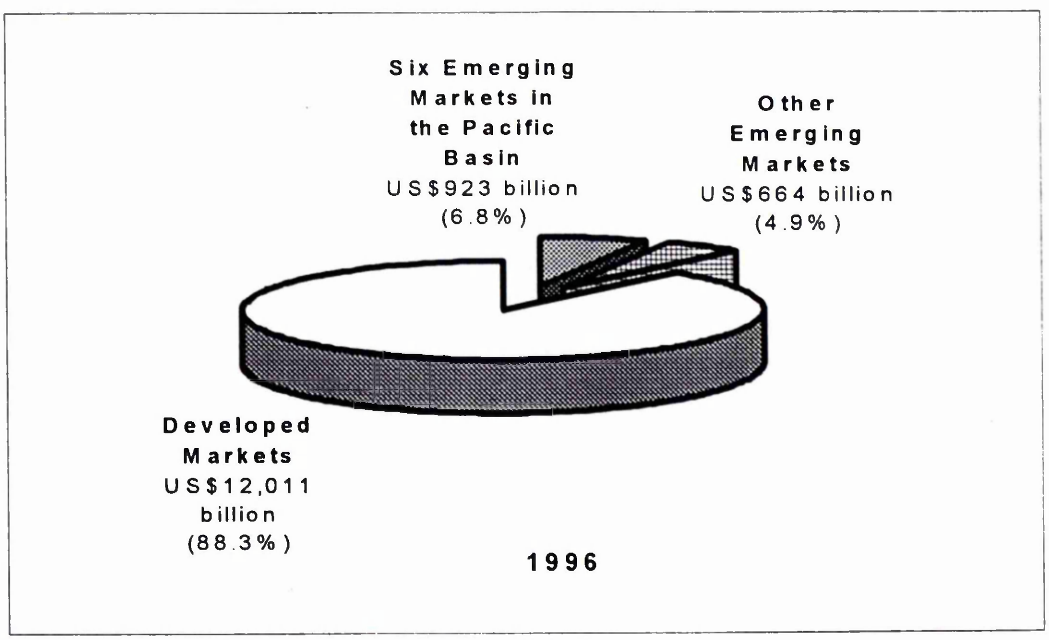


Source: International Finance Corporation, *Emerging Stock Markets Factbooks* 1995, 1997.

Figure 2.4 Emerging Markets' Share of World Market Trading Value in 1985 and 1996

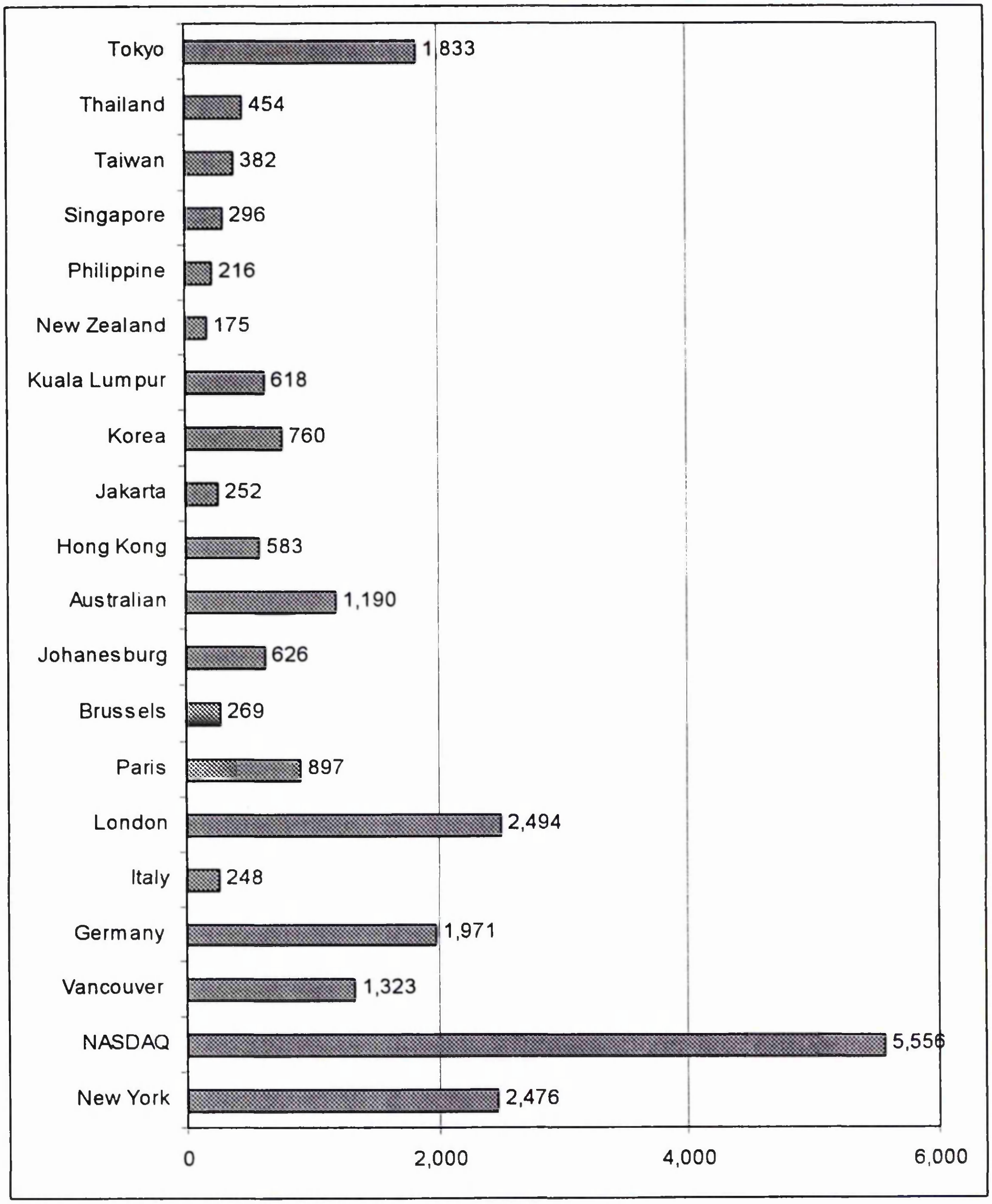


* refers five emerging stock markets excluding Indonesia.



Source: International Finance Corporation, *Emerging Stock Markets Factbooks* 1995, 1997.

Figure 2.5 Number of Listed Companies on the Selected World Stock Exchanges, 1996



Source: Federation Internationale des Bourses de Valeurs (FIBV).
Number of listed companies includes domestic and foreign companies but excludes investment funds.

Table 2.2 Market Concentration: Shares of Market Capitalisation and Trading Value by the Top 5% of Listed Companies, 1998

Market	Capitalisation[a]	Trading value[b]	No. of companies
Indonesia	67.4	63.5	14
Korea	67.5	50.5	37
Malaysia	54.9	59.7	36
Philippines	63.2	47.8	10
Taiwan	33.5	NA	21
Thailand	64.5	49.0	21
Australia	77.4	83.6	58
Hong Kong	81.4	76.6	33
Japan	58.1	62.0	92
New Zealand	55.8	68.4	6
Singapore	67.1	43.4	16
France	68.6	63.4	35
US*	63.8	51.4	114
UK	80.7	59.8	98

Source: Federation Internationale des Bourses de Valeurs (FIBV).
Figures in columns [a] and [b] are reported in terms of percentage.
* refers New York Stock Exchange.

3 An Overview of the Korean Stock Market

3.1 Introduction

Korea's stock market has developed remarkably over the last four decades. It has been claimed as one of the fast-growing emerging stock markets although it had been one of the strictly regulated markets until the early 1990s. In this chapter, a comprehensive review of the different aspects is provided including historical development and regulatory changes in the Korean stock market. Although a period from the mid 1950s to the late 1990s is covered, we are particularly interested in the 1980s and the 1990s since internationalisation and liberalisation of the stock market were concentrated in these two decades and most data analysed in this thesis is related to the period. This chapter also examines the main features and recent developments of the stock market, as well as the Korean financial market crisis in 1997, emphasising both the stock and derivatives markets.

There have been some studies of the Korean stock market, but most of the studies have concentrated on comparison with other markets rather than examination of the Korean stock market itself, for example, Hildeburn, 1986; Rhee, Chang and Ageloff, 1990; Feldman and Kumar, 1994; Freris and Blake, 1994; Clemente, 1994; Claessens, 1995; and Demirgüç-Kunt and Levine, 1996. Very little work has been done on the development of the Korean stock market. For instance, Cooper (1983), Koh (1992) and Roc (1995) examined the Korean stock market in historic and quantitative development perspectives. However, those studies did not seem to investigate the topic in depth, and also the recent development of the Korean stock market could not, of course, be covered. Therefore, this chapter aims to fill this gap by examining the Korean stock market in overview and also more closely from various perspectives. In particular, the stock market opening-up, the introduction of derivative securities trading, and the Korean financial market crisis in 1997 are also examined.

Rhee, Chang and Ageloff (1990) investigated eleven Pacific-Basin stock markets, including the Korean stock market, in terms of market size, trading volume, foreign ownership and other factors. In terms of restriction on foreign ownership, the Korean market was categorised in 1987, along with the Taiwan market, as severely restricted one. Roc (1995) examined eight emerging Asian markets including the Korean stock market with a historical perspective over the three decades and identified the major determinants of their development and the mini-boom between 1987 and 1990. Cheung and Mak (1992) reported that the estimated percentage of the value traded between local and foreign investors in the Korean stock market in 1991 is 98% for the former and 2% for the latter. They showed that the proportion of value traded by overseas investors was quite low compared to the figure of 93% for the Malaysian market and 40% for the Philippine market. With respect to the Korean financial crisis, Choe, Kho and Stulz (1999) examined the impact of foreign investors on stock returns in Korea from November 1996 to December 1997 and found no evidence that trade by foreign investors had a destabilising effect on the Korean stock market.

The securities market in Korea consists of three markets: stocks, bonds and derivatives. Among them, the main focus will be drawn on the stock and stock index futures market in the Korea Stock Exchange (KSE) since these markets are closely related to our empirical analysis. This is the first study, which covers the development of the Korean stock market from its first opening in the mid 1950s until the latter half of the 1990s including the stock market opening-up and the Korean financial market crisis.

In section 3.2, a brief overview of Korean stock market development up until the end of the 1970s is presented. Section 3.3 describes the main developments of the market during the 1980s, emphasising its internationalisation. Section 3.4 analyses the opening-up of the stock market and the development of foreign investment in it during the 1990s, drawing particular attention to how deregulation has speeded up. In addition, aspects of the Korean financial market crisis associated with the stock market are also noted. Section 3.5 examines some particular characteristics of the Korean Stock Exchange. In section 3.6, recent development of the stock market is explained. Finally, section 3.7 provides a summary and conclusions.

3.2 The Early Stock Exchange and Quantitative Growth of the Stock Market in Korea: Until the Late 1970s

An organised stock market, Chosun Kuraiso, was established in 1932 according to Chosun Securities Industry Surveillance Decree. It was renamed Chosun Stock Exchange in 1943 during the period of Japanese domination (1919-1945), but World War II forced it to close after Korea's independence from Japan in 1946. Since its purpose was solely to fund Japanese companies, the real history of the stock market in Korea should be considered only from when the first stock exchange was established in the capital, Seoul, in 1956. When Taehan Stock Exchange was opened on 3 March 1956, the principal securities initially traded were only twelve stocks and three bonds (see Table 3.1). Trading was dominated by government bonds issued largely to finance the Korean War and the subsequent post-war restoration, farm reform and the government budget deficit. Therefore, the stock market played a minor role as a means of raising long-term industrial capital. In fact, over 80% of the trading conducted in the stock exchange was generated by government bonds. This situation prevailed for a number of years between 1956 to 1961. It remained essentially a market for government bonds without an institutional structure until the early 1960s, when the government decided to foster capital market development in order to bolster domestic savings. With the inception of First Five Year Economic Development Plan (1962–1966), the Korean Government, recognising the potential of the securities market, enacted the Securities and Exchange Law, which was the first comprehensive set of regulations overseeing the Korean securities market.

A massive collapse of stock prices in May 1962 brought about the shutdown of the market. This crash was due to excessive speculative trading which led a sharp rise of the stock prices. At the early of 1963, the Ministry of Finance (MOF) closed the exchange on five occasions, with trading suspended for a total of seventy-three days, and instituted a series of reforms. On 3 May 1963, the stock exchange was reorganised into a non-profit government-owned corporation and renamed the Korea Stock Exchange (KSE). Unfortunately, there was relatively little financing of investment through the securities market. Also, relatively risk free bank deposit rates were an impediment to stock market growth. In these circumstances the major sources of corporate finance necessary to implement First Five Year Economic Development *Plan* were bank loans and, to some extent, foreign capital. This, in turn, resulted in the banks suffering from chronic over-extension of loans while highly geared business enterprises were burdened with heavy debt service charges.

Embarking on the Second Five-Year Economic Development Plan (1967-

1971), the Ministry of Finance recognised that comprehensive measures needed to be adopted to promote the securities market. This led to the milestone development of comprehensive reform legislation. In November 1968, the government enacted The Law on Fostering Capital Market to foster the local securities market. This legislation was designed to increase the number of listed companies, thereby distributing share ownership among all sectors of the investing body. The first investment trust, Korea Investment Corporation (KIC) was established in 1970 to stabilise securities prices and also facilitate the issuance, distribution and underwriting of securities. Until its liquidation in 1977, the KIC performed various other functions such as open market measures to stabilise prices, analysing securities, and financing securities on the basis of collateral. Furthermore, a heavy capital gains tax was imposed on sales of real estate to reduce property speculation, while bank deposit rates were halved between 1968 and 1972 so accelerating the flow of funds into the stock market.

On 3 August 1972, another government measure was taken in the form of a Presidential Emergency Decree for Economic Stability and Growth. The main purpose of this was to reduce the heavy cost of corporate financing through the informal financial sector, or the so-called 'curb' market.[4] The Emergency Decree required that all debts and credits of business enterprises created outside the organised financial market be reported to the government while the interest rates of bank loans and time deposits were lowered. In 1975, the stock market started undergoing a great boom, led by bullish buying of construction-related stocks. Throughout the latter half of the 1970s, the Korean securities market experienced an unprecedented rush of

[4] Although 'curb' market was the informal financial sector, it was a large and well organised system of credit brokers and dealers. The sources of funds in this market were heterogeneous, but the uses were principally for the working capital of large firms and small and medium-sized firms. The average interest rates on curb loans were much higher than those for loans in the regulated market, but most of these loans do not require the use of collateral, which indicated that the risk of default was accounted for in the interest rates charged.

public offerings. Later in July 1979, the KSE was moved from Myung-Dong to Yoido where Korea's Wall Street created. In particular, throughout the 1970s, the Korean stock market had grown rapidly. The number of listed companies, which stood at only 50 in 1971, jumped to 356 by the end of 1978. In terms of trading value, it was 34.4 billion won in 1971, but it sharply increased to 1,741.5 billion won in 1978— a fifty-fold increase (see Table 3.2). Overall, the period to the 1970s, it can be characterised as one in which the stock market emerged and played a minor role in the economy.

3.3 Market Internationalisation in the 1980s

Since the early 1980s, the Korean financial market has been through a process of gradual opening-up and liberalisation. The Korean government took a conservative approach, because it had been aware of both the benefits and adverse effects of financial market opening which other countries had experienced. At the early of the 1980s the authorities had sufficient confidence in the market to begin allowing foreign investors an indirect investment channel into the Korean market. In 1981, the government announced The Long-Term Plan for Internationalisation of the Capital Market, which was a comprehensive blueprint for the globalisation of Korean securities industry. The Long-Term Plan outlined the general phases for liberalisation. For the first stage of the plan, the Korea International Trust (KIT) and the Korea Trust (KT) were established to allow foreigners to invest in Korean equities. The establishment of these trusts was seen as a first step in instructing foreign investors and brokers in Korean equities since they were permitted to invest indirectly in the Korean market not through stocks and bonds but only in beneficial certificates (see

Table 3.3 for details). By the end of 1994, beneficial certificates were issued for forty-one occasions with a total of US$1.88 billion invested in the Korean market.

Since the capital market was opened to foreign investors in 1981 by indirect investment in trusts, there was increasing demand for other means of investment in the Korean stock market. In 1984, the listing on the New York Stock Exchange of Korea Fund, the first exchange-traded, closed-end country fund ever created, allowed indirect foreign participation in the Korean securities market for the first time. With US$60 million capital, it was quite popular among international investors as Korean equities boomed in the second half of the 1980s. Other funds, such as Korea Europe Fund in 1987 and Korea Asia Fund in 1990 quickly followed.

In December 1988, the MOF announced a revised form of the 1981 internationalisation plan to further promote the liberalisation of the Korean capital market for foreign investors. The mid-term plan provided new opportunities for non-residents to invest in Korean securities during 1989 and 1990. This was arranged by increasing the capital of overseas funds, such as Korea Fund, which was listed on the New York Stock Exchange (NYSE), and Korea Euro Fund, which ran by Ssangyong Investment Company and Barings and was listed on the London Stock Exchange, authorised for investments in Korean securities and by relaxing the qualifications to issue overseas securities by Korean companies, including convertible bonds (CB), bonds with warrants (BW), and depository receipts (DR).

As illustrated in Figure 3.1, the KOSPI began to pick up from 1986. It stood at 271.61 points at the end of 1986, and climbed to 907.21 points by the end of 1988. On 1 April 1989, the KOSPI hit 1,007.77 points which was an increase of 720% compared to 139.53 points in 1985. Breaking the 1,000 barrier for the first time was attributed to a higher rate of economic growth and the current account surplus. In particular, stock market capitalisation grew approximately 1,450% from 6,570.4 Korean billion won in 1985 to 95,476.8 billion won in 1989 (see Table 3.2).

3.4 Liberalisation in the 1990s

The remarkable quantitative growth in the Korean stock market throughout the late 1980s and the middle of the 1990s is also highlighted in Table 3.2. This was fuelled by the stable and strong performance of the economy. Korea took steps to improve the quality of the market by implementing comprehensive capital market liberalisation. One of these steps was opening of the stock market to foreigners. As described in section 3.3, this had its beginnings in the 1980s when foreign investors were permitted to invest on Korean stocks indirectly through convertible bonds and/or country funds and trusts that invested in the Korean stock market. Although the Korean economy itself began a liberalisation program as early as 1985, with direct foreign investment in some industries, opening the stock market was only a rumour up until the late of 1988, and even that was to occur with severe restrictions on foreign investors. Liberalisation of the stock market in the early 1990s heralded an era of gradual deregulation, although not comparable with that in the advanced markets, and it was regarded as a new departure in Korea's previously closed markets. The pace of stock market opening was thereafter accelerated. In 1991, prior to the stock market opening to foreign investors, the KSE opened its membership to foreign securities companies, and Korean securities companies also were permitted to establish overseas branch offices. Finally on 3 January 1992, the Korean stock market first opened to direct foreign investment. Subsequently, there has been escalation in the number of foreign investors, as well as growth in the volume of their market participation. Although their market share was still insignificant by comparison with that of domestic institutions, foreign investors began to play an important part in the domestic securities market.

3.4.1 The Stock Market Stabilisation Fund

After peaking for four years in the late of 1980s, the Korean stock market fell into a long slumber from 1990 to 1993. This occurred for a variety of reasons, including excess supply on the stock market, higher interest rates and economic slow-down. In spite of other government policies to stabilise the stock market, for example the Policy for Adjustment of Demand and Supply on the Issue Market and the Policy for Stock Market Stabilisation at the end of 1989, the stock market did not show signs of recovery. In order to boost and stabilise the deeply depressed stock market, the Stock Market Stabilising Fund was established for the first time on 4 May 1990 but it was abolished on 3 May 1996 in line with its six-year legal validity. The Stock Market Stabilising Fund was initially organised with 4.85 trillion Korean won by 32 securities companies, 22 commercial banks, 19 insurance companies, 28 investment companies and 536 listed companies on the KSE. Over the period of its six-year legal validity, the fund intervened six times by means of direct stock trading. Additionally, when the stock market was depressed it also intervened several times in an indirect way by lending funds at relatively low interest rates to institutional investors. The scope of investment by the fund was limited to stocks issued by listed companies on the KSE. At the time, the fund was criticised because it ignored the free market principle by distorting the price mechanism. In spite of high hopes for boosting the stock market, the positive effects of market intervention by the Stabilisation Fund were only short term.

3.4.2 The Real-Name Financial Transaction System

On 12 August 1993, the Real-Name Financial Transaction System was introduced by an emergency order, to eliminate the so-called 'dark link' between politics and business. Under this system, Koreans were required to use only their own names in financial transactions. Those who formerly traded under false names to evade taxes, to conceal sources of income or to avoid regulators were required to switch to their real names by 12 October 1993. This emergency order required banks' customers to produce identification documents to prove ownership of accounts. Banks also had to report to the authorities the names of all clients who withdraw more than 30 million Korean won during the period before 12 October 1993 and the names of people whose financial assets newly registered in real names exceed 50 million won. The tax collector could then investigate their sources of income. The announcement came as a massive shock to the financial markets and the banking system. The KOSPI declined 8% in the two days after the announcement, falling to 666. However, because investors expected a government support scheme, the market rebounded, although remained edgy.[5]

The Ministry of Finance and Economy (MOFE) announced deregulation of the stock market, the so-called Korean version of a 'Big Bang,' on 12 July 1996. This system implied that the government would move to lift its tight control in an effort to enhance the transparency of market regulations and to promote the working of market forces. The government released its grip on the supply volume of new stocks enabling private corporations to make initial public offerings or issue new stocks freely for

[5] In fact, nobody seemed to have much idea of what proportion of Korean financial assets was registered in false or borrowed names. Some economists reckoned it could amount to as much as 20 billion Korean won, which was a fifth of Korea's money supply.

cash payment. The government also announced it would not take steps to boost or cool down the stock market, and the daily price limits would be gradually expanded. The government also liberalised the margin requirement system. In the long run, stock brokerage houses would be given full autonomy in setting brokerage commissions. So far as investors concerned, they would be able to submit orders to brokerage firms and confirm transactions through their own computers.

On 11 October 1996 the Organisation for Economic Co-operation and Development (OECD), the Paris-based club of industrialised nations, officially invited Korea to join as its 29th member country. Korea became the second Asian member of the OECD after Japan. OECD membership was expected to have a large influence on the capital market. Before joining, Korea's original timetable for fully liberalising its financial markets was set for year-end 2000. The government initially planed to open domestic banking and securities markets fully to foreigners, allowing them to set-up wholly owned subsidiaries in Korea by December 1998. It was expected that, from the beginning of 1997, the government would eliminate a 10% limit on a foreign corporation's ownership of existing local securities firms, investment trust companies and investment firms. A ceiling on foreign ownership of local stock would also be raised to 23% in 1997, 26% in 1998, 29% in 1999 and finally 100% in 2000. However, with the sudden onset of the financial crisis, the process of liberalisation and opening-up of the market accelerated with the subsequent adoption of the IMF bailout program in December 1997.

3.4.3 Stock Market Opening-Up

The changes in foreign investors' ownership ceilings on the KSE are presented in Table 3.4. When the Korean stock market first opened to direct foreign investments on 3 January 1992 foreign investors were allowed to buy up to 10% of a Korean company's outstanding securities, with a maximum holding of a 3% for each investor. The aggregate foreign investment ceiling was increased to 12 % in December 1994, and then gradually increased at fairly regular intervals to 26% in November 1997 to meet foreign investors' increasing demand for Korean stocks. The aggregate ceiling on foreign ownership for public utilities such as Korea Electric Power Corporation (KEPCO) and Pohang Iron & Steel Company (POSCO) was raised several times from 8% to 21% in November 1997. In fact, it took only five years to double the foreign ownership ceiling to 20%. The ownership ceiling for each individual foreign investor was gradually increased from 3% to 7% until November 1997 for general companies but the ceiling for public utilities ~~was~~ remained at 1%. The aggregate ownership ceiling on foreign investors increased to 50% in 1997 and then increased again to 55% at the end of the year. This became 100% on 25 May 1998. Similarly, the ownership ceiling for each individual foreign investor jumped from 7% to 50% on 11 December and finally to 100% in 25 May 1998. By then, investment ceilings on all equity products were eliminated. Compared to the original schedule for expanding a ceiling on foreign ownership which is described in section 3.4.2, these rapid increasing were almost entirely in response to the Korean financial market crisis and International Monetary Fund (IMF) bailout program. Subsequently, foreign investors have been free to invest in stocks, bonds, derivatives and money market instruments, including repurchase agreements, certificate of deposits (CD) and commercial papers (CP). In addition, on 1 July 1998, foreign investment limits in stock index futures and options market were also fully liberalised. For example, foreign investment limits for the stock index futures market were set at 100% of the average daily open interest for previous three months on the aggregate basis, and 5% for the individual ceiling.

3.4.4 Korean Financial Market Crisis in 1997

Up until 1997, Korea's economic performance was rather impressive. In 1995, GNP per capita surpassed US$ 10,000 for the first time and became the eleventh largest economy in the world in a short period of time. During the earlier boom period of 1994-1995, the GDP growth rate was over 8%, the rate of inflation was around 5% and the domestic savings rate was approximately 35%. On the stock market side, its quantitative growth had been remarkable. From 1980 to 1995, market capitalisation increased over 5,500% and the stock market index, KOSPI rose almost 1,000% (see Table 3.2 and Figure 3.1). However, the outbreak of the Korean financial crisis in the last quarter of 1997 was preceded by a foreign currency market crash and followed by meltdown of the stock market. According to many economists, the Korean financial crisis emanated from both internal and external factors. The former includes structural weakness of the Korean economy and the latter is characterised by a contagion effect of the Southeast Asia financial market crisis in 1997.[6] On 3 December 1997, the Korean government and the IMF reached an agreement on a bailout loan package totalling US$58.35 billion, including loans worth US$21 billion from the IMF, US$14 billion from International Bank for Reconstruction and Development (IBRD) and Asian Development Bank (ADB), and US$23.35 billion from G7 and other countries. In response to the bailout program, the Korean government agreed with the IMF that it would pursue macroeconomic stabilisation and structural reform in the financial sector, the corporate sector, and the labour market, and accelerate trade and liberalisation of the capital account.

[6] Many other factors such as over investment and high costs also contributed to the Korean financial market crisis. The structural weakness of the Korean economy came from two sources, external and internal vulnerabilities. The former is characterised by the heavily short-term oriented external financing and the latter is characterised by highly leveraged corporate financial structure.

In particular, with regard to capital market liberalisation, the previous government schedule was accelerated. Other conditions of the IMF package involved restructuring of the troubled financial system, and further opening-up of Korean financial markets to foreign investors, including foreign stakes in banks. The newly introduced market-opening measures included the partial or complete removal of investment ceilings and restrictions on foreign investment in the stock, bond markets, short-term money market instruments and deregulation on mergers and acquisitions by foreign investors. The government also permitted foreign investors to buy shares in the stock market without limits for the purpose of friendly mergers and acquisitions (M & A).

Mainly due to the Southeast Asian financial crisis in 1997, most exchanges in this region experienced meltdown of their stock markets over 1997 and 1998. Although various reasons can be regarded as origins of the Asian financial market crisis, one of the major for the crisis was Thailand's financial market crash on Wednesday 2 July 1997 (henceforth Black Wednesday). During the second half of 1997, in particular, equity and currency markets in the most affected countries in the region recorded a great degree of drops, which ranges from 20 to 75 percent. The KSE was no exception. With the string of bankruptcies of listed firms and the lack of market liquidity, total market capitalisation of the KSE at the end of 1997 plummeted to 70.9 trillion won, which was equivalent to US$41.8 billion, less than one-third of what it was in 1996 in US dollar terms. During the year 1997, the KOSPI plunged 42.2% to 376.31 compared to 651.22 in the beginning of that year. In terms of the dollar-denominated International Finance Corporation Index (IFCI) Korea Index, it suffered a 68.9% drop in US dollar terms for the year. Also, the contraction in values precipitated a 39.5% decline in the market capitalisation of securities listed on the

KSE. In early 1998, however, the stock market regained liquidity, pushing the market capitalisation of all listed companies above 137.8 trillion won. Trading value of the KSE also had been decreased from US$177 billion in 1996 to US$145 billion in 1998. In particular, although the KOSPI rebounded sharply one year after the outbreak of the financial crisis, it dropped by 42% in 1997 compared to the end of 1998 that was the third worst figure among the Southeast Asian stock exchanges during the period (see Table 2.1 of Chapter 2). In particular, the stock market in Korea began its downward spiral from mid-1997 when the Southeast Asian financial turmoil started. In October 1997, the KOSPI plunged to 350.68 points by the end of 1997 from 645.15 points in early October and a low of 280.00 was recorded in June 1998. Since then, the stock market recovered rapidly due to positive developments in the economy, a sizeable trade surplus and stabilised currency, and liberalised investment status. At end of 1998, the KOSPI closed at 562, a 49% increase on a year-end basis, and the traded value of listed stocks increased by 19%.

3.4.5 Growth of Foreign Investment on the Stock Market

Table 3.5 provides data on the flow of stock investment in Korea. Over the period from when stock market was opened up in 1992 to the end of 1998, the total net inflow of foreign capital amounted to US$21 billion. Except for the second half of 1997, the inflow of foreign capital has dominated the outflow. By the end of 1998, Foreign investors brought in US$12.8 billion and remitted US$8.8 billion, resulting in a net inflow of US$3.9 billion.

Since the Korean stock market opened up, foreign investors have been net purchasers. As presented in Table 3.6, when the stock market was in the midst of a long recession in 1997, in terms of trading value, foreign investors bought only 424 billion won, the lowest since the market opening. However, in 1998, foreign investment increased dramatically and foreign investors made a net purchase of 5.7 trillion won, the largest recorded since the stock market opening. One of the reasons for the large inflow of foreign investment during 1998 was Korea's decisive measures of abolishing various restrictions in the stock market. Furthermore, active overseas investment attraction by the private sector and government, recovery in the economy during the second half of 1998 and the boost in sovereign credit rating also helped the inflow of foreign investment. Overall, by the end of 1998, foreign investors had purchased a total of 60.9 trillion won and sold 43.6 trillion won, resulting in a cumulative net purchase of 17.3 trillion won. In terms of trading volume, foreign investors have remained as net purchasers except the Korean financial period. In addition, as illustrated in Figure 3.2, the proportion of total market value of stocks owned by foreign investors has been increased rapidly from 2.7% in 1992 to 16.4% in 1998. In terms of number of listed shares, the rate has been increased almost four times from 2.1% in 1992 to 8.1% in 1998.

Table 3.7 and 3.8 report data on foreign investors from 1992 to 1998. When the stock market first opened to foreign investors only 1,572 investors from 37 countries registered for trading. Since then, the number of foreign investors had been increased continuously and over 8,000 foreign investors from 66 countries registered as of 1998. A breakdown by nationality is illustrated in Figure 3.3 and the reported figures are calculated by the average over the period from 1992 to1998. The majority was from US (35.8%), UK (15.1%), Taiwan (10.7%) and Japan (8.2%).

The number of listed companies was only 50 in 1971. The figure reached to 352 by the end of 1980, 669 in 1990 and 748 in 1998. In terms of the number of listed companies, the KSE ranked 16th among 35 member stock exchanges of the

International Stock Exchange Federation (FIBV: Federation Internationale des Bourses de Valeurs) in 1985. It ranked 11th among 51 member stock exchanges in 1998 (see Figure 2.1 of Chapter 2). The trading value for listed stocks on the KSE amounted to 34.4 billion won in 1971 and then it was increased to 1.13 trillion won in 1980. In 1998, it reached 192.8 trillion won, which was almost one hundred and seventy-fold increase over two decades.

Although the stock market has grown continuously with the expansion in the Korean economy, the stock market expanded rapidly in the period following the first trade surplus in late 1986. Qualitative growth of the KSE accelerated further after its opening to foreign investors in 1992. By 1998, total market value had increased twenty-fold, and the KSE-listed capital stock increased ten-fold, over 1985.

Table 3.9 shows the foreign investors' share ownership since 1981. In the period before the stock market opening-up in 1992 the percentage of foreign shareholders among total investors varied only over a range of 0.01% to 0.06%. However, the rate increased to 0.18% in 1993 and 0.28% 1995. Incidentally, the percentage of shares owned by foreign investors increased sharply compared to 2.49% in 1991 to 4.13% in 1992. Furthermore, the rate doubled to 8.74% in 1993 although the speed of increase slowed down to 9.1% in 1994 and 10.1% in 1995, an increase of more than 250% since 1992. In 1998, foreign investors' shareholding reached 1.2 billion shares or the value of 25.6 trillion won, which accounted for 10.5% of the total outstanding shares and 18.6 % of the total market value, respectively.

As presented in Table 3.10, at the end of 1998, the total number of shareholders reached to 1.9 million, accounting for approximately 4.2% of the Korean population. The number of shares held by individual and institutional investors accounted for 39.8% and 21.7% of all listed shares, respectively. Foreign investors' shareholdings have shown a slight decrease from 11.6% in 1996 to 9.1% in 1997 although the figure increased to 10.4% in 1998 (see Figure 3.4).

3.4.6 The Stock Exchange Versus the Over-the-Counter Market

In July 1996, the Korea Securities Dealers Association set up the Korea Securities Dealers Association Quotation Stock Market (KOSDAQ), in which listing requirements are less strict than those for the KSE. It was born as a development of the existing over-the-counter market and one of the its main roles is primarily to provide a method of raising public investment for promising small and medium-sized enterprises and venture businesses. The KOSDAQ has grown rapidly. Indeed, in two years since its foundation, trading value and volume have been increased by three-fold and six-fold, respectively. By the end of 1998, there were 331 listed companies on the KOSDAQ, which is equivalent to 44% of companies listed on the KSE, and the KOSDAQ's market capitalisation was 7.9 trillion won, which is 5.7% of the KSE's level.

3.5 Characteristics of the Korea Stock Exchange

The KSE is a privately incorporated association composed of member securities companies. Until the early part of 1988, the government owned 68% of the KSE's shares, with the remainder in the hands of the 25 member firms. In March 1988, the government sold its shareholding to these member firms and the KSE has since operated as a non-profit organisation. In 1991, the KSE opened its membership to all qualified foreign securities companies and in 1998 had 41 members including 10 foreign securities companies and two affiliates, the Korea Securities Depository (KSD) and the Korea Securities Computer Corporation (KOSCOM).

The KSE has become one of the most modern exchanges in Asia with a high degree of computerisation and a central depository system. KSE membership is granted only to securities companies licensed by the Ministry of Finance and Economy (MOFE) to engage in the securities business to act as a dealer, broker or underwriter. Thus the major sources of income of the securities companies comprise capital gains plus dividends, brokerage commission and underwriting fees. Securities companies are also permitted to operate other appending activities such as security savings business and trading of bonds.

3.5.1 Trading Scheme

The open outcry trading method was used from March 1956 to late 1974. KSE officials clapped wood chips to signal the beginning of bid for each stock and the end of trade for each stock. When a certain bid price and volume for a particular stock matched the ask price and volume for that stock, the chips were clapped.

For the period from January 1971 to August 1997, post trading was used. The main purpose of this method was to handle an increasing number of listed stocks, because call trading was incapable of handling a large number of shares. The KSE installed a trading place for each listed stock. This was, in effect, a post where buyers and sellers submitted their bid and ask prices and volumes to KSE officials. They then listed bid and ask prices and volumes in order of receipts, then matched them in the order.

In March 1988, the KSE partially introduced a computerised trading system, called SMATS (Stock Market Automated Trading System). On 1 September 1997, the

KSE fully automated its securities reading and runs two electronic systems, an order routing system and KATS (KSE Automated Trading System), to facilitate securities trading.

The KSE operates a continuous double auction system in which the computerised system replaces an auctioneer and determines the price by matching the best bids and offers. Through the trading session, customer orders are continuously matched at a price satisfactory to both parties according to price and time priority. At the time of market opening and closing, however, customer orders are pooled over a certain period of time and matched at a single price that minimise any imbalance between buying and selling parties.

The stock market in Korea is divided into two sections: first section and second section markets. To be listed on the first section, there are several major requirements. Among them, the number of minority shareholders must be at least 1,000, paid-in capital must be at least 5 billion Korean won, and the ratio of net profit to the capital stock must have been at least 10% for the last three business years. Also, the number of shares owned by one controlling shareholder must not be more than 51% of the total outstanding shares, excluding preferred (non-voting) shares. Companies, which do not satisfy these criteria, are traded on the second section.

3.5.2 Stock Indices

a) Korea Composite Stock Price Index

The KSE initially introduced the Korea Stock Price Index (KSPI) in 1972 and it was a price-weighted index of selected stocks representative of the market as a whole. Its base date was 4th January 1972, with a base index of 100. The original index was composed of 35 stocks, but the number of stocks had increased to 153 by 4 January

1979, and the base date was then adjusted to 4 January 1975.

From 1 January 1983 the KSE adopted a new method of calculating the index called the Korea Composite Stock Price Index (KOSPI), which is a comprehensive top-down and market capitalisation weighted index. It is based on aggregate market value and has a base value of 100 on the base date of 4th January 1980. The index is composed of all listed shares on the KSE to reflect the whole stock market. The KSE also publishes 40 supplementary indices categorised by section, industry and capital size. As the end of 1998, the KOSPI and its supplemental indices are published every thirty seconds of each trading session. The computation formula for the KOSPI is as follows:

$$KOSPI = (\sum_{i=1}^{n} P_{ci}Q_{ci} / \sum_{j=1}^{n} P_{0j}Q_{0j}) \times 100 \tag{3.1}$$

where $P_{0j}Q_{0j}$ and $P_{ci}Q_{ci}$ which are the market capitalisation of an individual stock, is derived by multiplying common stock price by the number of the outstanding shares in the base year and in current time, respectively. The aggregate market capitalisation is the sum of market capitalisation of all constituent stocks. In calculating the KOSPI, the number of preferred stocks is added to the number of common stocks and then multiplied by common stock price, not by preferred stock price.

b) Korea Stock Price Index 200 (KOSPI 200)

The KOSPI 200 is an underlying index for stock index futures and options contracts, which were introduced in 1996 and 1997, respectively. It has been published since 15 June 1994. The KOSPI 200 is a sampled constituent and market capitalisation weighted index. It is composed of 200 leading companies' stocks listed on the KSE that make up approximately 70% to 80% of total market capitalisation. The selection of the constituent stocks is based on the individual stock's liquidity and position in its industry. In principle, changes to constituents are made in two ways. One is through periodic changes every June and the other is the occasional changes when existing constituents are de-listed or merged between the periodic changes.

The KOSPI 200 is announced every thirty seconds on a real time basis. Basically, the methodology of the KOSPI 200 calculation is identical to the KOSPI calculation shown in equation (3.1) except for the fact that KOSPI 200 is a sampled constituent index and its base is 100 as of 3rd January 1990.

3.5.3 Trading Hours

The KSE operates as a continuous auction market where an auctioneer matches best bids and offers, which is similar to the trading mechanism found in the Tokyo Stock Exchange. Since 8 December 1997 the KSE closed its market on Saturdays and trading hours changed. From Monday through Friday, the morning session begins at 09:00 and finishes at 12:00 and the afternoon session begins at 13:00 and ends at 15:00. Besides the regular trading sessions, the KSE operates an after-hours session in which investors can trade securities at the closing prices for 30 minutes from 15:10 to 15:40. In addition, the opening auction prices of the morning and afternoon sessions are determined by an opening auction where the price is determined by referring to all bid and ask prices in the first five minutes of the trading session. Transmissions are handled in two ways, either regular-way or cash transactions, depending on the settlement period. The former is settled on the second business day following the contract date ($T+2$) while the latter is due on the day of the transaction.

3.5.4 Price Limits System

Price limits have been in force in the KSE since May 1964. The price limits refer to a range within which the price of a stock is permitted to rise or fall in a particular day from the pervious trading day's closing quote. All securities listed on the KSE are subject to daily price limits designed to protect investors from sharp falls in price, which may be caused by speculative trading on the part of few large investors.

Before April 1995, the price limits were expressed as *absolute* changes for specified ranges of base prices. Under this system of *absolute* changes, as the average equity price has increased over time, the set of ranges of base prices has increased. From the beginning of April 1995, price limits have been expressed as a *fixed* percentage rate. Under this system, for a given period, the price limits are the same percentage change of the base price, whatever that base price. Initially, the daily limits were price changes of ±6%, these were relaxed to ±8% from 25 November 1996 and again to ±12% from 2 March 1998. From 7 December 1998 the limits were widened to ±15% of the base price and circuit breakers were also introduced. The system of price limits is fully described in section 7.3 of Chapter 7.

3.5.5 Taxation and Transaction Costs

There is no capital gains tax on income from securities investment for residents. In principle, non-residents are taxed according to tax treaties. When an investor is from a country with which Korea has a taxation treaty, the tax is levied according to the rate range in the treaty. Non-residents without a permanent establishment in Korea are subject to 25% of final withholding tax on dividend and interest.

Investors incur two types of out-of-pocket transaction costs in the Korean stock market: Securities Transaction Tax and brokerage commissions. The Securities Transaction Tax is levied on the seller at a basic rate of 0.3% of sales value. However, there is no tax levied on stocks sold below par value or the public offering price during the first year of listing on the KSE, or sales of securities by investment trusts. Brokerage commissions are charged to both the seller and the buyer, and individual securities companies freely determine the rates.

3.5.6 Margin Transactions

A margin transaction is a purchase or sale of securities with only part of the money or securities supplied by the purchaser or seller, the balance being borrowed from securities companies. That is, securities companies extend credit to customers, thereby enabling them to settle their trading. There are two categories in a margin transaction: margin buying and short sale. Securities companies may extend credit to their customers by using their own money or stocks, or by borrowing from the Korea Securities Finance Corporation, which acts solely for the financing securities, market in various ways. With the exception of securities issued by securities companies, all stocks are eligible for margin trading. The initial margin requirement is a rate of 49% of the trading value. The regulations limit margin buying and short sale to 20% of the total shares of a listed company. A securities company may extend credit up to 150% of its shareholders' equity for margin buying and 50% for short sale, respectively. Foreign investors are not allowed to trade on margin or overdraw their cash accounts.

3.5.7 Regulatory Structure

The regulatory structure of the Korean stock market consists of three main types of regulator: the Ministry of Finance and Economy (MOFE), the Financial Supervisory Service (FSS), and self-regulatory bodies. The MOFE, controls and directs the stock market by setting overall policies, is primarily responsible for the interpretation of the securities laws, and the authorisation or revocation of licences for financial institutions. The FSS is responsible for the supervision and surveillance of securities and futures markets as well as securities institutions. In addition, self-regulatory bodies such as the KSE and the Korea Securities Dealers Association (KSDA) also play an important role in the Korean market. The KSE monitors all trading activities as well as price movements and market events. For example, if Stock Watch Department of the KSE detects unusual trading through a computerised system, Stock Watch Alert System (SWAS), on real-time basis, it analyses trading activities, rumours and news of the relevant stock and further analysis is referred to Market Surveillance Department for in-depth investigation. Subsequently, the suspicious trading is either referred to the Financial Supervisory Commission (FSC) or subject to disciplinary measures by the KSE. The KSDA promotes discipline and fair practice among its members as well as on the securities industry. It also recommends policies to the government to help develop regulations and laws to protect all market participants.

3.6 Recent Development

3.6.1 The Introduction of Derivative Securities Trading

Among the most important events in the 1990s was the introduction of derivative securities trading on the KSE. This was expected to add a new dimension to the Korean securities market. As a first step, stock index futures trading was introduced on 3 May 1996. Following the successful introduction and operation of KOSPI 200 futures market, the launch of the KOSPI 200 options followed on 7 July 1997. These new instruments provide risk management opportunities for investors.

Stock Index Futures

There are four delivery months: March, June, September and December. For the life of a contract, the longest maturity of one year is the same as the length of institutional investors' fiscal year. The last trading day of a contract is the second Thursday of the delivery month. A futures contract size is 500,000 won times the futures price and the minimum price change is 0.05 point (25,000 won).

Trading hours of the morning session are similar to the stock market. Trading hours in afternoon sessions are extended by 15 minutes for the purpose of giving investors time to adjust their futures position after the stock market has closed. The futures market is closed ten minutes earlier than the stock market on the last trading day of a contract. The KSE uses a computerised individual auction method for trading futures contracts, as in the cash market.

The size of daily price limits, ±10% of a base price, is determined to be similar to that of the cash market. If a futures price changes more than 10% of a base and if at the same time the magnitude of market basis is larger than 1%, then the futures trading will be halted for a while. The market basis is the percentage difference between market and theoretical prices. The introduction of a circuit breaker system is considered necessary to minimise the adverse effects of sudden fluctuations in the futures market on the underlying cash market and to provide investors with a 'cooling off' period.

Table 3.11 reports data on KOSPI 200 futures trading. The growth of stock index futures trading in Korea has been remarkable. In 1997, average daily trading volume and trading value increased 203% and 125%, respectively, compared to the first year of its introduction in 1996. By the end of 1998, average daily trading volume amounted to 61,279 contracts, which is an almost six-fold increase compared to 1997 and has become the second largest in the world, after the Chicago Mercantile Exchange (CME). In terms of total contract value, it recorded 405 trillion won. As shown in Table 3.12, in terms of trading value and volume, the average range of foreign investment were around 2 to 4%. The trading systems and development of the KOSPI 200 futures market are fully described in section 8.3 of Chapter 8.

Stock Index Options

There are four options contract months: March, June, September and December. The first or last trading is the same as futures contracts with unit in points. An option contract is 100,000 won times the option price. The minimum price change is 0.05 points for price quotations greater than or equal to 3.00 points, and 0.01 point for less than 3.00 points. Although there are no price limits in the options market the price quotation must be within the theoretical option price range if the KOSPI 200 should rise or fall by 15%. The ceiling on foreign investment in KOSPI 200 futures and options was completely lifted in May 1998.

The options market has grown rapidly despite of its short period of experience. During the first trading year of 1997, the average daily trading volume was 31,000 contracts. In 1998, it reached 110,000 contracts, and thus the KOSPI 200 options market became the fourth largest market in the world. Among investors, individuals were most actively traded investors and constituted approximately 77% of the total trading volume, whereas securities companies and foreign investors made up only 5.4% and 0.8%, respectively.

3.6.2 New Dimension: On-Line Stock Trading

The advent of cyber on-line stock trading through the internet or commercial networks has revolutionised the global stock marketplace from the largest of brokerage houses to the smallest of dealers. The growth of on-line trading has been remarkable. Compared to conventional transactions, on-line stock trading has some advantages such as promptness and accuracy. Above all, the chief merit of on-line stock trading is significantly reduced commission fees for stock investors. The Korean stock market is no exception. In January 1997, with the amendment of the Securities and Exchange Act, securities companies was allowed to receive customers' order through electronic communications such as the internet, mobile phones, etc. The innovative on-line trading method has become very popular because of the fast and wide spread of the internet. Initially, it started with text-based on-line trading services and modified into graphic-based internet trading in June 1998 when domestic brokerage houses launched their Home Trading Systems (HTS). With popular use of personal computers and internet, on-line stock trading has increased remarkably. As the end of April 1998 cyber trading amounted to 2.8% of all orders executed on the KSE. By December 1998 the ratio jumped to 6.4% and the trading value via on-line systems reached to 22.5 trillion won including 11.4 trillion won in stocks, 10.9 trillion won in stock index futures and 136 billion won in stock index options. In terms of trading value, on-line trading was remarkably increased by over 8,500% from 1999 to 2000, which is the fastest growth rate among the securities markets in the world. As the end of December 2000, the trading value by on-line stock trading system accounted for 51.2% in the KSE market.

3.7 Concluding Remarks

In this chapter, the development of the Korean stock market and its particular characteristics have been examined in order to provide some background understanding of (i) changes in the trading system; (ii) relevant regulation system; (iii) the internationalisation and liberalisation programme in a historical context; and (iv) particular features, for instance, Stock Market Stabilisation Fund, price limits system, and introduction of derivative securities trading.

The period since the opening of the stock market in the mid 1950s up until the late 1970s can be characterised as one in which stock market emerged and played a minor role in the economy. In particular, the Korean stock market has grown rapidly in the 1980s and 1990s. Since the early 1980s, the Korean financial market has been through a process of gradual opening-up and liberalisation. Although internationalisation of the market began in the early 1980s, its qualitative development has started in the 1990s when stock market liberalisation accelerated allowing direct investment by foreign investors, and derivative securities trading and a cyber stock trading system were introduced. Since 1992, Korea has been one of the emerging stock markets that is relatively open and easily accessible to foreign investors. The sudden outset of the Korean financial market crisis, which was partially triggered by the Southeast Asian financial market crisis in the last quarter of 1997, led meltdown of the Korean stock market—but it recovered rapidly due to positive developments in the economy and liberalised investment status.

Table 3.1 Principal Securities Traded on Taehan Stock Exchange at the Outset

Stocks	Bonds
Taehan Stock Exchange financed stock	Gunkuk Government Bond Ma-Ho
Korea United Stock	Gunkuk Government Bond Ba-Ho
Chohung Bank	Gunkuk Government Bond Sa-Ho
Saving Bank	
Korea Commercial Bank	
Hungyop Bank	
Kyungsung Textile	
Kyungsung Electric	
Namsun Electric	
Chosun Transports	
Taehan Haeun Public Co.	
Taehan Chosun Public Co.	

Source: Korea Stock Exchange, *Stock Market in Korea*, 1991.

Table 3.2 Key Statistics of Listed Stocks on KSE

End of period	No. of listed co.	No. of listed issues	Market capitalisation (billion won)	Capital stock listed (billion won)	Trading volume (million shares)	Trading value (billion won)	GDP nominal (billion won)	*Market capitalisation / GDP nominal (%)
1971	50	62	108.7	141.4	50.5	34.4	3,423	3.2
1972	66	97	246.0	174.3	84.7	71.1	4,212	5.8
1973	104	200	426.2	251.6	130.1	160.6	5,421	7.9
1974	128	221	532.8	381.3	157.1	179.4	7,664	7.0
1975	189	356	916.1	643.4	310.5	333.9	10,296	8.9
1976	274	516	1,436.1	1,153.3	591.8	628.7	14,088	10.2
1977	323	540	2,350.8	1,492.4	1,271.5	1,375.3	18,063	13.0
1978	356	594	2,892.5	1,913.5	1,368.5	1,741.5	24,388	11.9
1979	355	495	2,609.4	2,202.3	1,560.6	1,372.8	31,393	8.3
1980	352	437	2,526.6	2,421.4	1,645.3	1,134.0	38,148	6.6
1981	343	451	2,959.1	2,410.2	3,074.6	2,534.2	47,657	6.2
1982	334	416	3,300.5	2,811.3	2,872.4	1,973.5	54,721	5.5
1983	328	422	3,489.7	3,238.9	2,750.7	1,752.6	64,197	5.4
1984	336	455	5,148.5	4,336.2	4,350.3	3,118.2	73,605	7.0
1985	342	414	6,570.4	4,665.4	5,563.8	6,320.6	82,062	8.0
1986	355	485	11,994.2	5,649.7	9,272.5	9,598.1	95,736	12.5
1987	389	603	26,172.1	7,591.4	5,943.0	20,493.9	112,130	23.3
1988	502	970	64,543.7	12,560.4	3,037.0	58,120.6	133,134	48.5
1989	626	1284	95,476.8	21,211.5	3,397.6	81,199.6	149,165	64.0
1990	669	1115	79,019.7	23,981.6	3,162.1	53,454.5	179,539	44.0
1991	686	1013	73,117.8	25,509.6	4,094.4	62,564.9	215,734	33.9
1992	688	1014	84,712.0	27,064.7	7,064.2	90,624.4	240,392	35.2
1993	693	1045	112,665.3	28,800.7	10,398.4	169,918.1	267,146	42.2
1994	699	1089	151,217.2	34,402.6	10,911.2	229,772.0	305,970	49.4
1995	721	1122	141,151.4	38,047.0	7,648.4	142,914.1	351,975	40.1
1996	760	1143	117,370.0	42,991.9	7,785.4	142,642.2	389,813	30.1
1997	776	958	70,988.9	45,153.7	12,125.3	162,281.5	420,987	16.9
1998	748	925	137,798.5	54,865.6	28,533.1	192,845.2	398,313	34.6

Sources: Korea Stock Exchange, *Stocks*, various issues; Bank of Korea, *Monthly Economic Statistics*, various issues.

Table 3.3 Investment Vehicles for Foreign Investors from 1981 to 1990

Beneficial certificates for foreign investors	Fund establishment date	Amount of money (US$ million)	Investment principle of the fund (Domestic investment only)	Issuing area
Korea International Trust (KIT)	Nov. 1981	25	Listed stocks on the KSE (Investment over 90% of the net asset value)	
Korea Trust (KT)	Nov. 1981	25	Listed stocks on the KSE (Investment over 90% of the net asset value)	
Korea Growth Trust (KGT)	Mar. 1985	30	Listed stocks on the KSE and bonds (Investment over 80% of the net asset value)	Europe, Asia, Australia
Seoul International Trust (SIT)	Apr. 1985	30	Listed stocks on the KSE and bonds (Investment over 80% of the net asset value)	Europe, US, Asia
Seoul Trust (ST)	Apr. 1985	30	Listed stocks on the KSE and bonds (Investment over 80% of the net asset value)	Europe, US, Asia
Korea Small Company Trust (KSCT)	Dec. 1985	6	Listed and unlisted stocks on the KSE (Investment over 60% of the net asset value)	UK , Japan
Korea Emerging Company Trust (KECT)	Mar. 1986	6.2	Listed and unlisted stocks on the KSE (Investment over 60% of the net asset value)	UK, Japan
Korea 1990 Trust (KNT)	Apr. 1990	50	(Investment over 90% of the net asset value)	US
Korea Equity Trust (KET)	May 1990	50	(Investment over 90% of the net asset value)	Asia, etc.
Daehan Korea Trust (DKT)	May 1990	50	(Investment over 90% of the net asset value)	Europe, etc.
Daehan Asia Trust (DAT)	Jun. 1990	100	Domestic stock investment: 70%, Overseas stock investment: 30% of the net asset value	Domestic: 40% Overseas: 60%
Seoul Asia Index Trust (SAIT)	Jun. 1990	100	Domestic stock investment: 60%, Overseas stock investment: 40% of the net asset value	Domestic: 40% Overseas: 60%
Korea Pacific Trust (KPT)	Jun. 1990	100	Domestic stock investment: 70%, Overseas stock investment: 30% of the net asset value	Domestic: 40% Overseas: 60%

Sources: Korea Stock Exchange, *Stock Market in Korea*, 1991; Dongseo Economic Institute, *Securities Investment*, 1995.

Figure 3.1 Historical Movement of the KOSPI from 1980 to 1998

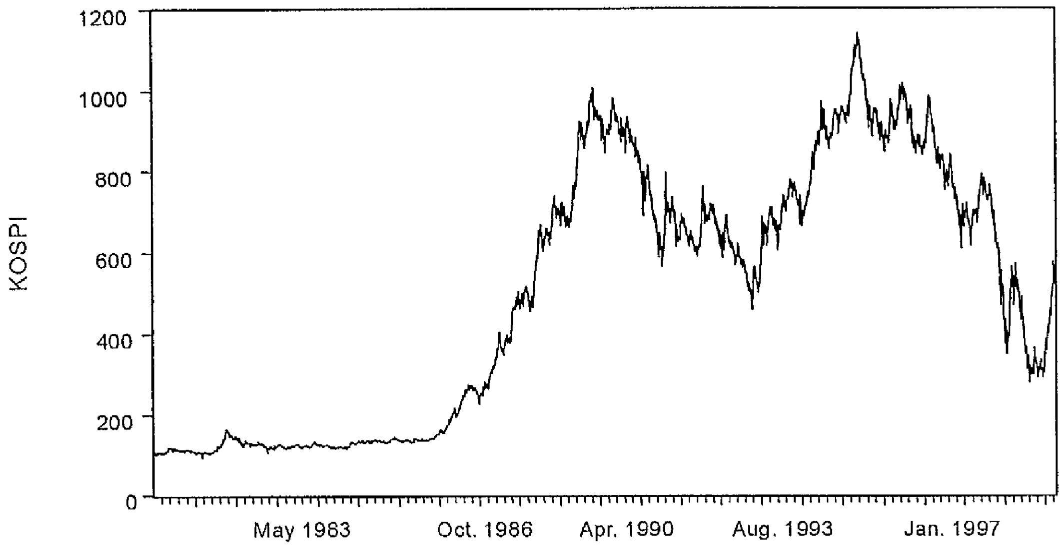


Table 3.4 Changes in Foreign Investors' Ownership Ceilings on KSE

	Starting date	Ceiling on the aggregate foreign ownership of a general company listed on the KSE	Ceiling on each foreign investor	Ceiling on the aggregate foreign ownership for a public utility* listed on the KSE	Ceiling on each foreign investor
Initial	3 Jan. 1992	10%	(3%)	8%	(1%)
1st expansion	1 Dec. 1994	12%	(3%)	8%	(1%)
2nd expansion	1 Jul. 1995	15%	(3%)	10%	(1%)
3rd expansion	1 Apr. 1996	18%	(4%)	12%	(1%)
4th expansion	1 Oct. 1996	20%	(5%)	15%	(1%)
5th expansion	2 May 1997	23%	(6%)	18%	(1%)
6th expansion	3 Nov. 1997	26%	(7%)	21%	(1%)
7th expansion	11 Dec. 1997	50%	(50%)	25%	(1%)
8th expansion	30 Dec. 1997	55%	(50%)	25%	(1%)
9th expansion	25 May 1998	100%	(100%)	30%	(3%)

Sources: *The Korea Economic Daily*, Seoul, various issues; *Dong-A Daily Newspaper*, Seoul, various issues.
Note: * Public utilities include POSCO (Pohang Iron & Steel Company) and KEPCO (Korea Electric Power Corporation).

Table 3.5 Flow of Stock Investment in Korea

End of period	Stock investment (US$ million)					
	Inflow (I)	Monthly average	Outflow (O)	Monthly average	Net flow (I – O)	Monthly average
1991	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
1992	2,716.1	(226)	681.5	(57)	2,034.6	(170)
1993	7,639.3	(636)	1,942.8	(162)	5,696.5	(475)
1994	8,559.8	(713)	6,599.5	(550)	1,960.3	(163)
1995	9,990.7	(833)	7,786.9	(649)	2,203.8	(184)
1996	12,422.4	(1,035)	8,049.4	(671)	4,373.0	(364)
1997	12,525.7	(1,044)	11,748.3	(979)	777.4	(65)
First half	7,009	(1,168)	4,835	(806)	2,174	(362)
Second half	5,517	(920)	6,9 13	(1,152)	-1,396	(-233)
1998	12,810.3	(1,075)	8,822.2	(729)	3,988.1	(347)

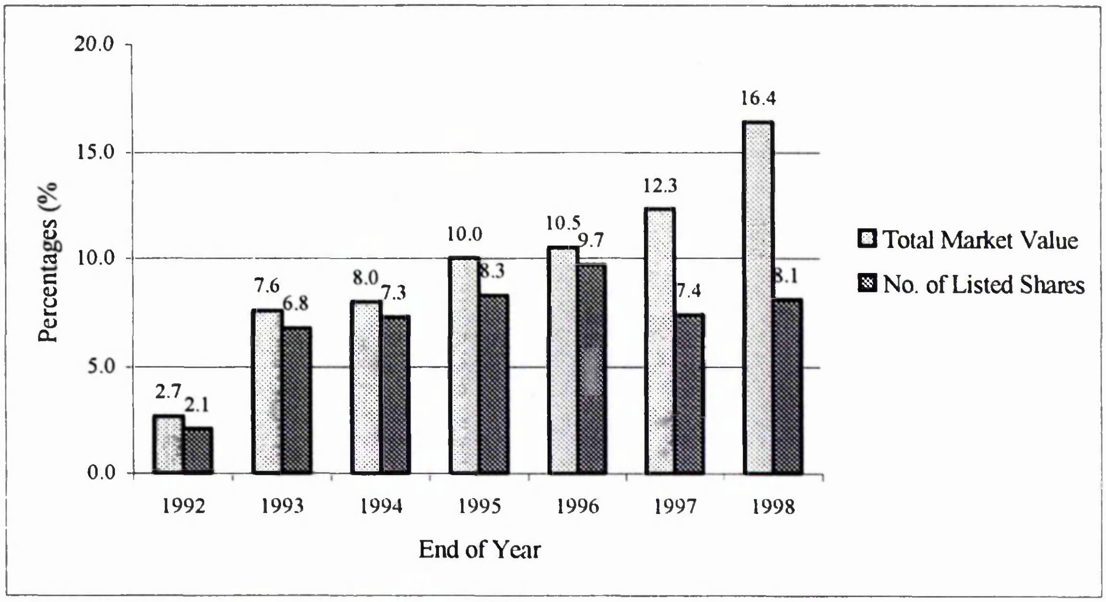
Source: The Bank of Korea, *Balance of Payments*, various issues.

Table 3.6 Stock Trading Value and Volume by Foreign Investors

End of year	Stock trading value (billion won)			Stock trading volume (million shares)		
	Purchases	Sales	Balance	Purchases	Sales	Balance
1992	2,385 (2.6%)	877 (1.0%)	1,508	129 (1.8%)	52 (0.7%)	77
1993	6,419 (3.8%)	2,089 (1.2%)	4,329	383 (3.7%)	126 (1.2%)	257
1994	6,101 (2.7%)	5,172 (2.3%)	929	335 (3.1%)	285 (2.6%)	50
1995	7,602 (5.3%)	6,284 (4.4%)	1,318	434 (5.7%)	371 (4.%9)	62
1996	10,123 (7.1%)	7,050 (4.9%)	3,074	537 (6.9%)	405 (5.2%)	132
1997	11,061 (6.8%)	10,637 (6.6%)	424	641 (5.3%)	864 (7.1%)	-222
1998	17,270 (9.0%)	11,546 (6.0%)	5,723	1,087 (3.8%)	990 (3.5%)	97

Source: Korea Stock Exchange, *Stock*, various issues.
Balance is calculated as Purchases – Sales.

Figure 3.2 Share Ownership by Foreign Investors



Source: Financial Supervisory Service (FSS).

Table 3.7 Foreign Investors Registered in Korean Stock Market by Nationality (Cumulative)

End of year	Number of investors									Total no. of nationalities
	US	UK	Japan	Taiwan	Canada	Malaysia	Ireland	Others	*Total*	
1992	502	314	110	266	24	8	14	334	*1,572*	37
1993	983	478	237	353	71	38	33	552	*2,745*	44
1994	1,228	565	293	400	111	55	76	699	*3,427*	49
1995	1,553	682	365	442	155	92	119	878	*4,286*	55
1996	1,939	719	451	492	197	183	155	1,158	*5,294*	61
1997	2,369	806	528	504	246	310	178	1,573	*6,514*	66
1998	3,225	859	677	514	308	360	251	2,286	*8,480*	66

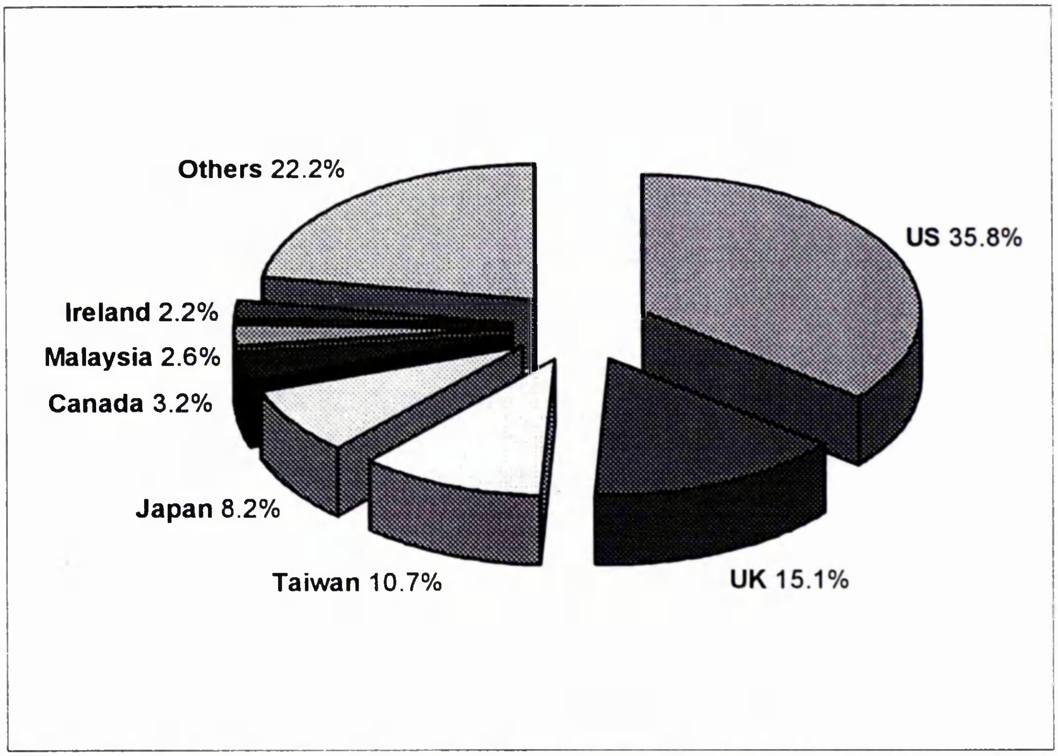
Source: Financial Supervisory Service (FSS) and Korea Stock Exchange.

Table 3.8 Investment Registration by Types of Foreign Investors

End of year	Number of Individual investors	Number of institutional investors							*Total*
		Investment companies	Funds	Securities companies	Banks	Insurance	Others	*Subtotal*	
1992	677	584	102	73	62	23	51	*895*	*1,572*
1993	1,092	1,080	240	88	101	48	96	*1,653*	*2,745*
1994	1,316	1,392	282	119	141	59	118	*2,111*	*3,427*
1995	1,520	1,895	351	138	165	76	141	*2,766*	*4,286*
1996	1,782	2,412	432	191	205	112	160	*3,512*	*5,294*
1997	1,995	3,198	476	250	243	144	208	*4,519*	*6,514*
1998	3,151	3,763	522	285	282	159	318	*5,329*	*8,480*

Source: Korea Stock Exchange.

Figure 3.3 Breakdown by Nationality of Foreign Investors



Source: Financial Supervisory Service (FSS) and Korea Stock Exchange.
Note: Reported figures are the averages, which are calculated over the period from 1992 to 1998.

Table 3.9 Foreign Investors' Share Ownership

End of year	Foreign shareholders		Shares held by foreign investors	
	Total number	(%)	Total number	(%)
1981	98	*(0.02)*	83,154,829	*(1.96)*
1982	87	*(0.01)*	96,891,208	*(2.04)*
1983	84	*(0.01)*	125,574,375	*(2.24)*
1984	106	*(0.01)*	163,581,612	*(2.20)*
1985	122	*(0.01)*	211,396,615	*(2.63)*
1986	154	*(0.01)*	288,747,732	*(3.01)*
1987	1,822	*(0.06)*	51,018,169	*(3.31)*
1988	3,444	*(0.04)*	67,525,104	*(2.69)*
1989	7,075	*(0.04)*	92,851,339	*(2.13)*
1990	607	*(0.03)*	81,897,483	*(1.69)*
1991	413	*(0.02)*	123,670,426	*(2.49)*
1992	1,572	*(0.05)*	220,633,805	*(4.13)*
1993	2,745	*(0.18)*	500,082,828	*(8.74)*
1994	3,427	*(0.20)*	634,857,767	*(9.11)*
1995	4,286	*(0.28)*	762,310,986	*(10.12)*
1996	5,294	*(0.36)*	989,201,238	*(11.58)*
1997	4,432	*(0.33)*	816,107,450	*(9.11)*
1998	8,320	*(0.43)*	1,181,311,142	*(10.39)*

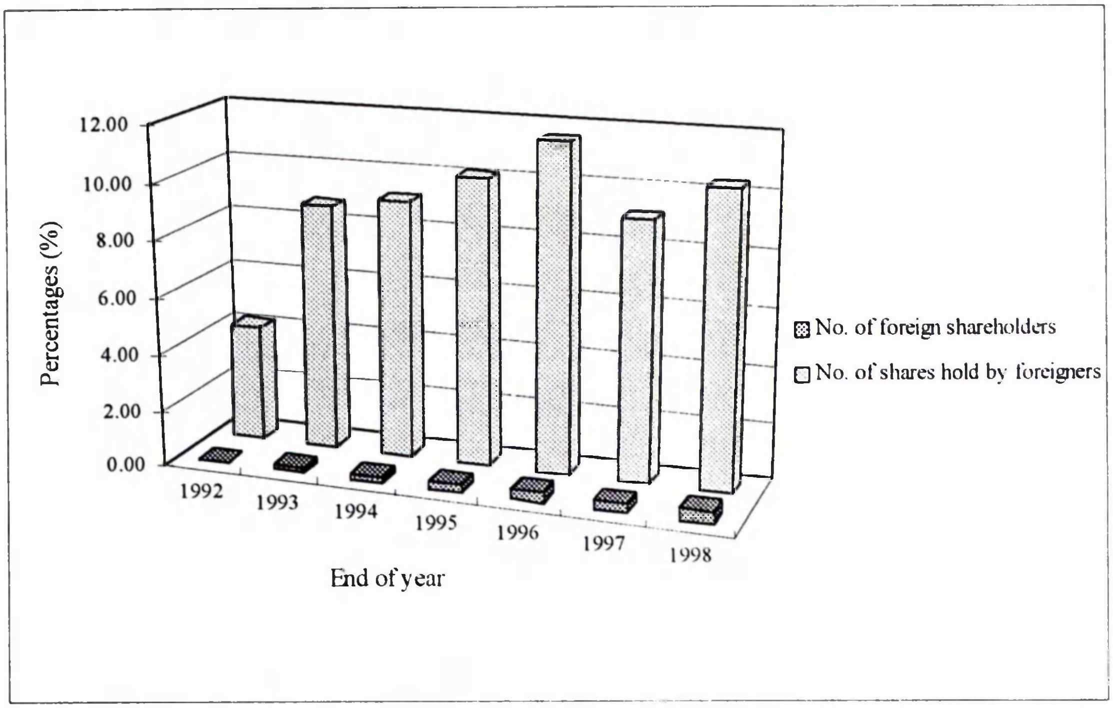
Source: Korea Stock Exchange.

Table 3.10 Breakdown of Share Ownership by Type of Investors

Type of investors	1990				1998			
	No. of shareholders	(%)	No. of shares (million shares)	(%)	No. of shareholders	(%)	No. of shares (million shares)	(%)
Government & public bodies	4	(0.00)	495	(10.25)	10	(0.00)	1,969	(17.32)
Banks	30	(0.00)	355	(7.34)	79	(0.00)	408	(3.58)
Securities companies	25	(0.00)	229	(4.74)	55	(0.00)	148	(1.30)
Investment trust companies	8	(0.00)	394	(8.15)	24	(0.00)	226	(1.99)
Insurance companies	48	(0.00)	265	(5.48)	42	(0.00)	411	(3.62)
Other financial companies	275	(0.01)	37	(0.76)	220	(0.01)	84	(0.74)
Other juridical persons	4,235	(0.18)	754	(15.06)	3,819	(0.20)	2,531	(22.26)
Individuals	2,413,097	(99.78)	2,223	(45.99)	1,902,779	(99.34)	4,410	(38.79)
Foreigners	607	(0.03)	82	(1.69)	8,320	(0.43)	1,181	(10.39)
Total	*2,418,329*	*(100)*	4,834	*(100)*	*1,915,348*	*(100)*	*11,368*	*(100)*

Source: Korea Stock Exchange.
Other financial companies include investment companies, finance companies, and mutual savings and finance companies.

Figure 3.4 Number of Foreign Shareholders and Shares Held by Foreign Investors



Source: Korea Stock Exchange

Table 3.11 Trading of KOSPI 200 Futures

End of year	Trading volume (contract)		Trading value (million won)	
	Total	Daily average	Total	Daily average
1996	715,624	3,670	30,698,920	157,384
1997	3,252,060	11,137	103,606,790	354,818
1998	17,893,592	61,279	405,903,406	1,390,080

Source: Korea Stock Exchange.

Table 3.12 Foreign Investment in KOSPI 200 Futures Market

End of year	Trading volume		Trading value	
	No. of contracts	(%)	million won	(%)
1996	43,152	(3.02)	1,765,032	(2.88)
1997	263,093	(4.05)	8,064,704	(3.89)
1998	812,388	(2.27)	18,008,767	(2.22)

Source: Korea Stock Exchange.

Appendix 3.1 Overview of the Historical Changes in the Korean Stock Market

03/Mar./1956	Taehan Stock Exchange (TSE) opened.
15/Jan./1962	Securities and Exchange Law enacted.
01/Apr./1962	TSE reorganised into a joint stock corporation.
03/May /1963	TSE renamed as Korea Stock Exchange (KSE).
08/May /1963	KSE reorganised into a government-run, non-profit organisation
22/Nov./1968	Law on Fostering the Capital Market enacted.
01/Feb./1969	Forward transactions replaced with regular-way transactions
03/Jan./1971	Margin trading started.
01/Jan./1972	Korea Composite Stock Price Index (KOSPI) published.
05/Jan./1973	Public Corporation Inducement Law enacted.
02/Nov./1973	Book-entry clearing system introduced.
08/Aug./1974	Korea Investment Trust Co. established.
06/Dec./1974	Korea Securities Settlement Co. (KKSC) established.
04/Jan./1975	Continuous trading system replaced call trading system.
19/Feb./1977	SEC and Securities Supervisory Board established.
20/Sep./1977	Korea Securities Computer incorporated.
02/Jul./1979	KSE moved to the present trading floor in Yoido.
24/Sep./1979	KSE joined the FIBV (International Federation of Stock Exchanges).
14/Jan./1981	Internationalisation plan of the capital market announced.
19/Nov./1981	International investment trusts(KIT and KT) launched,
04/Jan./1983	New KOSPI launched.(4/Jan/1980=100)
01/Feb./1983	Computerised order-routing system launched.
01/Mar./1988	KSE privatised and incorporated into a membership organisation.
03/Mar./1988	Stock Market Automated Trading System (SMATS) launched.
02/Dec./1988	Gradual internationalisation of the capital market announced.
04/May /1990	Stock Market Stabilisation Fund established.
15/Mar./1991	Foreign Securities, firms allowed to establish branched.
14/Jun./1991	KSE membership opened to foreign securities companies.
03/Jan./1992	Direct investment by foreign investors allowed.
12/Aug./1993	Real-Name Financial Transaction System introduced.
15/Jun./1994	KOSPI200 published.
01/Jul./1994	Bond market opened to foreign investors.
〃	Domestic individual investors allowed to invest in foreign securities.
14/Oct./1994	POSCO listed its stocks on the NYSE.
27/Oct./1994	KEPCO listed its stocks on the NYSE.
01/Dec./1994	Foreign investment ceiling extended from 10% to 12%.
22/Dec./1994	KSE changed trading hours to 09:30-11:30, 13:00-15:00.
04/Jan./1995	Comprehensive Surveillance and information System launched.
27/Feb./1995	Jardine Fleming became the first foreign member of the KSE.
01/Mar./1995	Daily price limits extended from an average ±4.6% to a flat ±6%.
03/Apr./1995	KSE operated mock trading of KOSPI futures.

01/Jul./1995	Foreign investment ceiling extended from 12% to 15%.
12/Aug./1995	Mutual entry of securities companies and investment trust companies permitted.
02/Oct./1995	Transactions of the small-lot public bonds centralised on the KSE.
11/Oct./1995	Plans to allow foreign companies to issue stocks in Korea announced.
01/Apr./1996	Foreign investment ceiling extended from 15% to 18%.
03/May /1996	Stock Index Futures Market opened.
01/Oct./1996	Foreign investment ceiling extended from 18% to 20%.
11/Oct./1996	Korea's admission into the OECD.
25/Nov./1996	Daily price limits extended from a flat ±6% to a flat ±8%.
01/Apr./1997	Home trading introduced.
07/Jul./1997	Stock index options market opened.
30/Aug./1997	Trading system fully computerised.
21/Nov./1997	IMF bailout fund requested.
31/Dec./1997	Foreigners' investment ceiling in the stock market raised to 55%.
25/May /1998	Foreigners' investment ceiling completely eliminated.
07/Dec./1998	KSE started to close its market on Saturdays and trading hours changed.
"	Circuit Breakers system introduced in the stock market.
"	Daily price limits expanded from ±12% to ±15% and for futures market from 7% to 10%.

Sources: Korea Stock Exchange, *Stock Market in Korea*, 1991; Korea Stock Exchange, *Korean Stock Market*, 1996; *The Korea Economic Daily*, Seoul, various issues; *Maeil Business Newspaper*, Seoul, various issues; *Joong-Ang Daily Newspaper*, Seoul, various issues.

4 Time Varying Stock Returns

4.1 Introduction

Over the last two decades, the presence of heteroscedasticity in financial time series has been widely researched. Since the early research of Mandelbrot (1963) and Fama (1965) there had been numerous studies on the characteristics of stock returns.[7] However, these early studies tended to focus on the first moment of returns of financial time series. The introduction of techniques for modelling the second moment is a more-recent event.

The general regularities of stock returns, which have been found by many researchers, are typically characterised as follows. First, the distributions of asset returns tend to be fat tailed and peaked, i.e., leptokurtic. There is evidence that the empirical distributions of changes in stock prices and indices yield a higher frequency of observations near the mean and fatter tails than that would be expected for a normal distribution (see Fama, 1965; Westerfield, 1977; and Kon, 1984). Secondly, there have also been investigations about volatility clustering. As noted by Mandelbrot (1963), "large changes tend to be followed by large changes - of either sign - and small changes tend to be followed by small changes."[8] Thirdly, the so-

[7] Mandelbrot (1963) and Fama (1965) showed departures from normality in the distributions of returns: the tendency of extreme tails as well as higher frequency distributions of the central bells than those of a normal distribution.
[8] See also Fama (1965).

called " leverage effect" first noted by Black (1976) refers to the tendency for stock prices to be negatively correlated with changes in stock volatility. Black (1976) and Christie (1982) suggested that a decline in stock prices (in relation to bond prices) increases leverage, increases the expected return on the stock in the future, and increases the variance of the stock return in the current period. A firm with debt and equity outstanding is typically more-highly leveraged when the value of the firm falls. This raises the equity return volatility. Finally, variance of stock returns for a certain period will be different if there exists non-trading periods. For instance, this has been captured by the day-of-the week or weekend effects in empirical work (see French and Roll, 1986).

In this context, a family of autoregressive conditional heteroscedasticity (ARCH) models seems to be extremely useful in modelling financial time series. Conditional volatility models have the important implication for finance that investors can predict risk. These models successfully characterise the fact that stock prices tend to go through long periods of high volatility and long periods of low volatility. In reality, it does matter when an investor has forecasted invested asset prices to be very volatile since the investor should either exit the market or require a larger premium as compensation for bearing an unusually high degree of risk. Consequently, market participants' volatility predictions have important implications.

In fact, much of the literature on stock market volatility has focused on developed markets. There has been relatively little literature examining the volatility of the Korean stock market. Lee and Ohk (1991) examined the conditional heteroscedasticity of stock returns and their predicted volatility in six countries including Korea, Taiwan, Hong Kong, Japan and the US and find that there are strong ARCH effects in all six countries. The results showed that participants in their stock markets are compensated with higher returns for bearing higher levels of risk. Corhay and Rad (1993) examine the stock price behaviour of seven Pacific-Basin countries; Australia, Hong Kong, Japan, New Zealand, Singapore, Thailand and Korea. The empirical results suggest that the behaviour of daily stock returns of these countries exhibits heteroscedasticity. Among various models, integrated generalised ARCH (IGARCH) fits the data best for Hong Kong and Thailand and generalised ARCH (GARCH) for rest of the countries. Huang, Liu and Yang (1995) investigated the weekend effects of stock markets in the US, the UK and six Pacific Basin countries: Korea, Taiwan, Indonesia, Malaysia, the Philippines, and Taiwan. The results show that the returns of these stock markets are not normally distributed and suffer from serial correlation and heteroscedasticity problems. However, with an ARCH-related model, these problems are much reduced. Poon and Taylor (1992) examined the relationship between the stock returns and market volatility in the UK stock market. Two types of volatility measures, and an ARIMA model are used. Expected returns are shown to have had a positive, though not statistically significant, relationship with expected volatility. The unexpected components of the returns and volatility series have a negative relationship but only when volatility expectations are represented by standard deviations.

The purpose of this chapter is to examine the empirical distribution of Korean stock returns of Korea and to find the best-fit model among a family of ARCH-type models. This is the first study to apply various ARCH-type models to the Korean stock market. Since very few studies have compared these methods empirically it is of interest to apply each of the various techniques to our data, with the aim of investigating the different implications each might have for the predictability of volatility. Investigating the volatility of the Korean stock market is particularly interesting for several reasons. First, the Korean stock market represents a typical emerging market. Although it is relatively small compared to major markets the market itself has been growing fast in terms of market capitalisation, trading volume and listed companies on the stock exchange since the mid 1980s. Secondly, the Korean stock market used to be one of the most restricted and controlled markets among emerging markets until liberalisation of the market took place in January 1992. Subsequently, it could be conjectured how the market liberalisation has affected the behaviour of the Korean stock market volatility by examining two subperiods, the pre-opening and the post-opening periods. Although some studies analysed before the stock market liberalisation, for example, Ng, Chang and Chou (1991), and Kim and Rogers (1995), there exists no study investigated the impact of the stock market opening-up in 1992 on the stock market volatility in Korea. Therefore, one could expect this to have had some implication for volatility estimates in recent years.

The remainder of this chapter is organised as follows. Section 4.2 introduces the family of ARCH and GARCH models and shows how these models are derived. Section 4.3 describes data sources and presents the sample properties of those data. In section 4.4 the results are presented. In section 4.5 and 4.6 the methodology for discriminating between alternative ARCH models and forecasting ability is discussed, and the interpretations of obtained results are offered. Section 4.7 provides a brief conclusion.

4.2 Various Autoregressive Conditional Heteroscedasticity Models

4.2.1 Linear ARCH /GARCH

The pioneer ARCH model by Engle (1982) and the generalised ARCH (GARCH) process in Bollerslev (1986) are particularly important because they can capture the temporal dependence of stock returns. Engle (1982) shows that it is possible to derive a model, which simultaneously has the mean and variance of a series. Bollerslev (1986) develops a technique that allows the conditional variance to be an ARMA process. These processes allow for volatility clustering, which has long been recognised as an important feature of the behaviour of stock returns.

In the linear ARCH(q) model, the time varying conditional variance is postulated to be a linear function of the past q squared innovations. It can be interpreted as the conditional variance of the error term is serially correlated with the past squared values of the error term in the ARCH model

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 = \omega + \alpha(L)\varepsilon_t^2 \tag{4.1}$$

where L is the lag operator. A sufficient condition for the conditional variance to be positive is that the parameters of the model satisfy the following constraints; $\omega > 0$ and $\alpha_1 > 0$, $\alpha_2 > 0$, $\cdots$ $\alpha_q > 0$.

Defining $\upsilon_t \equiv \varepsilon_t^2 - \sigma_t^2$ then the ARCH(q) process can be re-written as

$$\varepsilon_t^2 \equiv \omega + \alpha(L)\varepsilon_{t-1}^2 + \upsilon_t \tag{4.2}$$

(Notice that $\sigma_t^2 = E(\varepsilon_t^2 | \varepsilon_{t-1}^2, \varepsilon_{t-2}^2, \cdots))$

since $E_{t-1}(\upsilon_t) = 0$, the model corresponds to an AR(q) model for the squared innovations, ε_t^2. The process is covariance stationary, if and only if, the sum of the positive autoregressive parameters is less than one, in which case the unconditional variance equals

$$Var(\varepsilon_t) = \omega / (1 - \alpha_1 - \alpha_2 - \cdots - \alpha_q) \tag{4.3}$$

Although the disturbance terms, ε_ts are serially uncorrelated they are clearly not independent through time. In accordance with the stylised facts for asset returns discussed above, there is a tendency for large (small) absolute values of unpredictable sign.

Building on the basic ARCH model, Bollerslev (1986) subsequently introduces a new, more-general class of process, the generalised GARCH (GARCH) model. This model is more flexible in its lag structure and allows the conditional variance function to include past conditional variances as well as past squared disturbances. One of the main advantages of the GARCH process is that it allows a more parsimonious description in most time series, for which an accurate statistical fit could be obtained without having to estimate a large number of parameters. The conditional variance equation of GARCH(p,q) model can be written as:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 = \omega + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_t^2 \tag{4.4}$$

where $p \geq 0$, $q > 0$, $\omega > 0$, $\alpha_i \geq 0$, $\beta_i \geq 0$, and L is the lag operator.

A sufficient condition for the conditional variance in the GARCH(p,q) model to be well-defined is that all the coefficients in the infinite order linear AR representation must be nonnegative, where it is assumed that $\alpha(L)$ and $\beta(L)$ have no common roots and that the roots of the polynomial in L, $(1 - \beta(L)) = 0$ lie outside unit circle. This positive constraint is satisfied, if and only if, the coefficients of the infinite power series expansion for $\alpha(L) / (1 - \beta(L))$ are nonnegative.

$$\varepsilon_t^2 = \omega + (\alpha(L) + \beta(L))\varepsilon_{t-1}^2 - \beta(L)\upsilon_{t-1} + \upsilon_t \tag{4.5}$$

which defines as ARMA(max(p,q),p) model for ε_t^2. By standard arguments, the model is covariance stationary, if and only if, all the roots of $(1 - \alpha(L) - \beta(L))$ lie outside the unit circle.

The GARCH model implies that the variance today depends upon three factors: a constant, yesterday's news about volatility, which is taken to be the squared residual from yesterday (the ARCH term) and yesterday's forecast variance (the GARCH term). This specification makes sense in financial settings where an agent or investor predicts today's variance by forming a weighted average of a long-term average of constant variance, the forecast from yesterday, and what was learned yesterday. If the asset return was large in either the upward or the downward direction, then the trader will increase the estimate of the variance for the next day.

4.2.2 Asymmetric GARCH

Following the introduction of the ARCH and GARCH models, there have been numerous variations, refinements and applications of this approach to modelling conditional volatility. Even if GARCH models successfully capture thick tailed returns and volatility clustering, they tend not to capture the 'leverage effect' since the conditional variance is only linked to past conditional variances and squared innovations, and hence the sign of returns plays no role in affecting volatility. Nelson (1991) tests this leverage effect using exponential ARCH (EGARCH) with lagged standardised returns included in the conditional variance equation. The results show a significant leverage effect in the US for the period from 1962 to 1987. The EGARCH(p,q) is defined as

$$\ln\sigma_t^2 = \omega + \sum_{i=1}^{p}\beta_i \ln\sigma_{t-i}^2 + \sum_{i=1}^{q}\alpha_i[\varphi(\varepsilon_{t-i}/\sigma_t^{1/2}) + \gamma(|\varepsilon_{t-i}/\sigma_t^{1/2}|) - (2/\pi)^{1/2}] \qquad (4.6)$$

The advantage in using an exponential form for the conditional variance function $ln\sigma_t^2$ is that the variance will be positive for all possible choices of the parameters ω, β_i, γ and φ so that no restrictions need to be placed on these coefficients except $|\beta_i| < 1$ in order to guarantee that the process is stationary. In other words, by modelling the logarithm of the variance it is not necessary to restrict parameter values to avoid negative variance as in the ARCH and GARCH models. Because of the use of both $|\varepsilon_{t-i} / \sigma_{t-i}|$ and $(\varepsilon_{t-i} / \sigma_{t-i})$, σ_t^2 will also be non-symmetric in ε_{t-i}. And for negative δ, σ_t^2 will exhibit higher volatility for large negative ε_{t-i}.

For other asymmetric GARCH specifications, Glosten, Jaganathan, and Runkle (1993) also capture the leverage effect with the threshold GARCH (TARCH) model. The conditional variance function is

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 (1 + \gamma d_{t-i}) + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \tag{4.7}$$

where d_{t-i} is a dummy variable, which takes a value of 1 when $\varepsilon_{t-i} < 0$ and value of 0 when $\varepsilon_{t-i} \geq 0$.

Good news has an impact of α_i while bad news has an impact of $\alpha_i + \alpha_i\gamma$. If $\alpha_i\gamma$ is significantly different from zero, then the leverage effect exists. When $\alpha_i\gamma > 0$, negative shocks will have a larger impact on σ_t^2 than positive shocks. For instance, the variance equation for TARCH(1,1) model is

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \lambda \varepsilon_{t-1}^2 d_{t-1} \tag{4.8}$$

4.2.3 ARCH-in-Mean

Many theories in finance assume some kind of relationship between the mean of a return and its variance. One way to take this into account is to explicitly write the returns as a function of the conditional variance or, in other words, to include the conditional variance as another regressor. ARCH in mean or GARCH in mean models are included in this category.

The ARCH in mean (ARCH-M) model introduced by Engle, Lilien and

Robins (1987) extend the ARCH model to allow the conditional variance to affect the mean. In this way changing conditional variances directly affect the expected return on a portfolio. Most of the time this conditional variance term will have the interpretation of a time-varying risk premium. For instance, a simple version of the ARCH-M model can be written as

$$y_t = \psi\sigma_t^2 + \varepsilon_t \quad (4.9)$$

where $\varepsilon_t = v_t\sigma_t$, $v_t \sim N(0,1)$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_1 \varepsilon_{t-i}^2 . \quad (4.10)$$

The estimation of GARCH-in-mean type of models is numerically unstable[9] and many applications have used ARCH-M type models, which are easier to estimate. Bollerslev, Chou and Kroner (1992) argue that many theories in finance involve an explicit trade-off between the risk and the expected return. The ARCH-M model is ideally suited to handling such questions in a time series context where the conditional variance may be time-varying.

4.2.4 Integrated GARCH

Engle and Bollerslev (1986) extend GARCH to the class of integrated GARCH (IGARCH) models that have the restriction $\sum \alpha_i + \sum \beta_i = 1$. The basic GARCH model has been extended to allow the conditional variance to have a unit root. If this sum equals one, the IGARCH is said to be exhibited, implying that shocks to the conditional variance persist over future horizons. However, Sharma, Mougoue and

[9] For instance, Chyi (1997) investigated daily returns of five stocks on the Taiwan Stock Exchange by adopting a GARCH-M model for the period of 1976-1993. The results showed that the GARCH-M process cannot precisely model the distribution of daily returns even though the model does remove some of the serial dependence and reduce the observed leptokurtosis fairly for certain cases.

Kamath (1996) argued that with IGARCH class of models, second and fourth unconditional moments are non-existent even though the conditional distributions are well defined.

4.3 Data and Methodology

4.3.1 The Data and Their Properties

The basic sample consists of daily closing price data for the KOSPI over the period starting on 1 January 1980 and ending on 17 June 1997 (4,556 observations). A further 30 observations to 17 July 1997 are used for examining the forecasting ability of the ARCH class models. The sources are *Datastream*[10] and *Korea Stock Exchange Data Base*.[11] Unlike all previous studies of the Korean stock market data for Saturday trading is included to avoid omitting observations. The path of the daily stock returns over this period is plotted as Figure 4.1. The daily stock returns, R_t is calculated as the first differences of the logs of the stock prices

$$R_t = \ln\left(\frac{KOSPI_t}{KOSPI_{t-1}}\right).$$

Descriptive statistics for the daily returns are reported in Figure 4.2. The results confirm the well-known fact that daily stock returns are not normally distributed, but are leptokurtic and skewed to the left. Although Figure 4.2 confirms that the distribution is highly peaked, the distribution of returns does not seem to be thick tailed. One possible explanation can be that there have been daily price limits

[10] *Datastream* provides data only from Monday to Friday uniformly.
[11] Until the end of 1997 Korea Stock Exchange operated on Saturday from 9:30 a.m. to 12:30 p.m..

over the sample period.[12] Due to price limits system, some extreme movement of stock prices is censored thus not recorded with their true variations. Consequently, the generated returns are not possibly capture highly volatile values hence the lower volatility. Under the null hypothesis that the residuals are normally distributed, the result of the Jarque-Bera test confirms rejection of the normality assumption since the probability value of the computed χ^2-statistic is sufficiently low, i.e., zero.

4.3.2 Testing for ARCH Presence

Before estimating a GARCH process, it is important to examine whether there exist ARCH effects in the residuals of estimating models. Subsequently we should not estimate the conditional volatility of series in means of GARCH when there are no signs of ARCH effects.

Since the variance of a time series depends on past squared residuals of the process in an ARCH process, the appropriateness of an ARCH model can be tested by means of a Lagrange Multiplier (LM) test suggested by Engle (1982). The methodology involves the following two steps:

Under the null hypothesis it is assumed the model is estimated by an appropriate AR(p) model

$$y_t = \phi_0 + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t \qquad (4.11)$$

where ε_t is a Gaussian white noise process, $\varepsilon_t | I_{t-1} \sim N(0, \sigma^2)$ where I_t is the information set.

[12] Before April 1995, price limits were expressed as *absolute* changes for specified ranges of base prices. The price limits have been expressed as a *fixed* percentage rate from the beginning of April 1995. Under this system, for a given period, the price limits are the same percentage change of the base price, whatever that base price. Initially, the daily limits were price changes of ±6%, these were relaxed to ±8% from 25 November 1996 and again to ±12% from 2 March 1998. See section 7.3 of Chapter 7 for further details.

The test for an ARCH(q) effect simply consists on regressing

$$\hat{\varepsilon}_t^2 = \alpha_o + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \alpha_2 \hat{\varepsilon}_{t-2}^2 + \cdots + \alpha_q \hat{\varepsilon}_{t-q}^2 + u_t \; . \tag{4.12}$$

Under the null hypothesis of no ARCH process, that is, $\alpha_1 = \alpha_2 = \cdots = \alpha_q = 0$, the test statistic TR^2 where T is the number of observation and R^2 is obtained from (4.12) is asymptotically distributed χ_q^2. With a sample of T residuals, under the null hypothesis of no ARCH errors, the test statistic TR^2 converges to a χ_q^2 distribution.

The LM test has been applied to our data up to AR(5). The values, which are based on the regression of squared residuals on lagged up to 10 and squared residuals for the TR^2 and F-statistics are reported in Table 4.1. The F-statistic tests the hypothesis that the coefficients of the lagged squared residuals are all zeros, that is, no ARCH. The results show that the TR^2 and the F-statistics are all statistically significant at the 1% level for the pre-opening, the post-opening and the whole period. This indicates that there exist ARCH effects in the period of 1980-1997. Therefore, use of ARCH class models might be appropriate to describe our data.

4.3.3 Structural Breaks and ARCH Effects

Diebold (1986) shows that breaks in the variance might appear as ARCH effects when the whole sample is used. In other words, for a subperiod, it could be the case that the unconditional variance changes from σ_1^2 to σ_2^2 and then back to the previous level. In this case modelling the conditional variance as an ARCH model would be inappropriate. Consequently, it is recommended to divide the sample and test for ARCH effects for the subperiods. If no ARCH effects are found for any of the subperiods but are found for the whole sample period then that is a clear indication of a break in the unconditional variance and not of ARCH effects. Table 4.1 confirms that there is no structural break in the volatility since the ARCH effects are found not only in the two subperiods, the pre-opening and the post-opening but also in the whole period.

4.3.4 Determining the Order of GARCH Models

Some prior studies such as Chou (1988) and Baillie and DeGennaro (1990) have shown that GARCH(1,1) class models are the most appropriate types for daily stock return data. Poon and Taylor (1992) also argue that GARCH(p,q) models with $p + q \geq 3$ are very unstable and very much influenced by the starting values. The benefit of including additional parameters beyond $p + q = 2$ is very small. It is claimed that, in most cases, increase in the log-likelihood value is less than one. Consequently, our focus is drawn on $p + q \leq 2$ order formulations for GARCH class models.

4.4 Empirical Results

In this section, results of estimating various ARCH class models are presented in order to give an idea of the possible usefulness of the models for the behaviour of Korean stock market volatility. Table 4.2 reports the results of ARCH class model estimations of the KOSPI daily returns for the entire sample period. The value of maximum log likelihood (LL), the values of Akaike information criterion (AIC) and Schwarz criterion (SC) are also presented in order to compare models and to choose an appropriate model for the Korean stock market for the sample period. A post-opening dummy variable, d is created taking value of 1 in the post-opening subperiod afterwards 1992 and 0 elsewhere. The dummy variable is included in both the mean and the variance equations to examine the possibility of a structural break in the volatility which might be caused by the Korean stock market opening up in January 1992. The estimated GARCH(1,1) model with the dummy variable is

$$R_t = \alpha_0 + d_0 POD + \varepsilon_t \quad (4.13)$$

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + d_1 POD \quad (4.14)$$

where R_t is the KOSPI return, σ_t^2 is the conditional variance and POD is the post-opening dummy variable.

An interesting finding is that all the parameters of the variance equations, regardless classes of the models, are statistically significant at the 5% level. However, some coefficients of the mean equations for several models are not statistically significant at the 5% level: the POD dummy variable of the ARCH(1)-dummy, the constant of the GARCH(1,1), the constant of the GARCH(1,1) -MA(1), and the constant and the POD dummy of the TARCH(1,1)-dummy model. Another interesting finding is that the mean equations of all the simple models such as ARCH(1), GARCH(1,1), EGARCH(1,1) and TARCH(1,1), each of which includes the post-opening dummy (POD) variable as a regressor, are not significantly different from zero. Although the dummy variable, which is included in the variance equations of these models, is statistically significant at the 5% level this seems to be fairly small and nearly zero. This implies that the opening stock market, i.e. the liberalisation of the Korean stock market has caused no structure change in market volatility.

For the EGARCH class models, the signs of all the coefficients on $\varepsilon_{t-1}/\sigma_{t-1}$ term (δ) are negative, confirming the leverage effect. Subsequently, it suggests that σ_t^2 exhibits higher volatility for large negative ε_t. Whereas the TARCH class models, have significant coefficients (d_1) for the $\varepsilon_{t-1}^2 d_{t-1}$ terms. Since d_1 is significantly different from zero it also confirms the existence of the leverage effect.

Aside, in order to test the IGARCH(1,1) model, the value of $\alpha_1 + \beta_1$ among the GARCH class of models is calculated. They are in the range of 0.1298 to 0.9804. This shows that the IGARCH(1,1) model, where should be $\alpha_1 + \beta_1 = 1$, does not fit our data set for the period 1980 to 1997 and confirms no persistence in volatility. Our results are similar to that in Corhay and Rad (1993) which the value of $\alpha_1 + \beta_1$ is 0.9195 for the Korean stock market daily returns in Korean stock market for the period 1980 to 1990.

There are a number of approaches, which can be used to compare fitted models in Table 4.2. One of these approaches is to compare the maximised values of the log likelihood functions (LL). Another approach is to compare the Akaike information criterion (AIC) or the Schwarz criterion (SC), which is an alternative method of the AIC. In terms of the LL, the GARCH(1,1)-AR(1)-M turns out to be the best-fit model. In contrast to this, in terms of the AIC, the ARCH(1)-AR(1)-M shows the lowest AIC value that implies the best-fit model. By the way, the value of SC, which is similar to the AIC, confirms that the best-fit model is the ARCH(1)-AR(1)-M. In general, the GARCH type models show higher values of the log likelihood functions than the ARCH or the EGARCH class models.

4.5 Discriminating Between Alternative GARCH Models

Although it is possible to compare the estimated ARCH models using the criteria reported in Table 4.2, it is not straight forward to determine the best fit model for our data because the differences in the values of these criteria are negligibly small. Therefore, it is necessary to use a method for comparing the estimated ARCH models. There are several ways of discriminating between alternative GARCH class models. One of the ways is suggested by Pagan and Schwert (1990). They use an auxiliary regression as a mean of choosing between different GARCH models

$$\hat{\varepsilon}_t^2 = \alpha + \beta \hat{\sigma}_t^2 + \xi_t . \tag{4.15}$$

Equation (4.15) regresses the squared residuals on the fitted variance of the alternative GARCH models. If the chosen GARCH model is appropriate to explain the conditional volatility of the series under scrutiny, it should be expected that $\alpha = 0$, $\beta = 1$ and the fit (R^2) is good. The joint null hypothesis, $\alpha = 0$ and $\beta = 1$ is tested against the alternative hypothesis, $\alpha \neq 0$ and $\beta \neq 1$. The restrictions on these coefficients are tested by applying the Wald test.

As a second step, the models that are not rejected on the basis of goodness of fit will be compared. Similar to Pagan and Schwert (1990), equation (4.15) is regressed in logarithms in order to account for scale effects and then the goodness of fit of this alternative auxiliary regression is compared to the regression by the model in (4.15)

$$\ln \hat{\varepsilon}_t^2 = \alpha + \beta \ln \hat{\sigma}_t^2 + \xi_t . \tag{4.16}$$

The R^2 statistics for the model in (4.16) are motivated by the idea of a proportional loss function, rather than the quadratic loss function implied in (4.15). Mistakes in predicting small variances are given more weight in (4.16) than in (4.15).

Table 4.3 contains the results of comparison between alternative ARCH class models. We tested for all models in Table 4.2 by using the model in (4.15) and (4.16). However, we report some models among the presented models in Table 4.2. The first and the second columns present the coefficients of the model in (4.15). The fifth column, Q(10) is the heteroscedasticity-corrected Box-Pierce (1970) statistic for ten lags of the residual autocorrelations. Similarly, the sixth column, BG(10) is the serial correlation LM test statistic where uses the Breusch-Godfrey large sample test for autocorrelated disturbances for ten lags disturbances. The values of F-statistics are reported in this column. These two columns report tests of the null hypothesis of no autocorrelation tests against the alternative hypothesis of autocorrelation. The last column, lnR^2 is the R^2 statistics from the regression of the model in (4.16) where R^2 is the usual coefficient of determination. A good model is expected to have $\alpha = 0$, $\beta = 1$. In this context, we can eliminate models for which there is no * in the first column. Although the GARCH-AR, the GARCH-AR-M without a constant in the mean equation, the GARCH-AR-M, the GARCH-MA, the GARCH-MA-M without a constant in the mean equation, and the GARCH-MA-M model show statistically non-significant from zero coefficients for α they have all different βs. According to the model in (4.15), this coefficient should be unity for the best-fit model. It clearly shows that the GARCH-AR and the GARCH-MA model have good values of the β coefficient, 0.9554 and 0.9484, respectively than other models. In terms of autocorrelation, Models 12, 14, 15, 16, 17, and 18 show no signs of autocorrelations in their residuals. The Breusch-Godfrey serial correlation LM statistics, reported in the sixth column, also reveal that there is no autocorrelation. An interesting finding is that all the R^2 statistics for logs (lnR^2) are larger than the R^2's for the raw data.

It is useful to carry out the Wald coefficient test for the models * marketed in Table 4.3, which can be said as 'potentially good models.' The F-statistics are reported in Table 4.4. The joint null hypothesis of $\alpha = 0$, $\beta = 1$ is tested against the alternative hypothesis of $\alpha \neq 0$, $\beta \neq 1$. Since all the p-values exceed 0.01, the null hypothesis is accepted at the 1% critical value.

4.6 Forecasting Ability

Alternative way of comparing and discriminating the ARCH class models is to examine whether an estimated model adequately forecast the volatility. ARCH models allow us to forecast the conditional variance of a series, therefore a criteria which may enable us to choose different models is to choose that one that forecasts best. Akgiray (1989) argues the usefulness of forecasting the future volatility. First, good forecasts of volatility can be used to investigate any relationship between current prices and expected risk. Since risk is inherently related to volatility, expected future volatility is a major factor in the pricing of securities. Second, the predictive capabilities of ARCH and GARCH models constitute further evidence as to their relative merits as such. Notice that we calculate one-step ahead forecasts, i. e. we use the estimated models to forecast for t+1 while the models are forecasted for twenty-two year observations.

$$\text{Root Mean Square Error} = \sqrt{\left(\sum_{t=1}^{T} (\hat{\varepsilon}_t^2 - \hat{\sigma}_t^2)^2 / T\right)} \tag{4.17}$$

$$\text{Mean Absolute Error} = \sum_{t=1}^{T} |\hat{\varepsilon}_t^2 - \hat{\sigma}_t^2| / T \tag{4.18}$$

$$\text{Mean Absolute Percent Error} = \left(\sum_{t=1}^{T} |(\hat{\varepsilon}_t^2 - \hat{\sigma}_t^2) / \sigma_t^2| / T\right) \times 100 \tag{4.19}$$

Table 4.5 reports the forecasts of the conditional variance for the period of 1 January 1980 to 17 June 1997, where the model parameters were estimated using data from this period. The forecasts of the conditional variances on the Korean stock market daily returns are evaluated and compared through a number of statistics: root mean square error (RMSE), mean absolute error (MAE), and mean absolute percent error (MAPE). We only consider the six GARCH class models: GARCH(1,1)-AR(1), GARCH(1,1)-AR(1)-M (no constant), GARCH(1,1)-AR(1)-M, GARCH(1,1)-MA(1), GARCH(1,1)-MA(1)-M (no constant) and GARCH(1,1)-MA(1)-M. All the forecasts for these models appear to be reliable since the values of the RMSE and the MAE for these models are in the range of 0.008139 to 0.012130. It implies that a forecast is more accurate if the value of a parameter is smaller. In this context, the GARCH(1,1) - MA(1) model is the best forecasting performance model among the six models since this shows the smallest value of the RMSE, the MAE, and the second largest value of the MAPE. However, the differences between the RMSE and the MAE values of the GARCH(1,1)-MA(1) and those of the GARCH(1,1)-AR(1) are negligibly small (each of these are 0.000001). Moreover, the GARCH(1,1)-AR(1) shows larger MAPE value, which is desirable to be 100%, than the value of the GARCH(1,1)-MA(1). Since most of the forecasts are reasonably desirable i.e., the smallest MAPE is 98.35% of the GARCH-MA and the largest MAPE is 123.72% of the GARCH-AR-M it is useful to perform more forecasts in means of several subsample period models.

Table 4.6 contains forecasts of the conditional variance for three subsample periods i.e. pre-opening (1 Jan. 1986-31 Dec. 1991), post-opening (1 Jan. 1992-17 Jun. 1997), and post-sample (18 Jun. 1997-23 Jul. 1997), where the model parameters were estimated using three data sets for the periods of 1 Jan. 1980-31 Dec. 1985, 1 Jan. 1980-31 Dec. 1991, and 1 Jan. 1980-17 Jun. 1997, respectively. For the pre-opening period, although all the values of the RMSE, the MAE are reasonably small for a good forecasting model it does not seem to exist the best forecasting model among the six GARCH class models since there is no agreement on the best model. By the way, for the period of post-opening, the GARCH(1,1)-AR(1) obviously turns out to be the best model for forecasting. The RMSE and the MAE values of this model which are 0.005676 and 0.004186, respectively, are smaller than the values of the any other models. The MAPE value of this model, 101.6611 is also near to 100 which is desirable value for an accurate forecasting model. For the post-sample period, however, the GARCH(1,1)-MA(1) appears as the best forecasting model. The smallest RMSE (0.004783) and MAE value (0.003705) and the nearest MAPE value to 100(103.7624) among the six models confirm this fact.

In addition, the forecasts of variance for the three subsample periods are shown in Figure 4.3, Figure 4.4, and Figure 4.5. In Figure 4.3, for the pre-opening period, the variances for the GARCH(1,1)-AR(1) and the GARCH(1,1)-MA(1) appears to be falling sharply and then steady whereas those of the GARCH(1,1)-AR(1)-M (no constant), the GARCH(1,1)-AR(1)-M, the GARCH(1,1)-MA(1)-M (no constant) and the GARCH(1,1)-MA(1)-M appear to be rising sharply and then steady over the forecast horizon. However, all the variance shown in Figure 4.4 for the period of post-opening appear to be rising sharply and then steady over the forecast horizon. In Figure 4.5, all the variance forecasts for post-sample period seem to be monotonically rising. Since this period contains only 30 daily observations, we might observe a different pattern if forecasts covered a longer period or had other starting dates.

4.7 Conclusions

This chapter has examined the behaviour of Korean stock market volatility for the period from 1980 to 1997 using a set of models belonging to the class of ARCH/GARCH. The results of descriptive statistics confirm that the daily stock market returns are skewed to the left and leptokurtosis. Consequently, ARCH /GARCH class models are used to capture successfully these aspects of the abnormal distribution of our data. Prior to model estimation, we carry out a test for the ARCH effect presence. The results show that there are the ARCH effects in daily stock market returns of Korea. One interesting finding is that there is no structure change in volatility even after the stock market opening to foreign investors in 1992.

The results from using the EGARCH and the TARCH class models confirm the leverage effect whereas the IGARCH model does not fit our daily returns series. The estimated ARCH models are generally consistent with the behaviour of the stock market volatility. Overall, the class of GARCH models is found to be a better fit than the class of ARCH, EGARCH and TARCH models in terms of several criteria including the LL, the AIC and the SC. Among the GARCH class models GARCH(1,1)-AR(1) and GARCH(1,1)-MA(1) seem to be the best fit models. The test results to distinguish forecasting ability among the estimated models confirm that GARCH(1,1)-MA(1) is the most accurate forecasting model among the six different GARCH class models for the historical forecast for 1980-1997. However, since there exist negligibly small differences between these two models we also estimate forecasts for three subsample periods: pre-opening, the post-opening, and the post-sample. The results confirm that GARCH(1,1)-AR(1) and GARCH(1,1)-MA(1) are the best forecasting model for the post-opening and the post-sampling period, respectively.

Figure 4.1 Daily Returns of KOSPI, 1980-1997

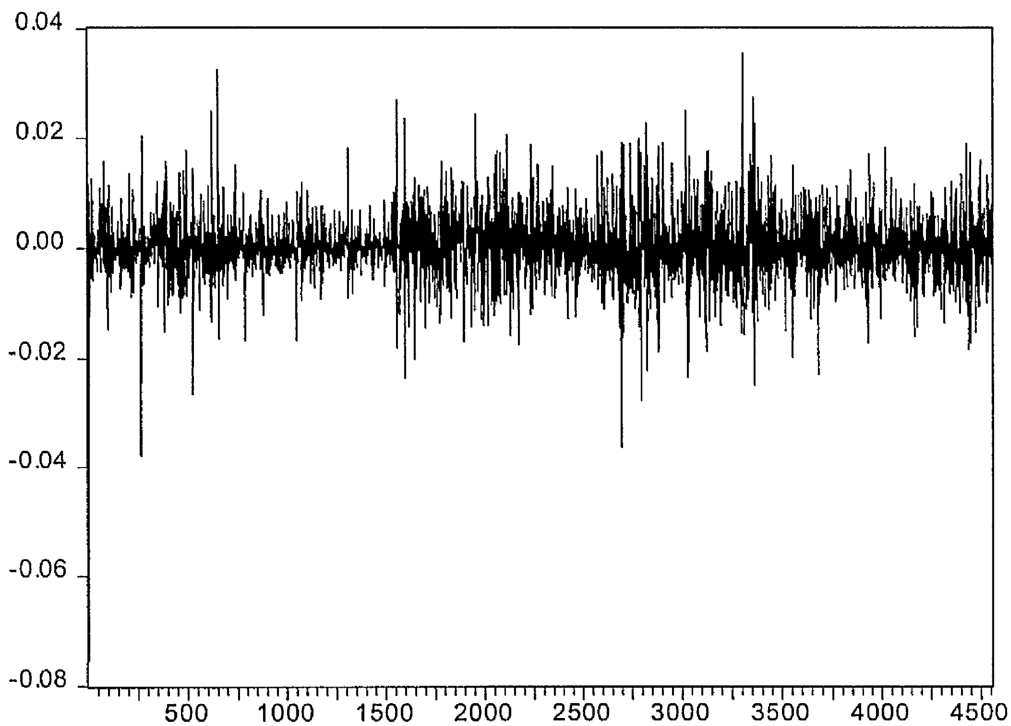
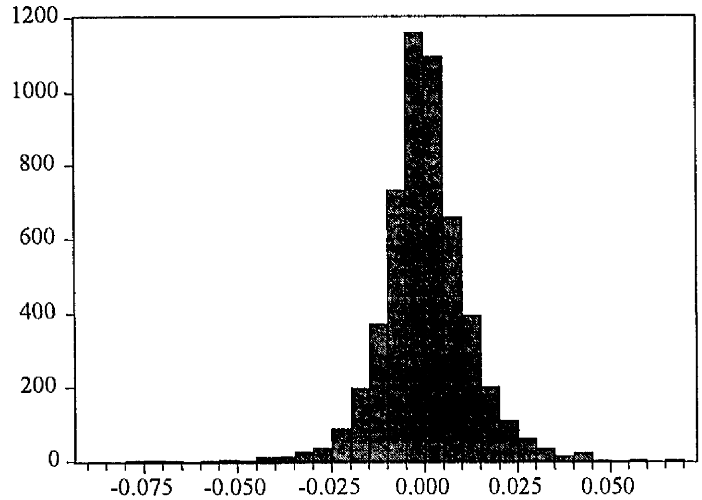


Figure 4.2 Descriptive Statistics of Daily Return Series



Mean	0.0003
Maximum	0.0697
Minimum	-0.0877
Std. Dev.	0.0122
Skewness	-0.0938
Kurtosis	7.6948
Jarque-Bera	4847.47
p - value	0.00

Table 4.1 Lagrange Multiplier Tests

	Pre-opening period (1980-1991)		Post-opening period (1992-1997)		Entire period (1980-1997)	
Lags	TR^2	F-statistic	TR^2	F-statistic	TR^2	F-statistic
ARCH(1)	341.56 (0.00)*	37.34 (0.00)*	753.94 (0.00)*	131.46 (0.00)*	1368.13 (0.00)*	184.53 (0.00)*
ARCH(2)	330.23 (0.00)*	36.35 (0.00)*	735.40 (0.00)*	125.89 (0.00)*	1335.99 (0.00)*	178.73 (0.00)*
ARCH(3)	330.19 (0.00)*	36.35 (0.00)*	744.70 (0.00)*	128.66 (0.00)*	1345.80 (0.00)*	180.51 (0.00)*
ARCH(4)	327.37 (0.00)*	36.01 (0.00)*	736.67 (0.00)*	126.27 (0.00)*	1341.07 (0.00)*	179.67 (0.00)*
ARCH(5)	326.96 (0.00)*	35.96 (0.00)*	757.11 (0.00)*	126.40 (0.00)*	1339.40 (0.00)*	179.38 (0.00)*

p-values are presented in parentheses.
* denotes significance at the 1% level.

Table 4.2 ARCH/GARCH Estimations of KOSPI Daily Returns for 1980-1997

	Mean equation				Variance equation								Criterion		
	α_0	ϕ	θ	ψ	d_0	ω	α_1	α_2	β_1	β_2	d_1	λ	LL	AIC	SC
1. ARCH(1)	0.0002 (1.41)					0.0001 (67.21)*	0.3180 (17.34)*						16039.1	-8.8065	-8.8028
2. ARCH(1) dummy	0.0003 (1.68)				-0.0003 (-1.19)	0.0001 (67.22)*	0.3166 (17.23)*				0.00004 (10.32)*		16039.6	-8.8068	-8.8018
3. ARCH(1) - M no constant				1.4547 (2.80)*		0.0001 (69.10)*	0.3147 (17.84)*						16037.9	-8.8069	-8.8032
4. ARCH(2)-M	-0.0006 (-4.20)*			6.2553 (8.00)*		0.00001 (46.69)*	0.2339 (14.13)*	0.3014 (17.91)*					16288.1	-8.8068	-8.8005
5. ARCH(1) -AR(1)	0.0003 (1.77)	0.1437 (16.35)*				0.00001 (67.80)*	0.3264 (17.97)*						16069.4	-8.8260	-8.8210
6. ARCH(1)-AR(1)-M	-0.0001 (-0.68)	0.1495 (16.22)*		3.3941 (6.31)*		0.00001 (63.62)*	0.3355 (17.41)*						16070.2	-8.8246	-8.8183
7. ARCH(1) -MA(1)	0.0003 (1.82)		0.1620 (18.83)*			0.0001 (68.64)*	0.3231 (18.08)*						16077.4	-8.8295	-8.8245
8. ARCH(1) -MA(1)-M	-0.0001 (-0.76)		0.1639 (18.84)*	3.5243 (6.36)*		0.0001 (64.59)*	0.3222 (17.58)*						16078.4	-8.8277	-8.8215
9. GARCH(1,1)	0.0002 (1.71)					0.00001 (17.80)*	0.2129 (17.66)*		0.7280 (57.13)*				16488.7	-8.8061	-8.8011
10. GARCH(1,1) dummy	0.0002 (1.92)				-0.0001 (-0.54)	0.00001 (17.67)*	0.2109 (17.77)*		0.7327 (58.49)*		3.5E-07 (2.43)*		16489.3	-8.8061	-8.7998
11. GARCH(1,1) -M no constant				2.7333 (2.80)*		0.00001 (19.05)*	0.2129 (18.04)*		0.7292 (59.62)*				16490.7	-8.8051	-8.8001
12. GARCH(1,2)-M	-0.0002 (-0.93)			3.8328 (2.36)*		0.00001 (14.38)*	0.1781 (13.99)*	0.0719 (4.23)*	0.6820 (37.60)*				16494.5	-8.8034	-8.7959

13. GARCH(2,1)-M	-0.0001 (-0.33)			3.3292 (2.04)*		0.00001 (16.74)*	0.2102 (16.40)*		0.6621 (10.27)*	0.0793 (1.42)			16488.5	-8.8032	-8.7957
14. GARCH(1,1)-AR(1)	0.0002 (1.95)	0.1041 (6.83)*				0.00001 (18.11)*	0.2073 (17.28)*		0.7326 (58.25)*				16509.2	-8.8242	-8.8180
15. GARCH(1,2)-AR(1)	0.0002 (2.01)*	0.1056 (7.20)*				0.00001 (14.88)*	0.1671 (13.28)*	0.0870 (4.95)*	0.6699 (35.48)*				16514.1	-8.8240	-8.8165
16. GARCH(2,1)-AR(1)	0.0003 (2.50)*	0.1039 (6.92)*				0.00001 (16.80)*	0.2059 (15.19)*		0.6841 (9.95)*	0.0565 (0.95)			16507.5	-8.8238	-8.8164
17. GARCH(1,1) - AR(1) -M	-0.00001 (-0.30)	0.1026 (6.78)*		3.3880 (1.90)*		0.00001 (17.89)*	0.2059 (17.72)*		0.7383 (60.77)*				16510.7	-8.8223	-8.8148
18. GARCH(1,1) – MA(1)	0.0002 (1.92)		0.1137 (7.32)*			0.00001 (18.03)*	0.2071 (17.21)*		0.7323 (57.80)*				16514.2	-8.8268	-8.8206
19. GARCH(1,2) – MA(1)	0.0002 (1.98)*		0.1153 (7.72)*			0.00001 (14.98)*	0.1671 (13.24)*	0.0881 (5.00)*	0.6679 (35.30)*				16519.2	-8.8266	-8.8191
20. GARCH(2,1) – MA(1)	0.0003 (2.47)*		0.1120 (7.32)*			0.00001 (16.59)*	0.2055 (15.13)*		0.6880 (9.93)*	0.0528 (0.89)			16512.7	-8.8263	-8.8188
21. GARCH(1,1) – MA(1) -M	-0.00001 (-17.82)*		0.1123 (7.27)*	3.3507 (1.86)		0.00001 (17.82)*	0.2057 (17.64)*		0.7378 (60.28)*				16515.8	-8.8249	-8.8174

	α_0	ϕ	θ	ψ	d_0	ω	α_1	α_2	β_1	γ_0	σ	λ	LL	AIC	SC
22. EGARCH(1,1)	0.0001 (1.02)					-4.0992 (-63.22)*			0.5797 (117.75)*	0.4027 (21.76)*	-0.0245 (2.30)*		16235.6	-8.8057	-8.7995
23. EGARCH(1,1) dummy	0.0001 (0.69)				-0.0003 (-1.20)	-4.3823 (-26.44)*			0.5532 (31.51)*	0.4647 (23.76)*	0.0063 (0.57)		16237.4	-8.8056	-8.7981
24. EGARCH(1,1) – AR(1)	0.0002 (1.02)	0.1198 (10.01)*				-4.3279 (-61.56)*			0.5546 (101.98)*	0.3918 (21.31)*	0.0158 (1.44)		16247.3	-8.8247	-8.8173
25. EGARCH(1,1) – MA(1) no constant			0.1338 (10.87)*			-4.2418 (-53.05)*			0.5692 (88.67)*	0.4471 (22.02)*	0.0051 (0.48)		16280.0	-8.8279	-8.8217
26. EGARCH(1,1) - M no constant				1.1405 (1.09)		-3.6973 (-45.45)*			0.6288 (93.03)*	0.4529 (21.71)*	0.0019 (0.17)		16289.9	-8.8057	-8.7994

27. EGARCH(1,1) – MA(1)-M no constant			0.1343 (10.83)*	0.7615 (0.61)*		-4.2561 (-53.47)*			0.5676 (89.03)*	0.7779 (22.06)*	0.0064 (0.55)		16279.5	-8.8277	-8.8202
	α_0	ϕ	θ	ψ	d_0	ω	α_1	α_2	β_1	β_2	d_1	λ	LL	AIC	SC
28. TARCH(1,1) dummy	0.0001 (0.79)				-0.0001 (-0.51)	0.00001 (17.86)*	0.1680 (14.36)*		0.7384 (59.56)*		-3.2E-06 (-2.89)*	0.0811 (4.12)*	16497.8	-8.8055	-8.7980
29. TARCH(1,1) – AR(1)	0.0001 (0.48)	0.1068 (6.99)*				0.00001 (18.14)*	0.1622 (13.85)*		0.7362 (58.82)*			0.0892 (4.37)*	16518.4	-8.8239	-8.8164
30. TARCH(1,1) – MA(1)	0.00001 (0.48)		0.1150 (7.39)*			0.00001 (18.06)*	0.1627 (13.81)*		0.7361 (58.49)*			0.0874 (4.31)*	16523.1	-8.8264	-8.8189

Note: 'no constant' refers a model without a constant term in its mean equation.
t-ratios are presented in parentheses.
* indicates statistically significant at the 5% level.
The diagnostics are the maximum value of the log-likelihood function (LL), the Akaike information criterion (AIC) and the Schwarz criterion (SC). The model with the smallest AIC and SC values are preferred.

Table 4.3 Comparison Between Alternative ARCH Models

	α	β	R^2	Q(10)	BG(10)	$ln R^2$
3. ARCH - M no constant	0.0001 (0.00)	0.3368 (0.00)	0.007	95.117 (0.00)	8.031 (0.00)	0.041
4. ARCH - AR	0.00008 (0.00)	0.4548 (0.00)	0.012	79.101 (0.00)	6.793 (0.00)	0.041
8. ARCH - MA no constant	0.00008 (0.00)	0.4543 (0.00)	0.012	80.288 (0.00)	6.89 (0.00)	0.034
***12. GARCH - AR**	-1.6E-06 (0.91)	0.9554 (0.00)	0.02	18.068 (0.05)	1.83 (0.05)	0.06
***14. GARCH - AR -M** no constant	9.6E-06 (0.51)	0.8854 (0.00)	0.019	17.025 (0.07)	1.76 (0.06)	0.067
***15. GARCH - AR -M**	0.00001 (0.24)	0.8612 (0.00)	0.02	17.255 (0.07)	1.85 (0.05)	0.085
***16. GARCH -MA**	-3.5E-07 (0.98)	0.9484 (0.00)	0.02	18.194 (0.052)	1.853 (0.05)	0.059
***17. GARCH - MA -M** no constant	9.6E-06 (0.51)	0.8852 (0.00)	0.019	16.934 (0.08)	1.755 (0.06)	0.066
***18. GARCH -MA -M**	0.00001 (0.24)	0.8605 (0.00)	0.02	17.291 (0.07)	1.86 (0.05)	0.084
19. EGARCH	0.0001 (0.00)	0.0936 (0.00)	0.001	143.63 (0.00)	14.621 (0.00)	0.047
21. EGARCH - AR	0.0001 (0.00)	0.1133 (0.00)	0.003	135.66 (0.00)	13.904 (0.00)	0.05
23. EGARCH - MA no constant	0.0001 (0.00)	0.0824 (0.00)	0.003	142.64 (0.00)	14.37 (0.00)	0.058
24. EGARCH - M no constant	0.0001 (0.00)	0.1306 (0.00)	0.002	138.89 (0.00)	14.402 (0.00)	0.053
28. TARCH - AR no constant	0.00004 (0.00)	0.6857 (0.00)	0.016	21.813 (0.016)	3.742 (0.00)	0.059
29. TARCH - MA no constant	0.00004 (0.00)	0.685 (0.00)	0.016	21.667 (0.017)	3.721 (0.00)	0.037
30. TARCH -M no constant	0.00005 (0.00)	0.0628 (0.00)	0.015	16.742 (0.08)	2.951 (0.00)	0.063

All the ARCH, GARCH, EGARCH, and TARCH type models refer ARCH(1),GARCH(1,1), EGARCH(1,1), and TARCH(1,1), respectively. AR and MA also refer AR(1) and MA(1), respectively.

p-values are shown in parentheses.

t-statistics non-significant at the 5% level are underlined.

* indicates model with the statistically non-significant coefficient α and significant coefficient β that implies a good GARCH type model.

R^2 is the coefficient of determination.

Q(10) is the heteroscedasticity-corrected Box-Pierce (1970) statistic for ten lags of the residual autocorrelations. BG(10) is the serial correlation LM test statistic where uses the Breusch-Godfrey large sample test for autocorrelated disturbances for ten lags disturbances. The values of *F*-statistic are reported.

The last column, $ln R^2$ shows the R^2 statistic from the regression of the model in (4.14).

Table 4.4 Wald Coefficient Tests

	F-statistic	p-value
GARCH-AR	0.864	(0.42)
*GARCH-AR-M	1.623	(0.20)
GARCH-AR-M	1.821	(0.16)
GARCH-MA	0.88	(0.42)
*GARCH-MA-M	1.626	(0.20)
GARCH-MA-M	1.835	(0.16)

p-values are shown in parentheses.
* refers a model without a constant term in its mean equation.

Table 4.5 Forecasts of the Conditional Variance of Daily Stock Returns: 1980-1997

	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percent Error
GARCH - AR	0.012107	0.008140	98.35838**
GARCH - AR -M no constant	0.012109	0.008172	106.8638
GARCH - AR -M	0.012130	0.008245	123.7206
GARCH -MA	0.012106*	0.008139*	98.35189
GARCH - MA -M no constant	0.012108	0.008171	106.8412
GARCH -MA -M	0.012128	0.008240	122.8929

* indicates the smallest value among the six GARCH models.
** indicates the nearest value to 100.00 which is the desirable value for an accurate forecast.

Table 4.6 Out-of-Sample Forecasts for the Conditional Variance of Stock Returns

	Statistic	GARCH - AR	GARCH - AR -M no constant	GARCH - AR -M	GARCH -MA	GARCH - MA -M no constant	GARCH -MA -M
Pre-opening (1 Jan. 1986- 31 Dec. 1991)	RMSE	0.006205	<u>0.006189</u>	0.006191	0.006205	<u>0.006189</u>	0.006191
	MAE	0.004443	0.004444	<u>0.004439</u>	0.004443	0.004444	<u>0.004439</u>
	MAPE	<u>98.98997</u>	103.0687	98.48241	98.81296	103.0393	98.95627
Post-opening (1 Jan.1992- 17 Jun. 1997)	RMSE	<u>0.005676</u>	0.005679	0.005680	0.005683	0.005679	0.005680
	MAE	<u>0.004186</u>	0.004197	0.004199	0.004207	0.004197	0.004198
	MAPE	<u>101.6611</u>	108.8840	109.9056	114.8117	108.8442	109.5344
Post-sample (18 Jun. 1997- 23 Jul. 1997)	RMSE	<u>0.004783</u>	0.004812	0.004805	<u>0.004783</u>	0.004812	0.004804
	MAE	0.003706	0.003748	0.003741	<u>0.003705</u>	0.003747	0.003739
	MAPE	103.8068	106.3459	105.8596	<u>103.7624</u>	106.3271	105.7794

RMSE, MAE and MAPE refer root mean squared error and mean absolute error, and mean absolute percent error, respectively. Underlined values for the RMSE and the MAE are the smallest value, which implies the best forecasting model among the six GARCH class models in each subsample period. Underlined values for the MAPE are the nearest value to 100, which is desirable one for an accurate forecasting model.

Figure 4.3 Variance Forecasts for Pre-Opening Period from 1986 to 1991

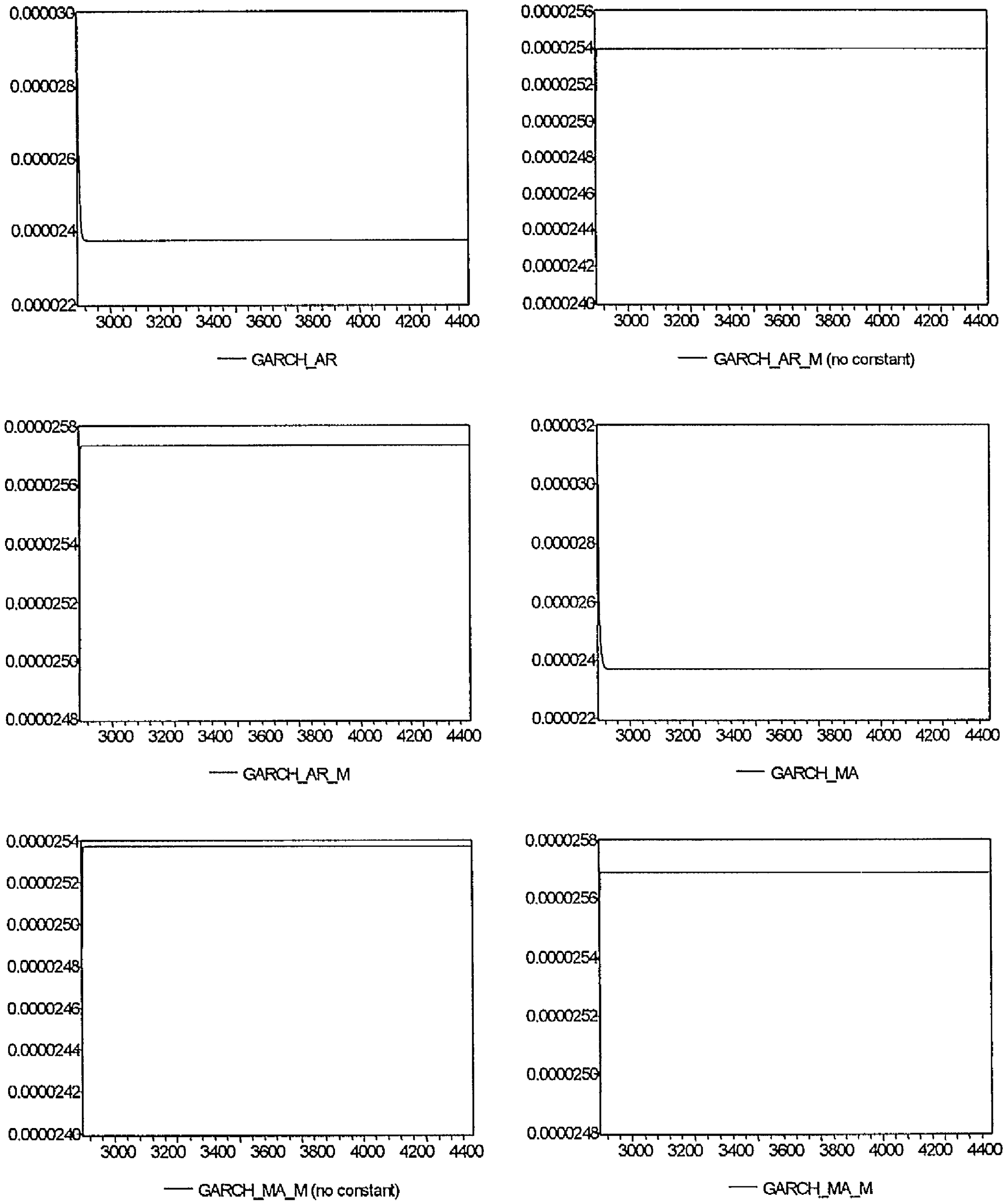


Figure 4.4 Forecasts of the Conditional Variance for Post-Opening Period from 1992 to 1997

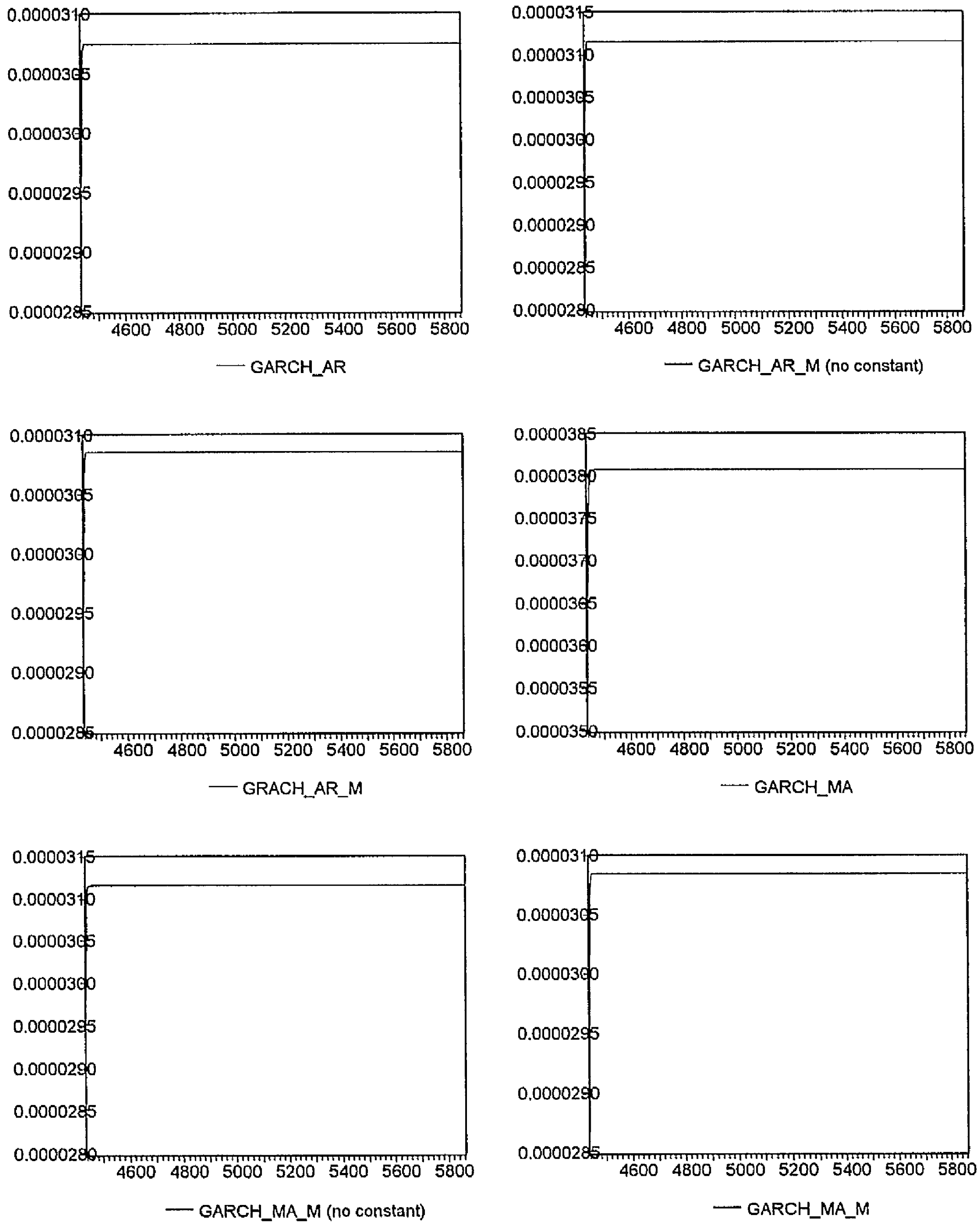
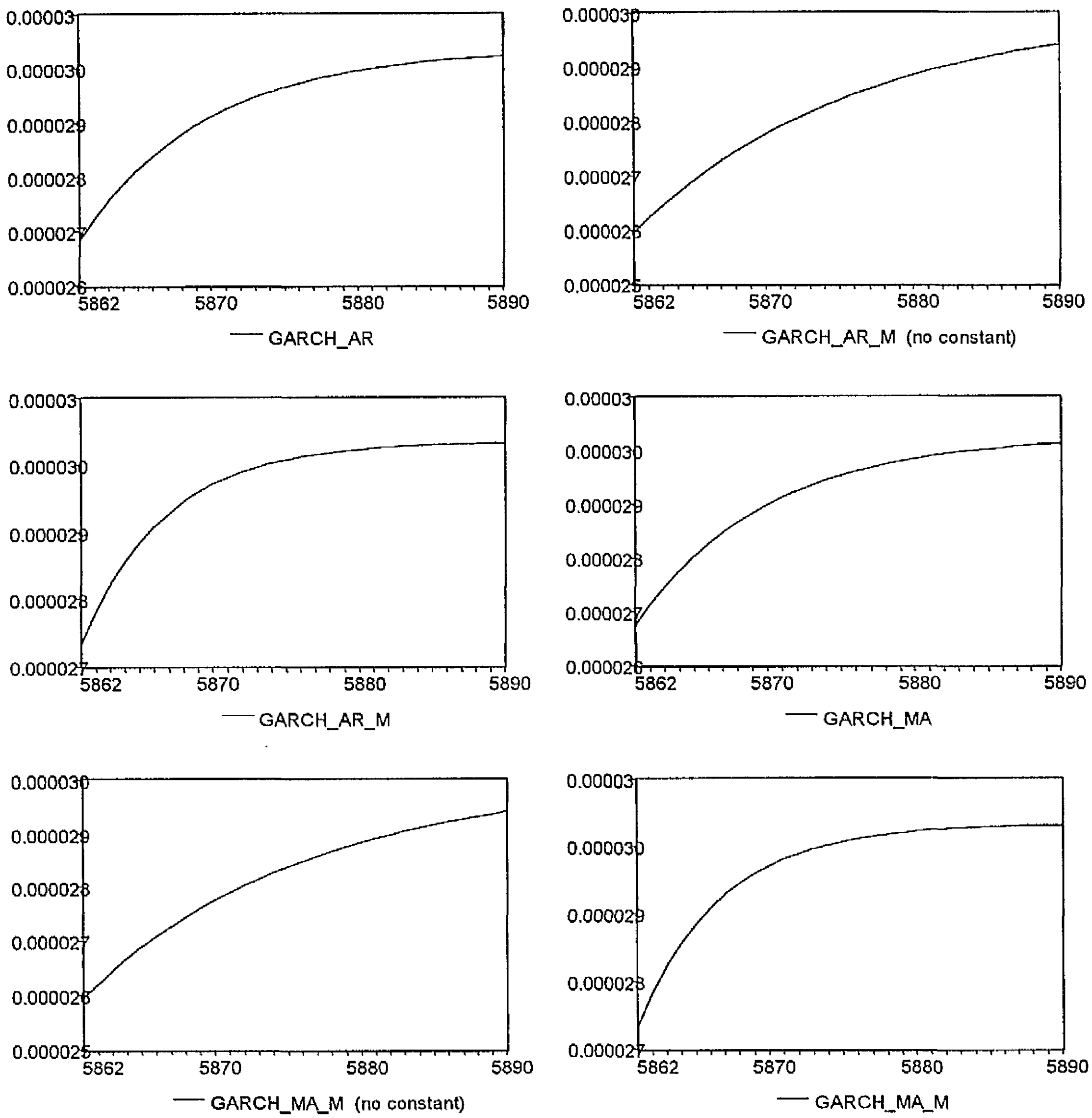


Figure 4.5 Forecasts of the Conditional Variance for Post-Sample Period from 18 June 1997 to 23 July 1997



5 Macroeconomic Variables and Stock Returns

5.1 Introduction

A series of stock market and foreign exchange market crashes in East and Southeast Asia in the second half of 1997 bring us to the question of the relationship between macroeconomic variables and stock market performance. Empirical evidence suggests that some macroeconomic variables contain important information for stock market participants and can play an important role in determining stock market performance.

Basically, stock prices are determined by people's expectations about firms' future profitability. Future profitability, in turn, depends on the state of the economy. Hence, stock prices are determined by expectations about the future state of the economy. But those expectations turn out to be wrong almost as often as they turn out to be right. Thus, stock prices are not entirely reliable predictors of the state of the economy and vice versa. In general, stock prices are dependent on both macroeconomic variables and micro-market variables. However, it is not easy to outline the major determinants of stock prices because a stock market is affected by a variety of economic and political factors. In other words, movement of a stock price is related to a company's specific profitability so that the macroeconomic variables can provide an external environment for the performance of companies as a whole. In this context, it is interesting to investigate whether macroeconomic variables are useful in forecasting stock market variability.

While empirical studies on advanced markets abound (see for example, Rogalski and Vinso, 1977; Geske and Roll, 1983; Bulmash and Trivoli, 1991; Smith, 1992; Belden, 1995; and Mookergee and Yu, 1997) few studies have examined the relationship between macroeconomic variables and stock prices in emerging markets. As the Korean stock market is representative of a typical emerging market and has experienced fast changes since opening-up in January 1992, a closer examination of this market might also help to understand particular aspects of some other emerging stock markets in the Pacific Basin.

The main purpose of this chapter is to explore whether changes in macroeconomic variables contain important information for stock market participants in Korea. The chapter analyses the effects of changes in major macroeconomic variables on stock market returns in Korea within a multivariate vector autoregression (VAR) framework using the Korea Composite Stock Price Index (KOSPI). In particular, our macroeconomic variables including the current account balance, money supply, interest rates and exchange rates, and stock price series are analysed dividing into two subperiods, pre-opening (from January 1987 until the end of 1991) and post-opening (from the early of 1992). While most economic variables included in the analysis have been used in different forms in stock price analysis, the effects of changes in macroeconomic variables on stock returns before and after stock market opening-up in Korea has not been analysed empirically. This chapter also aims to evaluate the usefulness of the relationships between macroeconomic variables and stock returns as a forecasting tool in the implementation of investment strategies.

The rest of this chapter is organised as follows. The next section reviews related literature and describes the theoretical foundation. Section 5.3 describes the empirical methodology employed. Section 5.4 discusses the data and their properties. In section 5.5 the results are presented. The final section summarises this chapter.

5.2 Macroeconomic Variables and Stock Prices

One of the most important macroeconomic variables that has been identified as a major determinant of stock prices is the money supply but there are, of course, others; exchange rates and interest rates are typical macro variables that have been researched widely.

5.2.1 Money Supply

The money supply-stock market nexus has been widely tested and documented. The existing findings show conflicting results. Among many others, Homa and Jaffee (1971) have shown that past increases in money growth lead to increases in equity prices. On the other hand, money supply growth can also affect stock prices through a different channel. For example, Tatom (1985) argued that increased volatility in money growth increases uncertainty about the direction of monetary policy, causing erratic movements in interest rates. As interest rates move erratically investment in financial assets such as stocks becomes riskier and uncertain. Investors will tend to shift away from financial assets to holding money. Thus, money growth and stock prices could be negatively associated. On the other hand, Rogalski and Vinso (1977) found bi-directional causality between money supply and stock returns in the US over the period 1963-1974.

5.2.2 Interest Rates

Interest rates can affect the profitability of firms in various ways. If interest rates increase then firms incur higher costs of borrowing money and decreases. Thus stock prices decrease. In the short term, they can be influenced by substitution among financial assets. If interest rates decline then investors turn to the stock market which can provide higher profitability than somewhat less riskier but less profitable assets such as bonds and bank deposits. The opposite would occur with rising rates, as higher interest rates increase the attractiveness of alternative investments (see for example, Geske and Roll, 1983; Solnik, 1983; and Bulmesh and Trivoli, 1991).

5.2.3 Exchange Rates

Economic theory suggests that, for an export dominant economy, exchange rate appreciation reduces international competitiveness of export markets. Subsequently it affects the domestic stock market negatively. On the other hand, if the economy is import dominant then the domestic stock market reacts favourably to the expected currency appreciation since exchange appreciation lowers input costs and generates a positive impact on the stock market. An appreciation usually occurs when positive net exports increase so that it helps the trade balance surplus that, in turn, has a positive effect on the current balance surplus. Therefore, an appreciation of own currency (decrease in exchange rates) might be positively related to stock prices in the economy. In particular, the number of foreign investors on the Korean Stock Exchange has increased since stock market opening in 1992. Thus stock prices can be affected by net purchases by foreign investors, that is, sales minus purchases by foreign investors, whose investment on the stock market is easily influenced by exchange rate movements. For example, although foreign investors expect a decrease in stock prices they might purchase stocks if the expected decrease in exchange rates exceeds the expected decrease in stock prices. On the contrary, although they expect an increase in stock prices they might not purchase stocks if the expected increase in exchange rates exceeds the expected increase in stock prices. Consequently, an appreciation of own currency (decrease in exchange rates) would induce an inflow of foreign capitals and, in turn, the demand for stocks might increase. Thus stock prices will be positively affected.

There is conflicting evidence on the relationship between exchange rates and stock prices. Some studies have shown that exchange rates have a significant impact on stock prices. For example, Ma and Kao (1990) demonstrated two possible impacts of changes in a country's currency values on stock price movements. One is the financial effect of exchange rate changes and the other is the economic effect from exchange rate changes. The former suggests that if the investment is denominated in a strong currency, foreign investors expect to receive an ultimately higher rate of return after the payoff is converted into their own currency. Consequently, appreciation of currency generates a favourable transaction exposure and creates excess demands for domestic stocks. However, the economic effect from exchange rate changes suggests, for an export dominant country, the currency appreciation reduces the competitiveness of export markets and has a negative effect on the domestic stock market and vice versa for an import dominant country. However, empirical evidences suggest mixed results. Bahmani-Oskooee and Sohrabian (1992) reported a feedback effect from stock prices to exchange rates in the U.S. context. Using data form the UK, as well as the US and Germany, Smith (1992) also found that equity values have a significant impact on the UK pound- US dollar exchange rate over the period 1979Q2-1988Q3. On the contrary, Mookerjee and Yu (1997) found no causal ordering between exchange rate changes and stock price changes in Singapore. Using

Kearney and Daly (1998) also found no statistically significant relationship between the conditional volatility of the foreign exchange market and the conditional volatility of the stock market in Australia.

As previously mentioned, most studies on the relationship between macroeconomic variables and stock prices have focused on developed markets with relatively few investigating emerging markets. For example, Kwok (1994) investigated relations between stock returns and inflation variables, and between stock returns and future real activity in Korea over the period 1975-1990. The results show a highly significant negative relationship between stock returns and expected and unexpected inflation whereas an insignificant relationship between stock returns and real output is detected. Habibullah and Baharumshah (1996) examined whether money supply and output are important in predicting stock prices in Malaysia for the period from 1978 to 1992. Using cointegration methodology, they found no long-run equilibrium between stock price indices and money supply, which suggests that Malaysia's stock market is informationally efficient with respect to money supply. Abdalla and Murinde (1997) investigated interrelations between exchange rates and stock prices in the emerging financial markets of Korea, India, Pakistan and the Philippines for the period 1985–1994. Using bivariate VARs, they found that exchange rates Granger cause stock prices in Korea, Pakistan and India, whereas stock prices Granger cause exchange rates in the Philippines. That is, there exists unidirectional causality from exchange rates to stock prices in all the sample countries, except the Philippines.

5.3 Methodology

$$y_t = a_{20} + a_{21}x_t + \phi_{21}x_{t-1} + \phi_{22}y_{t-1} + u_{yt} \tag{5.2}$$

where u_{xt} and u_{yt} are uncorrelated white noise disturbances.

This system can be rewritten as:

$$AX_t = \Phi_0 + \Phi_1 X_{t-1} + u_t \tag{5.3}$$

where

$$A = \begin{bmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{bmatrix},\ X_t = \begin{bmatrix} x_t \\ y_t \end{bmatrix},\ \Phi_0 = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix},\ \Phi_1 = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix},\ u_t = \begin{bmatrix} u_{xt} \\ u_{yt} \end{bmatrix}$$

Premultiplication by A^{-1} allows us to obtain the VAR model in standard form:

$$X_t = B_0 + B_1 X_{t-1} + \varepsilon_t \tag{5.4}$$

where $B_0 = A^{-1}\Phi_0$, $B_1 = A^{-1}\Phi_1$, $\varepsilon_t = A^{-1}u_t$.

In the VAR, it is important to determine the appropriate lag length. If the lag length, p is too small, the model is misspecified but if p is too large, degrees of freedom are wasted. One way of determining appropriate lag length is the multivariate generalisation of the Akaike information criterion (AIC). This is defined as

$$\text{AIC} = T \log |\Sigma| + 2N \tag{5.5}$$

where $|\Sigma|$ is determinant of the variance covariance matrix of residuals, N is the total parameters estimated in all equations. Thus, if there are n variables and have n equations and each variable has p lags and an intercept, $N = n(np + 1)$; each of the n equations has np lagged regressors and an intercept. Adding additional regressors will reduce log $|\Sigma|$ at the expense of increasing N. By choosing a model that has the lowest AIC value we can select an appropriate lag length for VAR model.

Now, consider a matrix form of equation (5.4):

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{xt} \\ \varepsilon_{yt} \end{bmatrix} \tag{5.6}$$

If we iterate backwards, it is possible to form:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} \mu_x \\ \mu_y \end{bmatrix} + \frac{1}{1-a_{12}a_{21}} \sum_{i=0}^{\infty} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} u_{xt} \\ u_{yt} \end{bmatrix} \tag{5.7}$$

By defining the (2 × 2) matrix Ψ_i with elements $\psi_{jk}(i)$ such that $\Psi_i = [B_1^i/(1-a_{12}a_{21})] \begin{bmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{bmatrix} = \begin{bmatrix} \psi_{11}(i) & \psi_{12}(i) \\ \psi_{21}(i) & \psi_{22}(i) \end{bmatrix}$ and $\mu = [\mu_x \quad \mu_y]'$, it can be rewritten as:

$$X_t = \mu + \sum_{i=0}^{\infty} \Psi_i u_{t-i} \tag{5.8}$$

The four sets of coefficients of $\psi_{11}(i), \psi_{12}(i), \psi_{21}(i)$ and $\psi_{22}(i)$ are called the impulse response functions. Plotting the impulse response functions is a practical way to visually represent the behaviour of the $\{x_t\}$ and $\{y_t\}$ series in response to the various shocks. An impulse function describes the effect on current and future values of the endogenous variable of a one standard deviation shock to one of the innovations.

While an impulse response function traces out the response of an endogenous variable to a one standard deviation shock to one of the innovations, the forecast error variance decomposition of a VAR gives information about the relative importance of the random innovations. In other words, it illustrates the proportion of the movements in a sequence due to its own shocks versus shocks to the other variable. If we use equation (5.8) to conditionally forecast n-step ahead then the n-step ahead forecast error $X_{t+n} - E_t X_{t+n}$ becomes

$$X_{t+n} - E_t X_{t+n} = \sum_{i=0}^{n-1} \Psi_i u_{t+n-i} \tag{5.9}$$

If we focus solely on the $\{x_t\}$ sequence, the n-step ahead forecast error is

$$x_{t+n} - E_t x_{t+n} = \psi_{11}(0)u_{xt+n} + \psi_{11}(1)u_{xt+n-1} + \cdots + \psi_{11}(n-1)u_{xt+1} \\ + \psi_{12}(0)u_{yt+n} + \psi_{12}(1)u_{yt+n-1} + \cdots + \psi_{12}(n-1)u_{yt+1} \tag{5.10}$$

If we denote the variance of the n-step ahead forecast error of x_{t+n} as $\sigma_x(n)^2$, then it is possible to decompose $\sigma_x(n)^2$ due to shocks in the $\{u_{xt}\}$ and $\{u_{yt}\}$ sequences are

$$\frac{\sigma_x^2[\psi_{11}(0)^2 + \psi_{11}(1)^2 + \cdots + \psi_{11}(n-1)^2]}{\sigma_x(n)^2}$$

and $$\frac{\sigma_y^2[\psi_{12}(0)^2 + \psi_{12}(1)^2 + \cdots + \psi_{12}(n-1)^2]}{\sigma_x(n)^2} \tag{5.11}$$

By construction, as in equation (5.1) and (5.2), the innovations u_{xt} and u_{yt} are serially uncorrelated white noise disturbances. In reality, however, the innovations are never totally uncorrelated and they might be correlated contemporaneously. When the innovations are correlated they have a common component which cannot be identified with any specific variable. To quantify the cumulative response of an element of a single equation in VAR to an innovation, it is necessary that u_{xt} and u_{yt} be orthogonal. On of the most widely used orthogonalisation procedures is the Choleski decomposition, which is based on decomposing the original VAR innovations (u_{xt} and u_{yt}) into a set of uncorrelated components.[13]

5.4 Data

Monthly data on the stock price index, money supply, interest rate, exchange rates, balance of trade and flow of stock investment are used for the period starting in

[13] For a full technical discussion of these issues, see Hamilton (1994), pp. 318-323.

January 1987 and ending in June 1997 (126 monthly observations). The first and last observations were dictated by both the availability of the yields of corporate bond with 3-year maturity and the exclusion of the Asian financial market crisis in 1997. The data on trade balance were collected from *Monthly Bulletin of Statistics.*[14] The data on money supply, interest rate, foreign exchange rates and flow of stock investment were obtained from *The Bank of Korea Database*. The Korea Stock Price Composite Index (KOSPI) were obtained from *Korea Stock Exchange Database* with the index of 4 April 1980 as the base, i.e., it equals 100.

Since Korea is an export-lead economy, the exports/imports ratio (EXPIMP), which is computed as exports divided by imports, is used as a proxy variable for balance of trade in goods. For a money supply variable, we use the broad (M2) money supply measure. For an interest rate series, the yields of corporate bond with 3-year maturity (CB3Y) is chosen because this rate has been regarded as the most sensitive and representative money market rate in Korea. The selected exchange rates series are the Korean won-US dollar (KOUS), and the Korean won-100 Japanese yen (KOJP) exchange rates. As foreign investors have traded actively in the Korean stock market since the market opened-up in 1992, we also consider net stock investment by foreign investors (NETSTOCK), which is computed as the difference between an inflow and an outflow of stock investment fund, and net stock trading value (NETPURCH), which is generated as purchase minus sale by foreign investors.

The data on exports, imports and M2, were seasonally unadjusted; seasonally adjusted series were generated using an *additive method.*[15] First, a centred moving average of the series, which covers a whole year centred around the current

[14] *Monthly Bulletin of Statistics* is published by the Bank of Korea.
[15] Our raw data are seasonally adjusted using an additive method described in the *EVIEWS* manual.

observation, is computed. Second, the difference from the moving average is obtained. Third, we average the ratio over the years in the sample, for each month separately. These averages are seasonal factors. Fourth, the seasonally adjusted series are generated by subtracting it from the seasonal factors.

Initially the series KOSPI, M2, KOUS and KOJP are transformed using logarithmic first differences. The transformed series are designated as DLKOSPI for Korean stock market returns; DLM2 for M2 money growth; DEXPIMP for changes in the exports/imports ratio, a proxy variable for the balance of trade in goods; DLKOUS for the Korean won-US dollar exchange rate growth, DLKOJP for the 100 Korean won-Japanese yen exchange rate growth; DCB3Y for changes in yield rates of 3-year corporate bond; DNETSTOCK for changes in net stock investment by foreign investors; and DNETPURCH for changes in net stock purchase by foreign investors. In order to examine the consequence of stock market opening-up, two sub periods are used: Pre-opening period from January 1987 to December 1991 and Post-opening period from January 1992 to June 1997.

5.5 Empirical Results

5.5.1 Cross-Correlation Analysis

Table 5.1 reports the cross-correlation coefficients computed between KOSPI returns and changes in trade balance variables. If stock returns and trade balance are independent, then the estimated cross-correlation coefficients are expected to be zero for all lags/leads. As shown in Table 5.1, this is clearly not the case. The estimated cross-correlation coefficients between stock market returns (DLKOSPI) and changes in balance of trade (DEXPIMP) are not significantly different from zero in the pre-opening period whereas the coefficients at lags one and eight in the entire period, and the coefficients at lags two and eight in the post-opening period are significant at the 5% level. In the post-opening period, in particular, the coefficients at lag two and eight exhibit significant a positive relationship and the computed Q-statistics also confirm that the set of cross-correlation coefficients at lags is not zero for the post-opening period. The results suggest that unidirectional feedback generally exists in the post-opening period because some of the estimated cross-correlation coefficients are significant for lags. Thus, these results suggest that the change in the balance of trade variable is positively related to KOSPI returns in the post-opening period.

The estimated cross-correlation coefficients between stock market returns and changes in net purchases, and stock investment by foreign investors in the post-opening period are presented in Table 5.2. As shown in panel A, the concurrent coefficient, 0.342 and the coefficient at lag nine, 0.227 are positive and significantly different from zero at the 5% level. In panel B, the estimated cross-correlations between stock market returns and net stock investment reported. The results indicate that, only the estimated concurrent coefficient 0.403 is positive and significantly different from zero at the 5% level. The results imply that, no significant relationship between stock market returns and net purchases/net stock investment by foreign investors only exhibits in the long term.

Table 5.3 reports cross-correlation function computed between money growth and stock returns series. In the entire period, the estimated coefficients between KOSPI returns and the growth rates of money supply are significant and positive at lead eight. In the pre-opening period, the coefficients at lag three and leads seven, eight and nine are significantly different from zero. These results suggest a bi-directional theory of causality. The computed Q-statistics also indicate that all of the cross-correlation coefficients at leads are not zero. This might suggest that causality goes from money supply to stock market returns in the entire and pre-opening periods. However, no significant correlation between KOSPI returns and money growth is found in the post-opening period.

The yield rates of a 3-year corporate bond in Korea, which is a representative market rate, were around 10 to 13%, which implies approximately 7% of real interest rate, given the 4 to 5% inflation rate. Under this circumstance, it is clear that, for foreign investors, Korea is an attractive market that has not yet been sufficiently explored. It is well known that official interest rates in Korea were maintained at levels far below the market rate by severe government controls until the first half of the 1980s. The gap between the official rates and the curb loan market rates substantially narrowed as a result of the continuous financial market deregulation since the second half of 1980s.

Figure 5.1 shows that when the mid-term interest rate was high during the early period of stock market opening in 1992 and 1993, the stock price index (KOSPI) was relatively low. Subsequently, when the KOSPI increased in 1994 and 1995, the mid-term interest rate followed a declining trend. A negative relationship between the stock price index and the interest rate was evident the period 1995-96.

Table 5.4, reports results of cross-correlations between stock returns and changes in interest rates. Over the entire period, the concurrent coefficient is -0.357 and significantly different from zero at the 5% level. Its negative sign is consistent with the conclusions of Bulmash and Trivoli (1991) that stock prices appear to react negatively to rising interest rates and vice versa for falling interest rates as higher interest rates increase the attractiveness of alternative investments.[16] It is also consistent with Geske and Roll (1983), who found a negative relationship between stock prices and interest rates.[17] The results for the subperiods are interesting. The concurrent coefficient is –0.369 in the pre-opening period and becomes –0.397 in the post-opening period. This suggests that the negative relationship between the stock market returns and changes in interest rate has strengthened slightly since stock market opening.

In Table 5.5, the cross-correlation between the stock market returns and the growth rates of the Korean won-US dollar exchange rate are reported. Irrespective of sample period, all of the significant cross-correlation coefficients are negatively associated. In the entire period, the coefficients at lag two and zero and the coefficients at lead one, six and seven are significantly different from zero at the 5% level and negatively associated. In pre-opening period, the results are similar to those in the entire period except that the coefficient at longer lead eleven and lag eight is significant, whereas –0.265 the concurrent coefficient and –0.336 the coefficient at lead seven are significantly different from zero at the 5% level in the post-opening period.

These negatively associated coefficients can be explained by two aspects. First, the depreciation of the Korean won against the US dollar could negatively affect stock market prices. This can be explained the fact that although the Korean economy is export-oriented, most of the essential materials for export goods, for instance crude oil, are imported from abroad. Thus, currency depreciation can

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[16] Bulmash and Trivoli (1991) use monthly data of the US 3-month Treasury bill auction average yield and the US Composite Treasury bond issues over 10 years maturity as the interest rates variables for the period of 1961-1987. They use the monthly Standard & Poor's Composite Stock Market Average as the stock prices variable for the same period.

[17] Geske and Roll (1983) use Treasury bill rates as a proxy for expected inflation.

negatively affect export industries if they rely heavily on imported materials. Thus, the stock market as a whole can also react badly to currency depreciation. Second, although foreign investors expect an increase in stock prices they may reduce their portfolio balance by selling stocks if an increase in exchange rates exceeds an increase in stock prices. Consequently, a depreciation of own currency (increase in exchange rates) could result in selling stocks held by foreign investors since they tend to remit their invested amount to their own countries until the environment of the local financial market improves. Thus, an outflow of foreign capital due to a decrease in demand for stocks by foreign investors could also affect the demand for stocks by domestic investors. Consequently stock prices and the exchange rate are expected to be negatively associated.

The results of cross-correlation estimation between stock returns and growth rates of the Korean won-Japanese yen exchange rate are interesting. As shown in Panel B, the estimated coefficients between stock returns (DLKOSPI) and the growth rate of the Korean won-Japanese yen exchange rate (DLKOJP) are smaller, and longer lead coefficients are significant than those with DLKOUS. In the pre-opening period, although the significant coefficients at lead one and six are negatively associated, the lead coefficient at nine exhibit positive sign. In the post-opening period, the significant coefficient at lead four is positive whereas the coefficient at lead twelve is negative. Consequently the overall effect seems to be negative in both the pre- and post-opening periods. However, the positive correlation might be explained by the exogenous compared to other variables in the system.

Figure 5.2 plots the impulse responses of DLKOSPI to a one standard deviation shock to the innovations in four equations in the pre-opening period. As mentioned in section 5.3, the VAR errors are orthogonalised using a Choleski decomposition that eliminates any contemporaneous correlation between the innovation in DLKOSPI equation and the other four innovations, which precede it in the chosen ordering. When the innovation in the DLM2 equation changes by a value of one standard deviation, stock market returns (DLKOSPI) decrease at 2-month horizon then DLKOSPI increases in the following month. In general, a shock to the money supply seems to have a small impact on DLKOSPI at longer horizon. When there is a one standard deviation shock on the growth rates in the Korean won-US dollar exchange rate, stock market returns respond negatively to the shock up month three then DLKOSPI increases for the following one month. The responses to exports/imports ratio show that stock market returns increase up to month four after decreasing slightly in the first period. However, stock market returns seem to respond negatively to the shock on changes in interest rate after increasing slightly in the first period.

In Table 5.7, the estimated forecast error variance decompositions of stock returns are presented. The results indicate that approximately 80.1% of the first month variation of stock returns is attributable to its own innovations. However, the contributions of own innovations decrease to 34.8% and 32.9% at 12 and 24 months horizon respectively as the shock evolves over time and system approaches a stable equilibrium. In particular, among the remaining model variables, the strongest influence on stock price movements is exerted by changes in the balance of trade. For example, DEXPIMP accounts for 19.3% and 20.7% of the variance in DLKOSPI at 12- and 24-months horizon, respectively. The decrease in the explanatory contributions of DLKOSPI due to its own innovations is incrementally picked up by the remaining model variables over the 24 months forecast horizon of which gets the larger share. The contribution of money growth innovations on the variance of stock returns is also considerable. DLM2 accounts for 15.3% and 18.2% of the variance in DLKOSPI at 6- and 24-months horizon, respectively. The contribution of the remaining variables, DLKOUS and DCB3Y in the model in explaining the variance of stock returns are approximately the same, which is approximately 14%, at 12- and 24-months horizon.

At 3-month horizon, the variance of stock returns is decomposed of the innovations of stock returns (52.1%), growth rates of the Korean won-US dollar exchange rate (20.6%), money supply growth (13.2%), changes in interest rate (12.6%) and changes in balance of trade (1.5%). At 24-month horizon, although the contributions of the innovations of stock returns (33%) have decreased, the attributions of changes in balance of trade (20.7%), money supply growth (18.2%), growth in the Korean won-US dollar exchange rate (14.6%) and changes in interest rate (13.5%) have increased.

Table 5.8 reports a multivariate VAR(6) in the post-opening period. Although the computed AIC suggests the order of six for a VAR, the VAR specification does not seem be fit very well in the post-opening period since only one of the coefficients in the RKOSPI equation is significant. Our results indicate that DEXPIMP(-3) is positive and significant in the RKOSPI equation.

The responses of RKOSPI to one standard deviation shocks in the post-opening period are presented in Figure 5.3. When the innovation in the DLM2 equation changes by a value of one standard deviation, DLKOSPI responses to the money supply shock by decreasing slightly in the first following month then DLKOSPI increases up to month four in the future. The results of the response of DLKOSPI to DLKOUS innovation show that stock DLKOSPI do not seem to respond to the shock in the Korea won-US dollar exchange rate shock in the first following two months. However, DLKOSPI decrease after increasing slightly for a month. The results of the response of stock market returns to exports/imports ratio indicates that DLKOSPI increases up to month three then it decreases for the following two months. Although the pattern of the response of DLKOSPI to interest rate changes exhibit the repeat of a decrease and an increase, DLKOSPI seems to decrease in the first following month.

The results of variance decomposition of DLKOSPI in the post-opening period are shown in Table 5.9. Irrespective of forecast horizon, the forecast error variance of DLKOSPI is mainly due to its own innovations and partially due to the innovations of DCB3Y and DEXPIMP. One of the interesting findings in the post-opening period is that the forecast error variance of stock returns explained by changes in interest rate is approximately 9.2% in the first month but the remaining variables in the model do not seem to attribute to the forecast error variance of DLKOSPI. Unlike our findings in the pre-opening period, the innovations of the Korean won-US dollar exchange rate growth hardly attribute to the decomposition of forecast error variance of stock returns.

Our results suggest that DCB3Y accounts for 12.5% of the variance of DKLOSPI and that DLKOSPI accounts for 12.3% of the variance of DCB3Y indicate the existence of co-movement between these two variables rather than one causing the other in the Granger (1969) sense. A strong co-movement between two variables x and y may simply indicate that x causes y, and in the process y moves closely with it. This aspect of the relationship between DCB3Y and DLKOSPI can be examined following the procedure implemented in Abdulah (1994). To determine if x causes y in the Granger sense one computes the forecast error variances by running a pair of decompositions, first with x and y placed next to each other from the last position, and reversing only their positions in the second running. The variable, which accounts for a larger proportion of the variance when placed last in the ordering of the decomposition scheme, is considered as causal in their co-movements. Our implementation of this procedure at a 12-month horizon finds that DLKOSPI accounts for 12% of the variance of DCB3Y when DLKOSPI is placed last in the ordering whereas DCB3Y accounts for 4.6% of the variance of DLKOSPI when DCB3Y is placed in the last ordering. This suggests that stock returns exert a larger influence on changes in interest rate in their co-movements in the post-opening period.

To sum up, changes in exports/imports ratio and money supply growth are important determinants of stock price movement in the pre-opening period whereas changes in interest rate and balance of trade seem to play an important role in forecasting the variance of stock returns in the post-opening period.

5.5 Summary and Conclusions

In this chapter, we have investigated the nexus between Korean stock market returns and macroeconomic variables for the period from January 1987 to June 1997. Since the Korean stock market has been affected by different economic and political environment following its opening in 1992 the series has been divided into two subperiods: Pre-opening period from January 1987 to December 1991 and Post - opening period from January 1992 to June 1997.

Cross-correlation analysis and a five variable VAR framework are used together with innovation accounting procedures to assess the economic implications of the model. The results of cross-correlation analysis reveal that (i) the balance of trade variable is positively related to the stock returns in the post-opening period; (ii) strong negative relationship between stock returns and changes in interest rate at lag zero is found and has strengthened since the stock market opening; (iii) the Korean won-US dollar exchange rate is negatively related to stock market returns in all sample periods.

Our findings using forecast error variance decompositions are interesting. The results show that a substantial proportion of the variance of stock returns is attributable to its own innovations in the pre- and post-opening periods. The evidence suggests that changes in the exports/imports ratio is an important determinant of the variance of stock returns in both the pre-and post-opening periods. In the pre-opening period, changes in money growth together with the exports/imports ratio jointly account for over one third of the variance of stock returns, and a considerable proportion of the variance of stock returns are also attributed to changes in the Korean won-US dollar exchange rate and interest rate. In the post-opening period, however, the results show that changes in the interest rate and the exports/imports ratio have relatively more significant influence on stock returns variability than those due to money growth and exchange rate fluctuations. Therefore, the findings suggest that changes in the balance of trade is one of the important determinants in forecasting the variance of stock returns in the Korean export-oriented economy.

Figure 5.1 KOSPI and Mid-Term Interest Rates

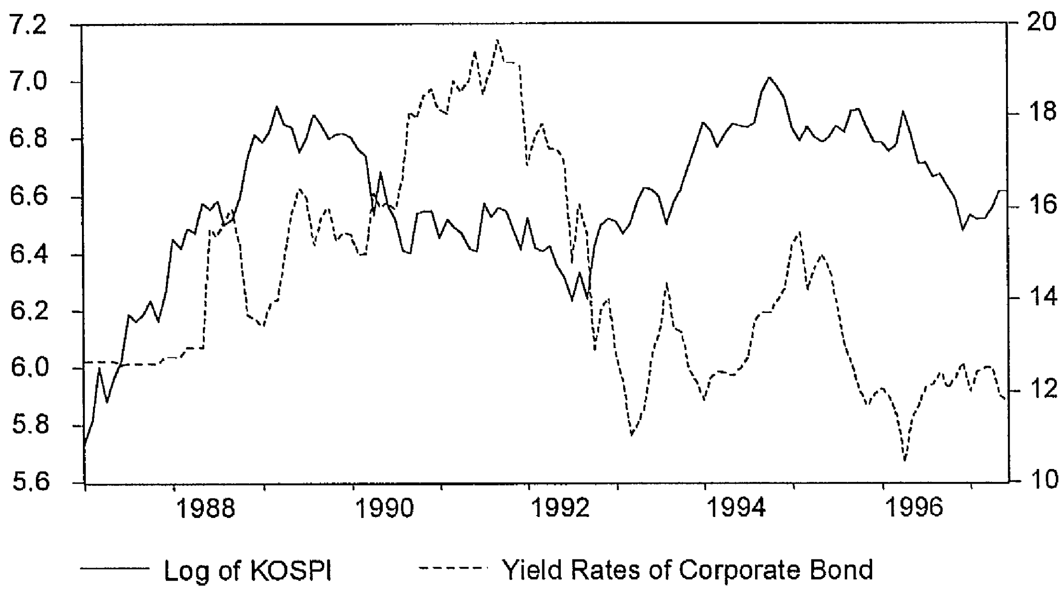


Table 5.1 Estimated Cross-Correlation Coefficients Between KOSPI Returns and Balance of Trade

	DLKOSPI & DEXPIMP(i)		
i	Entire period	Pre-opening period	Post-opening period
12	0.014	-0.026	0.087
11	0.036	0.089	-0.018
10	0.003	0.037	-0.040
9	-0.052	-0.110	0.030
8	-0.098	-0.079	-0.128
7	0.120	0.147	0.037
6	0.008	0.175	-0.162
5	-0.051	-0.131	0.065
4	0.050	0.069	0.067
3	-0.101	-0.105	-0.081
2	-0.003	0.017	-0.054
1	0.067	0.053	0.056
0	-0.078	-0.077	-0.076
-1	-0.157 *	-0.188	-0.156
-2	0.154	0.070	0.361 *
-3	0.050	0.120	-0.071
-4	0.067	0.135	0.000
-5	-0.091	-0.208	0.068
-6	0.046	0.070	0.128
-7	-0.103	-0.048	-0.224
-8	0.180 *	0.060	0.306 *
-9	-0.124	-0.078	-0.079
-10	0.058	0.055	-0.123
-11	-0.130	-0.130	-0.032
-12	0.060	0.013	0.039
	Q-statistic	Q-statistic	Q-statistic
H_0: all $\rho_{xy}(+i) = 0$	6.448	8.109	5.726
H_0: all $\rho_{xy}(-i) = 0$	19.889	10.325	25.697 *

Note: For a proxy variable for balance of trade, Exports/Imports ratio (EXP/IMP) variable is computed as exports divided by imports.
* denotes significance at the 5% level.

Table 5.2 Estimated Cross-Correlation Coefficients Between DLKOSPI and Flow of Stock Investment

i	A. DLKOSPI & DNETPURCH(*i*)	B. DLKOSPI & DNETSTOCK(*i*)
12	-0.029	-0.024
11	-0.126	-0.183
10	0.048	0.086
9	0.038	0.073
8	-0.060	-0.093
7	0.074	0.065
6	0.063	0.093
5	-0.149	-0.133
4	-0.026	-0.045
3	0.010	-0.026
2	-0.141	-0.196
1	-0.124	-0.103
0	0.342 *	0.403 *
-1	0.001	0.032
-2	-0.091	-0.088
-3	0.228	0.190
-4	-0.143	-0.118
-5	-0.072	-0.089
-6	-0.078	-0.078
-7	0.119	0.112
-8	-0.205	-0.203
-9	0.227 *	0.196
-10	0.004	0.011
-11	-0.082	-0.062
-12	0.026	0.047
	Q-statistic	*Q*-statistic
H_0: all $\rho_{xy}(+i) = 0$	6.798	10.327
H_0: all $\rho_{xy}(-i) = 0$	15.611	12.919

Note: NETPURCH is computed as the value of purchase minus the value of sale by foreign investors in the Korea Stock Exchange. NETSTOCK is calculated as an inflow of stock investment minus an outflow of stock investment fund.
* denotes significance at the 5% level.

Table 5.3 Estimated Cross-Correlation Coefficients Between KOSPI Returns and Money Supply

	DLKOSPI & DLM2(i)		
i	Entire period	Pre-opening period	Post-opening period
12	0.106	0.187	-0.039
11	-0.113	-0.207	0.059
10	0.109	0.163	-0.016
9	-0.165	-0.343 *	0.111
8	0.174 *	0.339 *	-0.079
7	-0.220	-0.281 *	-0.128
6	-0.018	-0.027	-0.081
5	0.077	0.008	0.194
4	0.062	0.083	-0.013
3	0.092	0.089	0.072
2	-0.001	-0.051	0.079
1	0.015	0.061	-0.046
0	-0.057	-0.049	-0.081
-1	-0.165	-0.212	-0.135
-2	0.119	0.220	0.003
-3	-0.132	-0.265 *	0.041
-4	0.102	0.169	0.013
-5	-0.001	-0.076	0.123
-6	-0.016	0.109	-0.179
-7	-0.050	-0.030	-0.053
-8	0.051	0.054	-0.009
-9	0.078	0.090	0.142
-10	0.020	0.024	-0.097
-11	-0.018	-0.073	0.062
-12	0.042	0.014	0.012
	Q-statistic	Q-statistic	Q-statistic
H_0: all $\rho_{xy}(+i)=0$	21.998 *	31.738 *	7.358
H_0: all $\rho_{xy}(-i)=0$	10.934	14.967	7.801

*denotes significance at the 5% level.

Table 5.4 Estimated Cross-Correlation Coefficients Between KOSPI Returns and Interest Rates

	DLKOSPI & DCB3Y(*i*)		
i	Entire period	Pre-opening period	Post-opening period
12	-0.016	0.011	0.015
11	0.042	0.090	-0.054
10	0.039	-0.164	0.156
9	-0.061	-0.068	-0.053
8	0.195 *	-0.044	0.348 *
7	0.105	-0.059	0.174
6	-0.073	0.080	-0.157
5	0.102	0.117	0.030
4	0.047	0.004	0.079
3	0.052	0.022	0.068
2	0.046	0.021	0.026
1	0.130	0.037	0.172
0	-0.357 *	-0.369 *	-0.397 *
-1	-0.035	0.107	-0.183
-2	0.006	-0.101	0.095
-3	-0.046	-0.003	-0.091
-4	0.037	-0.040	0.071
-5	0.126	0.154	0.108
-6	0.014	0.105	-0.029
-7	0.011	0.007	-0.037
-8	0.071	0.059	0.106
-9	-0.146	-0.111	-0.166
-10	-0.001	0.009	-0.022
-11	-0.031	-0.021	-0.039
-12	-0.075	-0.104	-0.022
	Q-statistic	Q-statistic	Q-statistic
H_0: all $\rho_{xy}(+i) = 0$	12.845	4.013	17.221
H_0: all $\rho_{xy}(-i) = 0$	8.464	5.626	9.146

* denotes significance at the 5% level.

Table 5.5 Estimated Cross-Correlation Coefficients Between KOSPI Returns and Exchange Rates

	A. DLKOSPI & DLKOUS(i)		
i	Entire period	Pre-opening period	Post-opening period
12	-0.136	-0.113	-0.076
11	-0.120	-0.227 *	0.051
10	-0.107	-0.092	-0.103
9	-0.102	-0.209	-0.042
8	-0.007	-0.156	0.084
7	-0.313 *	-0.248 *	-0.336 *
6	-0.178 *	-0.233	-0.172
5	-0.068	-0.006	-0.026
4	-0.160	-0.254 *	0.030
3	-0.113	-0.183	0.011
2	-0.091	-0.221	0.058
1	-0.215 *	-0.298 *	-0.110
0	-0.246 *	-0.225	-0.265 *
-1	-0.170	-0.382 *	0.049
-2	-0.197 *	-0.314 *	-0.078
-3	-0.115	-0.201	-0.029
-4	-0.072	-0.089	-0.033
-5	-0.070	-0.080	-0.013
-6	-0.121	-0.097	-0.160
-7	0.023	-0.164	0.219
-8	-0.078	-0.297 *	0.179
-9	-0.103	-0.164	-0.023
-10	-0.076	-0.155	-0.025
-11	-0.077	-0.100	-0.035
-12	0.063	0.009	0.094
	Q-statistic	Q-statistic	Q-statistic
H_0: all $\rho_{xy}(+i) = 0$	37.958 *	33.720 *	14.210
H_0: all $\rho_{xy}(-i) = 0$	18.371	31.377 *	9.729

	B. DLKOSPI & DLKOJP(i)		
i	Entire period	Pre-opening period	Post-opening period
12	-0.263 *	-0.170	-0.334 *
11	-0.118	-0.132	-0.126
10	-0.019	-0.029	-0.066
9	0.157	0.234 *	0.062

8	0.007	-0.064	0.111
7	-0.062	-0.100	0.050
6	-0.120	-0.253 *	0.088
5	0.068	0.083	0.097
4	0.051	-0.087	0.262 *
3	-0.111	-0.198	-0.004
2	-0.033	-0.020	-0.072
1	-0.149	-0.248 *	-0.005
0	-0.002	0.017	-0.024
-1	0.048	0.150	-0.127
-2	0.023	-0.004	0.096
-3	0.057	0.001	0.136
-4	0.007	-0.027	0.053
-5	0.131	0.187	0.119
-6	0.010	-0.015	0.070
-7	-0.066	-0.175	0.150
-8	-0.111	-0.130	-0.055
-9	0.032 .	0.030	0.065
-10	0.091	0.145	0.027
-11	0.059	0.060	0.008
-12	0.127	0.110	0.079
	Q-statistic	Q-statistic	Q-statistic
H_0: all $\rho_{xy}(+i)=0$	23.288 *	20.454	18.953
H_0: all $\rho_{xy}(-i)=0$	9.451	10.054	7.539

* denotes significance at the 5% level.

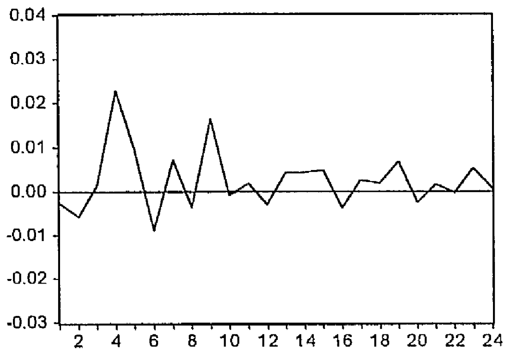
Table 5.6 VAR Estimations in the Pre-Opening Period: Jan. 1987 – Dec. 1991

	DLKOSPI	DLM2SAA	DLKOUS	DEXPIMP	DCB3Y
DLKOSPI(-1)	-0.594 (-2.95) *	0.053 (0.80)	-0.006 (-0.24)	0.086 (0.31)	1.433 (0.61)
DLKOSPI(-2)	-0.237 (-1.20)	-0.066 (-1.03)	0.012 (0.46)	-0.032 (-0.12)	-1.639 (-0.71)
DLKOSPI(-3)	-0.110 (-0.56)	0.035 (0.54)	0.002 (0.07)	0.078 (0.29)	-2.794 (-1.22)
DLKOSPI(-4)	-0.016 (-0.08)	0.062 (1.01)	0.006 (0.26)	0.087 (0.33)	-1.863 (-0.84)
DLKOSPI(-5)	0.514 (2.88) *	-0.009 (-0.15)	-0.006 (-0.25)	-0.145 (-0.59)	-3.734 (-1.80)
DLKOSPI(-6)	0.241 (1.41)	0.002 (0.03)	-0.014 (-0.64)	0.177 (0.75)	-1.931 (-0.97)
DLM2(-1)	-1.555 (-2.28) *	-0.226 (-1.01)	0.087 (1.00)	-0.580 (-0.61)	3.930 (0.49)
DLM2(-2)	-1.744 (-2.40) *	0.121 (0.51)	0.214 (2.29) *	-0.897 (-0.89)	5.120 (0.60)
DLM2(-3)	-1.840 (-2.55) *	-0.184 (-0.78)	-0.002 (-0.02)	-0.139 (-0.14)	0.634 (0.08)
DLM2(-4)	-0.390 (-0.57)	-0.057 (-0.25)	0.058 (0.66)	0.449 (0.47)	-4.865 (-0.61)
DLM2(-5)	0.694 (1.06)	-0.300 (-1.40)	0.109 (1.30)	-0.908 (-1.00)	-9.581 (-1.25)
DLM2(-6)	0.937 (1.46)	0.008 (0.04)	0.028 (0.34)	-0.506 (-0.57)	-19.113 (-2.56) *
DLKOUS(-1)	-1.553 (-0.90)	0.103 (0.18)	0.505 (2.29) *	1.151 (0.48)	8.111 (0.41)
DLKOUS(-2)	-3.939 (-2.28) *	0.133 (0.24)	-0.061 (-0.28)	1.923 (0.80)	27.382 (1.36)
DLKOUS(-3)	-1.810 (-0.97)	-0.038 (-0.06)	0.206 (0.86)	1.137 (0.44)	-20.291 (-0.94)
DLKOUS(-4)	2.436 (1.35)	-0.553 (-0.94)	-0.224 (-0.97)	-1.007 (-0.40)	-32.376 (-1.55)
DLKOUS(-5)	0.517 (0.27)	0.401 (0.64)	0.388 (1.56)	-1.094 (-0.41)	-17.009 (-0.76)
DLKOUS(-6)	1.084 (0.68)	0.278 (0.54)	-0.021 (-0.10)	-0.396 (-0.18)	-1.275 (-0.07)
DEXPIMP(-1)	-0.264 (-1.60)	0.100 (1.86)	0.004 (0.19)	-0.465 (-2.04) *	0.241 (0.13)
DEXPIMP(-2)	-0.272 (-1.42)	0.065 (1.04)	-0.019 (-0.79)	-0.179 (-0.68)	2.354 (1.05)
DEXPIMP(-3)	0.126 (0.68)	-0.086 (-1.41)	-0.021 (-0.89)	-0.075 (-0.29)	1.261 (0.58)
DEXPIMP(-4)	0.313 (1.76)	0.037 (0.64)	-0.028 (-1.23)	0.038 (0.15)	-1.549 (-0.74)
DEXPIMP(-5)	0.165 (0.92)	0.019 (0.32)	-0.008 (-0.35)	0.019 (0.08)	0.218 (0.10)
DEXPIMP(-6)	0.194 (1.16)	-0.003 (-0.06)	-0.036 (-1.67)	0.158 (0.68)	-0.815 (-0.42)

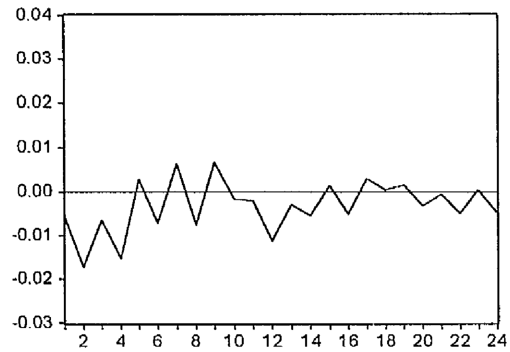
DCB3Y(-1)	0.019 (1.09)	0.003 (0.52)	0.000 (0.12)	-0.023 (-0.95)	-0.058 (-0.28)
DCB3Y(-2)	0.007 (0.40)	0.002 (0.33)	0.001 (0.22)	-0.011 (-0.43)	-0.244 (-1.16)
DCB3Y(-3)	-0.005 (-0.27)	0.006 (1.11)	-0.001 (-0.44)	0.036 (1.51)	0.078 (0.39)
DCB3Y(-4)	0.003 (0.19)	-0.002 (-0.31)	-0.002 (-0.66)	0.036 (1.46)	-0.180 (-0.86)
DCB3Y(-5)	0.066 (3.49) *	-0.003 (-0.54)	-0.003 (-1.42)	-0.019 (-0.72)	-0.518 (-2.37) *
DCB3Y(-6)	0.033 (1.42)	0.001 (0.14)	0.003 (0.95)	0.013 (0.39)	-0.279 (-1.03)
C	0.043 (1.20)	0.024 (2.02) *	-0.007 (-1.54)	0.024 (0.48)	0.646 (1.54)

t-statistics are shown in parentheses.
* denotes significance at the 5% level.

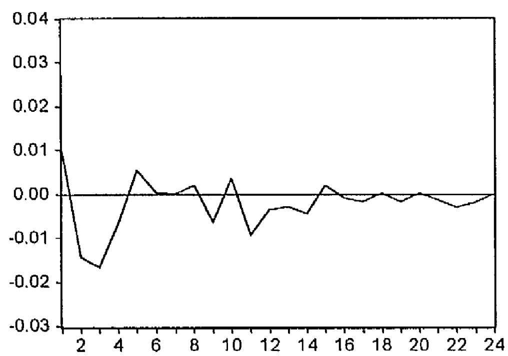
Figure 5.2 Impulse Response Functions for KOSPI Returns and Macro Variables in the Pre-Opening Period



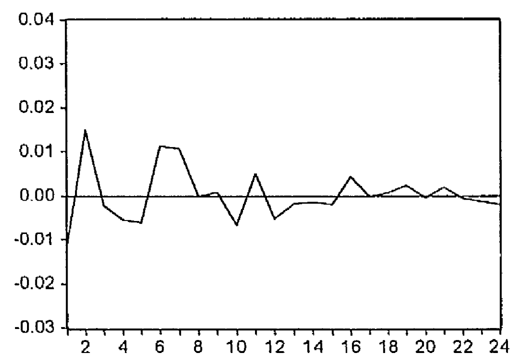
Response of DLKOSPI to DEXPIMP



Response of DLKOSPI to DLM2



Response of DLKOSPI to DLKOUS



Response of DLKOSPI to DCB3Y

Response of DLKOSPI to DLKOSPI

Table 5.7 Variance Decompositions in the Pre-Opening Period

A. Variance Decomposition of DEXPIMP:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.051	100.000	0.000	0.000	0.000	0.000
3	0.060	91.207	1.539	2.476	3.393	1.385
6	0.067	75.540	3.186	2.776	12.466	6.032
12	0.071	70.826	6.033	3.122	13.483	6.535
24	0.074	69.531	6.606	3.230	14.171	6.463

B. Variance Decomposition of DLM2:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.012	3.259	96.741	0.000	0.000	0.000
3	0.014	16.562	75.822	0.224	0.739	6.654
6	0.017	29.785	59.146	2.221	1.158	7.689
12	0.018	28.753	55.793	2.832	3.705	8.918
24	0.018	29.247	54.984	2.911	4.217	8.641

C. Variance Decomposition of DLKOUS:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.005	17.465	1.155	81.379	0.000	0.000
3	0.006	17.050	24.627	57.309	0.092	0.922
6	0.008	22.512	28.354	45.981	2.045	1.107
12	0.008	24.599	27.316	43.018	2.979	2.088
24	0.009	26.178	28.068	40.781	2.903	2.070

D. Variance Decomposition of DCB3Y:

Period	Std Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.431	0.152	3.630	5.249	90.970	0.000
3	0.479	1.945	6.278	12.164	75.882	3.731
6	0.542	5.384	6.131	12.625	68.219	7.641
12	0.612	9.346	14.849	12.669	56.639	6.496
24	0.633	10.072	16.248	12.287	54.789	6.603

E. Variance Decomposition of DLKOSPI:

Period	Std Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.037	0.555	2.446	7.189	9.704	80.106
3	0.053	1.469	13.248	20.605	12.556	52.122
6	0.066	16.450	15.338	15.113	12.593	40.507
12	0.074	19.316	17.212	14.832	13.820	34.821
24	0.077	20.660	18.218	14.609	13.532	32.981

Ordering: DEXPIMP DLM2 DLKOUS DCB3Y DLKOSPI

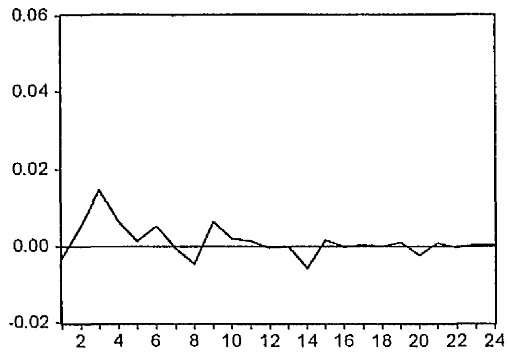
Table 5.8 VAR Estimations in the Post-Opening Period: Jan. 1992 – Jun. 1997

	DLKOSPI	DLM2	DLKOUS	DEXPIMP	DCB3Y
DLKOSPI(-1)	-0.037 (-0.22)	-0.013 (-0.38)	-0.002 (-0.09)	-0.027 (-0.21)	2.148 (1.27)
DLKOSPI(-2)	0.050 (0.29)	0.047 (1.32)	-0.011 (-0.49)	0.006 (0.04)	0.192 (0.11)
DLKOSPI(-3)	-0.070 (-0.40)	-0.011 (-0.31)	-0.003 (-0.14)	-0.058 (-0.43)	1.663 (0.94)
DLKOSPI(-4)	-0.049 (-0.28)	0.006 (0.17)	0.002 (0.09)	-0.014 (-0.11)	-1.186 (-0.69)
DLKOSPI(-5)	-0.056 (-0.33)	0.043 (1.25)	-0.033 (-1.44)	0.080 (0.63)	1.268 (0.75)
DLKOSPI(-6)	0.134 (0.73)	0.018 (0.48)	-0.026 (-1.07)	-0.180 (-1.29)	-1.763 (-0.96)
DLM2(-1)	-0.663 (-0.83)	-0.414 (-2.54) *	0.216 (2.00) *	-0.003 (-0.01)	14.313 (1.78)
DLM2(-2)	-0.558 (-0.62)	-0.204 (-1.13)	0.062 (0.52)	-0.887 (-1.31)	12.516 (1.40)
DLM2(-3)	-0.090 (-0.10)	-0.253 (-1.35)	0.202 (1.62)	0.207 (0.30)	10.111 (1.10)
DLM2(-4)	-0.018 (-0.02)	-0.194 (-1.01)	0.102 (0.81)	-0.147 (-0.20)	-2.178 (-0.23)
DLM2(-5)	-0.168 (-0.19)	-0.038 (-0.21)	-0.165 (-1.38)	-0.840 (-1.24)	5.672 (0.64)
DLM2(-6)	-1.260 (-1.48)	0.120 (0.70)	0.001 (0.01)	-0.642 (-1.00)	9.022 (1.06)
DLKOUS(-1)	0.003 (0.00)	0.088 (0.36)	0.119 (0.74)	-0.017 (-0.02)	7.421 (0.62)
DLKOUS(-2)	-0.317 (-0.27)	-0.016 (-0.07)	0.132 (0.85)	0.439 (0.50)	-10.800 (-0.93)
DLKOUS(-3)	0.121 (0.10)	0.206 (0.87)	-0.025 (-0.16)	-0.516 (-0.58)	-1.836 (-0.16)
DLKOUS(-4)	-0.394 (-0.30)	0.110 (0.42)	0.026 (0.15)	0.399 (0.41)	5.379 (0.42)
DLKOUS(-5)	-0.074 (-0.06)	-0.127 (-0.52)	0.000 (0.00)	1.883 (2.05) *	11.834 (0.98)
DLKOUS(-6)	-0.931 (-0.75)	0.305 (1.21)	0.185 (1.11)	-0.577 (-0.61)	-17.440 (-1.40)
DEXPIMP(-1)	0.142 (0.65)	-0.008 (-0.18)	-0.034 (-1.14)	-0.608 (-3.64) *	-3.663 (-1.66)
DEXPIMP-2)	0.489 (1.82)	-0.034 (-0.63)	-0.088 (-2.45) *	-0.361 (-1.77)	-5.787 (-2.15) *
DEXPIMP(-3)	0.409 (1.25) *	-0.068 (-1.03)	-0.071 (-1.61)	-0.011 (-0.05)	-2.590 (-0.80)
DEXPIMP(-4)	0.257 (0.76)	-0.081 (-1.17)	-0.062 (-1.36)	0.107 (0.41)	-0.050 (-0.02)
DEXPIMP(-5)	0.241 (0.72)	-0.052 (-0.76)	-0.026 (-0.58)	-0.036 (-0.14)	-0.487 (-0.15)

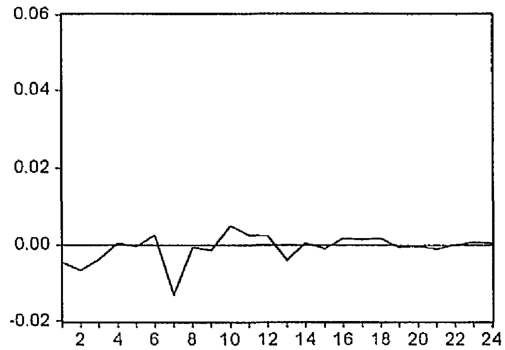
DEXPIMP(-6)	0.211	-0.056	-0.043	0.004	-0.035
	(0.82)	(-1.08)	(-1.24)	(0.02)	(-0.01)
DCB3Y(-1)	-0.007	-0.003	0.002	-0.008	0.010
	(-0.43)	(-0.87)	(0.76)	(-0.65)	(0.06)
DCB3Y(-2)	0.007	0.004	-0.006	0.008	0.019
	(0.45)	(1.33)	(-2.76) *	(0.62)	(0.12)
DCB3Y(-3)	0.000	0.000	-0.003	0.005	0.229
	(0.01)	(-0.05)	(-1.28)	(0.34)	(1.20)
DCB3Y(-4)	0.011	-0.004	0.000	0.010	-0.149
	(0.59)	(-1.06)	(0.02)	(0.69)	(-0.76)
DCB3Y(-5)	0.004	0.001	-0.002	-0.001	-0.136
	(0.20)	(0.38)	(-0.76)	(-0.10)	(-0.76)
DCB3Y(-6)	-0.008	-0.001	0.001	-0.006	0.244
	(-0.44)	(-0.23)	(0.35)	(-0.48)	(1.43)
C	0.044	0.024	-0.005	0.029	-0.717
	(0.97)	(2.66) *	(-0.85)	(0.84)	(-1.60)

t-statistics are shown in parentheses.
* denotes significant at the 5% level.

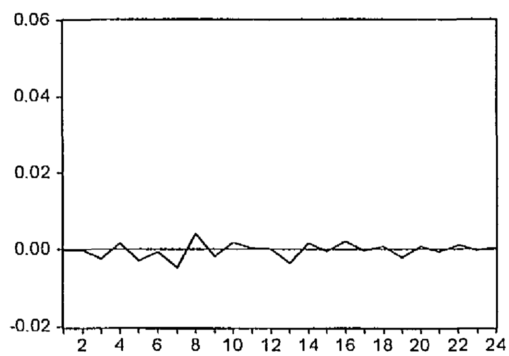
Figure 5.3 Impulse Response Functions for KOSPI Returns and Macro Variables in the Post-Opening Period



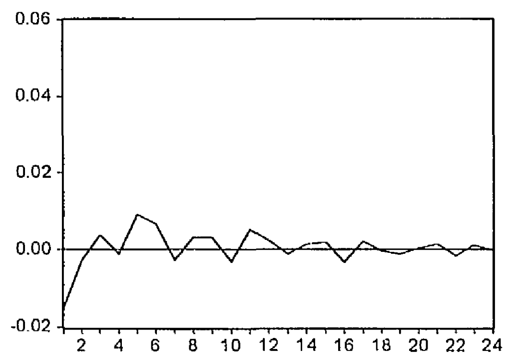
Response of DLKOSPI to DEXPIMP



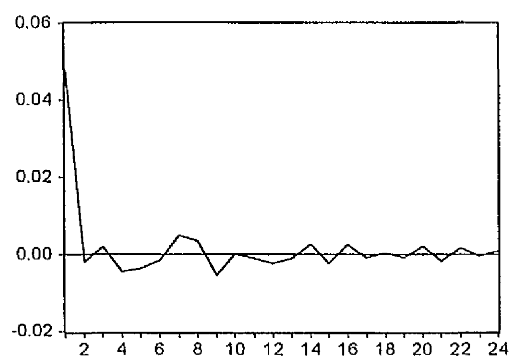
Response of DLKOSPI to DLM2



Response of DLKOSPI to DLKOUS



Response of DLKOSPI to DCB3Y



Response of DLKOSPI to DLKOSPI

Table 5.9 Variance Decompositions of KOSPI Returns in the Post-Opening Period

A. Variance Decomposition of DEXIMSAA:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.039	100.000	0.000	0.000	0.000	0.000
3	0.047	92.879	4.155	0.497	2.385	0.085
6	0.052	77.524	11.751	4.745	2.429	3.551
12	0.058	64.279	10.733	6.841	7.745	10.402
24	0.059	62.581	10.802	6.929	8.438	11.249

B. Variance Decomposition of DLM2:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.010	2.298	97.702	0.000	0.000	0.000
3	0.012	3.892	87.506	0.156	4.595	3.852
6	0.013	4.985	79.257	3.015	6.831	5.912
12	0.013	6.403	72.324	6.116	7.965	7.192
24	0.014	6.803	69.801	7.176	8.533	7.687

C. Variance Decomposition of DLKOUS:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.007	3.846	0.515	95.639	0.000	0.000
3	0.008	10.991	8.219	66.933	13.509	0.348
6	0.009	9.428	17.902	52.886	16.157	3.628
12	0.010	11.349	17.918	45.766	17.256	7.712
24	0.010	11.669	18.232	44.621	17.376	8.102

D. Variance Decomposition of DCB3Y:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.511	3.394	0.407	1.018	95.181	0.000
3	0.580	12.792	7.503	2.470	74.026	3.208
6	0.625	12.038	7.713	4.011	68.372	7.866
12	0.708	9.551	10.348	7.337	60.766	11.999
24	0.728	10.141	10.758	7.440	59.329	12.332

E. Variance Decomposition of DLKOSPI:

Period	Std. Error	DEXPIMP	DLM2	DLKOUS	DCB3Y	DLKOSPI
1	0.051	0.399	0.845	0.010	9.162	89.584
3	0.054	8.472	2.835	0.218	8.837	79.639
6	0.057	10.004	2.821	0.568	11.974	74.634
12	0.060	10.614	8.245	1.696	12.289	67.157
24	0.062	11.320	8.678	2.351	12.495	65.155

Ordering: DEXPIMP DLM2 DLKOUS DCB3Y DLKOSPI

* denotes significance at the 5% level.

6 Total Returns in Developed and Emerging Markets in the Pacific Basin

6.1 Introduction

There is considerable interest in relationships between national equity markets. This interest has been stimulated by the globalisation of financial markets, the gradual relaxation and abolition of controls on international capital movements, and international investment associated with portfolio diversification. However, the empirical evidence on long-run relationships in the Pacific-Basin yields conflicting results.

Coray, Rad and Urbain (1995) investigate the long-run relationship between the stock price indices of five developed, Pacific Basin equity markets, Australia, Hong Kong, Japan, Singapore and New Zealand using monthly data for the period 1972_2 - 1992_2. Using Johansen cointegration tests based on a VAR(6) they find a single cointegration vector for the five stock markets. In a vector error correction framework, the long-run equilibrium relationship between stock price indices enters the equations for Japan, Hong Kong and Singapore, but not those for Australia and New Zealand; within the region, geographical separation plays a significant role.

Hung and Cheung (1995) use weekly data over the period from January 1981 to December 1991 for three emerging equity markets, Korea, Malaysia and Taiwan and two developed markets, Hong Kong and Singapore.[18] Using data in local currency, they find no cointegrating vectors for either the full sample period or the two sub-periods before- and after the 1987 crash. Using VAR(3) and US$ adjusted series, they find three cointegrating vectors for the four-year period after the 1987 crash, November 1987 – December 1991. Further investigation of the five exchange rates against he US$ finds three cointegrating vectors for the same period. The common-currency long run equilibria appear to result from common responses to the depreciation of the US$ in the late 1980s.

An investigation for the earlier period by Chan, Gup and Pan (1992) using local currency provides consistent results. They use both daily and weekly data for the period February 1983 – May 1987 in a study of linkages between the stock markets of Hong Kong, Japan, Korea, Singapore, Taiwan and the United States. Both bivariate and multivariate Engle Granger cointegration tests using ADF(4) and ADF(6) statistics carried out. No evidence of cointegration is found.

These results contrast with those found by Kwan, Sim and Cotsomitis (1995) who use monthly data denominated in local currencies for the Pacific Basin markets of Australia, Hong Kong, Japan, Korea, Singapore, together with Germany, the United Kingdom and the United States. This study implements Engle-Granger tests for the sample period 1982_1 – 1991_2. Within the Pacific-Basin region they find bivariate cointegration between Hong Kong and Taiwan, Japan and Korea, Korea and Taiwan and Singapore and Taiwan. Mulivariate tests find no cointegration between

[18] Huang and Cheung classify all of their markets as 'emerging'. However, in this thesis the definition provided by the International Finance Corporation is used: an emerging stock market is one which satisfies two criteria: (i) it is located in an economy with GNP per head not exceeding the threshold adopted by the World Bank for classification as 'high income' (US$ 9,656 in 1997) and (ii) the investable market capitalisation to GDP ratio is low recent years.

Hong Kong, Korea, Singapore and Taiwan but if *either* Japan *or* Germany *or* the UK *or* the US is additionally included then the null of no cointegration is rejected.

There is conflicting evidence between tests in local currency of Hung and Cheung and Kwan, Sim and Cotsomitis. These papers differ in their sample periods (by only one year and ten months), the frequency of the data employed, weekly and monthly, and the types of test implemented, Johansen and Engle-Granger. Given the countries selected for these studies, there is potential for supporting results in three of the four bivariate tests of cointegration. This is not found. However, there is consistency between the lack of cointegration between Hong Kong, Korea, Singapore and Taiwan and between these four markets with Malaysia additional included. In multivariate tests it would seem important for developed markets also to be included.

This chapter re-examines the question of the interdependence of Pacific Basin equity markets. It extends the previous literature in five principal ways. First, a larger set of stock markets is considered: eleven Pacific Basin markets are examined. Second, both developed and emerging markets are included in the tests together with those of the UK and the US. Third, data on total returns is used; this includes dividends paid and reinvested, since these are what matter to international investors. Fourth, a common currency, the US$, is used. Previous results of work in local currency and in a common currency differ. Where exchange rates change significantly it would seem important not to ignore currency risk by using equity prices denominated in local currency. Fifth, the data span the period of Asian financial market crises. Consequently so unit root tests which allow for a possible crash are used. Also, tests of cointegration are carried out for two periods: the first period ends immediately before Black Wednesday on the Bangkok stock exchange, the start of the Asian crisis, and the entire sample ends in April 2000. In this chapter, therefore, preliminary results of the consequences of the Asian crisis for long-run equilibria between stock markets in the region are reported.

The rest of this chapter is organised as follows. Section 6.2 describes the model of international returns and the empirical methodology employed. Section 6.3 describes the equity markets and their characteristics and section 6.4 discusses the data and their properties. In section 6.5 the results are presented. Section 6.6 provides a brief conclusion.

6.2 International Returns: The Model and Methodology

The extent to which stock markets are linked internationally depends upon whether they are integrated or segmented. With integrated markets, prices of domestically traded equities depend on international factors. In segmented markets, equity prices are determined by purely domestic considerations. To examine the extent to which national stock markets are segmented or integrated this chapter draws on Solnik (1974) in which the international asset pricing model is represented by two equations which relate the price of a security to domestic and world factors respectively. Assuming a common currency and hence a common world risk-free rate of interest, ρ, then for security ji of country j

$$Dr_{ji} = \rho + \alpha_{ji}(Dr_j - r_w) \qquad \forall\ i \text{ and } j \qquad (6.1)$$

in which Dr_{ji} is the required return on the equity market of country j. Dr_j is the required return on country j's market portfolio and α_{ji} is the domestic systematic risk of security ji.

For national stock market, consider

$$Dr_j = \rho + \beta_{ji}(Dr_w - \rho) + u_j \qquad \forall\ j \qquad (6.2)$$

in which Dr_j is the required return on the equity market of country j, Dr_w is the required return on the world market portfolio and β_j is the *international* systematic risk of country j. The term v_j represents factors specific to country j. Substituting (6.2) into (6.1) gives

$$Dr_{ji} = \rho + \beta_{ji}(Dr_w - \rho) + u_j \tag{6.3}$$

where $\beta_{ji} = \alpha_{ji}\beta_j$ is the international systematic risk of security ji and $u_j = \alpha_{ji}v_j$. If v_j = 0 then u_j = 0 and equity markets are integrated since the required return on the domestic security corresponds to that on the world market portfolio.

A simple test of the importance of country-specific factors is provided by correlation coefficients. Using data on returns on a national market and world returns, Dr_I and Dr_w, a low correlation coefficient implies country-specific factors are important. The larger the correlation coefficient the more integrated is the national market with world markets. This test, however, focuses on short-run, contemporaneous correlations and does not capture any long-run equilibria. To examine the latter we use tests of cointegration.

The returns on national and world equity markets Dr_{It} and Dr_{wt} are given by Δr_{It} and Δr_{wt} respectively, where r_I and r_w are the logarithms of the respective total returns indices. Long run integration implies a linear relationship between the total returns indices. Equation (6.3) implies a long run relationship between r_I and r_w such that

$$r_{1t} - a_1 r_{wt} = r_{1t-1} - a_1 r_{wt-1}$$

or $$r_1 = \gamma_1 + \gamma_2 r_w + \varepsilon \tag{6.4}$$

since in long-run equilibrium $r_{jt} = r_{jt-1} = r_j$. The parameter γ_1 a constant scalar and ε is a random variable representing country-specific factors which may distort the long-run relationship in the short run. That is, long run integration implies a linear relationship between the logarithms of the total returns indices. However, in the short run, this may be affected by factors specific to each of the two markets. Usually total returns indices are I(1) therefore for equation (6.4) to be a valid long-run relationship ε must be I(0) and so r_1 and r_w must be cointegrated. Thus if a set of equity markets is closely integrated then there should be more cointegrating vectors than if the set of market is segmented.

Three tests of cointegration are used. First, the Engle-Granger cointegrating regression augmented Dickey-Fuller (CRADF) test based on the residuals of the cointegrating regression (6.4) is used. However, if total returns are cointegrated then they are generated by error correction models (ECMs), and conversely, (Engle and Granger, 1987). Therefore following Bannerjee *et al* (1993) the second test is based upon the '*t*' statistic associated with the estimated coefficient $\hat{\beta}_4$ in the simple ECM

$$\Delta r_1 = \beta_1 + \beta_2 \Delta r_w + \beta_3 [r_1 - r_w]_{t-1} + \beta_4 r_{wt-1} + \varepsilon_{1t}. \qquad (6.5)$$

The third test utilises the Johansen Method is used (see Johansen, 1988). Consider a *k*th order vector autoregression model, VAR(k), for n variables each integrated of order one

$$X_t = \mu + A_1 X_{t-1} + \cdots + A_k X_{t-k} + \varepsilon_t \qquad t = 1, \ldots, T \qquad (6.6)$$

in which X_t is an $n \times 1$ vector of variables, μ is a $n \times 1$ vector of constants, the A_i are $n \times n$ matrices of parameters and ε_t is a $n \times 1$ vector of *iid* Gaussian processes.

The error correction form of this general VAR is

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \varepsilon_t \qquad t = 1, \ldots, T \qquad (6.7)$$

in which Γ_i and Π are $n \times n$ matrices of unknown parameters. The hypothesis of cointegration can be expressed as $\Pi = \alpha \cdot \beta'$ in which the rank of the matrix Π is z where $z \leq n-1$ and the matrices α and β have full rank of order $n \times z$. If the rank of Π is z where $z \leq n-1$ then there are z linearly independent cointegrating vectors. We use Johansen's likelihood ratio test based on the trace of the stochastic matrix for the full hypothesis that there are at most z cointegrating vectors, $0 \leq z < n$

$$\lambda_{trace} = -T \sum_{i=r+1}^{p} \ln(1-\hat{\lambda}_i) \qquad z = 0, 1, 2, \ldots, n-2, n-1. \qquad (6.8)$$

where the $\hat{\lambda}_i$ are the $n-z$ smallest squared canonical correlations between ΔX_t and X_{t-k} (adjusted for all intervening lags). With z cointegrating vectors, there are $n-z$ common stochastic trends driving the system. That is, a large number of cointegrating vectors among a set of integrated stock markets is associated with those markets sharing a small number of stochastic common trends.

6.3 The Equity Markets

The eleven Pacific Basin stock markets investigated in this chapter comprise of five developed markets, Australia, Hong Kong, Japan, New Zealand, Singapore and six emerging markets, Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand. Table 6.1 reports market capitalisation for 1988 and 1998 for these markets together with, comparative purposes, those of the United Kingdom and United States. Capitalisation varies considerably across markets and through time. It has increased between these two years, in US$ terms, for all of the markets except Japan. The three largest markets throughout the period are Japan, Australia and Hong Kong and the two smallest are Indonesia and the Philippines. Capitalisation, in US$ terms, has grown fastest in the emerging markets. At the beginning of the period, all of the developed markets were larger than the emerging markets. By 1998, three emerging markets (Korea, Taiwan and Malaysia) had larger capitalisation than the smallest Pacific Basin developed markets (New Zealand and Singapore). Market liquidity, measured by turnover ratio, also varies widely, particularly among emerging markets. As presented in Table 6.1, the turnover ratios of Taiwan (330% in 1988 and 323% in 1998) and Korea (128% in 1988 and 176% in 1988) were much higher than those of Japan, the United Kingdom and the United States, which indicates that those two markets are the most actively traded markets in the world. Of all of the markets reported in Table 6.1, the three most liquid are Taiwan, Korea and Thailand while Indonesia and Malaysia have relatively illiquid markets.

The extent to which the stock markets are regulated varies considerably and has changed through time. At one extreme is the Hong Kong market which is one of the most open in the world: there are no restrictions on foreign portfolio investment in the market; there is complete flexibility in the movement of capital, repatriation of funds and remittance of dividends and there are no exchange control regulations. The developed markets of Australia, Japan, New Zealand and Singapore have also been largely unrestricted throughout the sample period. While the Philippines market is also largely unrestricted, in other emerging markets the process of liberalisation generally started later than in the developed markets; Indonesia (liberalised from December 1987), Malaysia (exchange controls liberalised in 1991) and Thailand (liberalised in spring 1990) have relatively few restrictions. In Malaysia, exchange controls were liberalised in 1991 but, following the Asian financial crisis, restrictions were imposed on equities. In September 1998 a twelve-month holding period for equities was imposed. In February 1999, this was replaced with a levy of 10-30% (depending on holding period) to be paid on repatriation of capital.

In two of the historically most restricted markets, Korea and Taiwan, the liberalisation process has been gradual. The Korean experience is typical with restrictions on the individual/aggregate foreign ownership of domestic shares being relaxed at intervals of several months from 3%/ 12% in December 1994 to 6%/23% in May 1997 and 50%/55% after IMF intervention in December 1997. This has been associated with gradual changes to limits in daily stock price changes. These limits ere relatively fixed over a range from ±2.3% to ±5% of the previous day's closing prices, the base prices, until April 1995. The system then formally expressed in absolute limits was modified to a fixed percentage rate system with a daily price limit of ±6% of base prices; this became ±8% in November 1996, ±12% in March 1998 and ±15% the following December. The Taiwan stock market has operated a similar system. The ceiling on individual/aggregate foreign ownership of a listed company was 10%/25% in 1996 and became 15%/30% early in 1998. Foreign share ownership of equities on this market is low and relatively stable lying within the range from 7.01% to 8.69% for 1990-1996, and 8.43% by the end of 1997. The limit on daily stock price changes was ±5% of the closing stock price on the previous business day for the nine years to October 1987. The limit was tightened to ±3% for the following year, because the market was 'too hot', and then gradually relaxed to ±5% on 14 November 1988 and ±7% on 11 October 1989.

Many other countries impose maximum limits (of varying degrees) on the foreign ownership of domestic companies either as a general restriction on individual/aggregate foreign ownership on all companies (for example, Australia 15%/40% of share capital) or on foreign ownership in specific sectors, for example, Malaysia (banking ≤ 30%), Philippines (industries traditionally reserved for Filipinos: retail trade, mass media, rural banks, most professions) and Singapore (finance, newspaper and airline companies).[19]

6.4 The Data and Their Properties

The stock market indices used in this paper are total returns indices, which cover both equity prices and dividends paid and reinvested. Indices of this type are frequently used in measuring performance. The percentage change in a total returns index measures the total return in terms of the change in the capital value of the index and the reinvestment of gross dividend income in additional units of the index. For all of the Pacific Basin equity markets in the sample and the World, *Datastream Total Market Indices* (datatype RI) are used. For the UK and the US markets, total returns on the FTA All-share index and total returns on the Standard and Poor's 500 Composite Index, respectively, are used. All series are expressed in a common currency, the US$, for comparability. The observations are weekly and cover the period from 4 May 1988 until 12 April 2000 (624 observations) except the Philippines data for which is available form 9 November 1988 (597 observations) and those of Indonesia which start on 4 April 1990 (524 observations). The start of the sample period was determined by the availability of the total returns index for Taiwan. The data refer to Wednesdays to minimise any possible day-of-the-week effects; the source is *Datastream*. The series include the crash of the Bangkok Stock Exchange on Wednesday 2 July 1997 and subsequent crises affecting other markets in the region. The presence of these events in the data may affect our statistical results and so we allow for this possibility.

Tables 6.2 and 6.3 report correlation coefficients for the first differences of the

[19] See Appendix 6.1 for further details.

logarithms of each total returns index, which are the one-period total returns from investing in each market, for the period to 25 June 1997 and the entire period respectively. Irrespective of time period, almost all of the correlation coefficients involving world returns are significantly different from zero—the exception involves the Taiwan market. The equity markets most influenced by country-specific factors are Taiwan and the Philippines. All correlation coefficients involving the Taiwan market are insignificantly different from zero. For the Philippines, only correlations with world returns and, for the full period only, returns on the Japanese market are significant. The Philippines and Taiwanese markets are particularly affected by local, rather than international, news resulting in low correlations of returns with other markets whether developed or emerging. In general, contemporaneous correlations are greater between stock markets within a geographical region than they are between markets in different regions. The markets of Australia and New Zealand illustrate this regional effect with a correlation coefficient of 0.53 largely unaffected by the Asian stock market crises. A further regional effect involves the markets of Singapore, Malaysia, Indonesia, and Thailand. There is, however, negligible regional effect evident for the stock markets of Japan and Korea. This is not surprising because over most of the sample period the Korean market is one of the least liberalised with few Japanese investors trading in it. Indeed correlations involving returns on the Korean market are generally low but are significantly different from zero except where Taiwan and the Philippines are involved.

Table 6.4 reports Phillips-Perron tests for the logarithms of the US$-adjusted total returns indices for the entire period. In implementing these tests we test sequentially from the general model

$$Y_t = \tilde{\mu} + \tilde{\beta}\left(t - \frac{T}{2}\right) + \tilde{\alpha}Y_{t-1} + \tilde{\varepsilon}_t \quad (6.9)$$

to the more specific models

$$Y_t = \mu^* + \alpha^* Y_{t-1} + \varepsilon_t^* \quad (6.10)$$

and

$$Y_t = \hat{\alpha}Y_{t-1} + \hat{\varepsilon}_t. \quad (6.11)$$

The standard notation follows Perron (1988). The results can be summarised concisely: the returns index for the Australian market is trend stationary and all of the other series are I(1).

The conventional Phillips-Perron approach is widely used in tests of stochastic nonstationarity for financial time series. However, these conventional tests of the unit root hypothesis against trend stationary alternatives frequently fail to reject the null if the true data generating process is characterised by stationary fluctuations around a trend with a single shift in either its intercept or its slope or both, Perron (1989). The Asian financial market crises from mid-1997 could be associated with shifts in the intercept of the trend function—a crash. Graphs of the series suggest particularly marked downward shifts in the intercept for Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand in the last half of 1997 and for Taiwan in the period from October 1990 through to May 1991.

Clearly, tests of the unit root hypothesis should allow for a possible crash. Two sets of tests re reported. First, Perron (1989) unit root tests with an exogenous time break, T_b. These are based on Perron's model A which captures a single shift in the level of the series. The unit root null hypothesis is characterised by a dummy variable which takes the value one at the time of the break

$$y_t = \mu + \delta D(T_b)_t + y_{t-1} + \varepsilon_t, \quad (6.12)$$

in which T_b is the period when the change on the parameter occurs and $D(T_b)_t = 1$ if $t = T_b + 1$ otherwise $D(T_b)_t = 0$. The trend stationary alternative hypothesis allows for a once-and-for-all shift in the intercept of the trend function

$$y_t = \mu_t + \beta_t + (\mu_2 - \mu_1)DU_t + \varepsilon_t, \tag{6.13}$$

where $DU_t = 1$ if $t > T_b$ otherwise $DU_t = 0$.

Table 6.5 provides results based on the regression model

$$y_t = \hat{\mu} + \hat{\theta}DU_t + \hat{\beta}t + \hat{\delta}D(T_b)_t + \hat{\alpha}y_{t-1} + \sum_{t=1}^{k}\hat{c}\Delta y_{t-i} + \varepsilon_t \tag{6.14}$$

with T_b set at 3 September 1997 for all series. For each series, the estimated coefficients together with t statistics for the six null hypotheses $\mu = 0$, $\theta = 0$, $\beta = 0, \delta = 0, \alpha = 0$ and $\alpha = 1$ are reported. Under the unit root null hypothesis, in general $\mu \neq 0$, $\theta = 0$, $\beta = 0, \delta \neq 0$ and $\alpha = 1$. Under the alternative hypothesis of stationary fluctuations around a deterministic trend function with a single shift in the intercept $\mu \neq 0, \theta \neq 0, \beta \neq 0, \delta = 0$ and $\alpha < 1$. Critical values for the test of the null hypothesis that $\alpha = 1$ depend on λ, the ratio of the pre-break sample size to the total sample size (Perron, 1989). Exact critical values are calculated using the response surface estimates in Carrion, Sansó and Artís (1999). The unit root hypothesis is rejected at the 0.01 level or better for two series, the returns indices for Hong Kong and Indonesia. Where the unit root hypothesis is rejected, the asymptotic distribution of the *t*-statistics for the other coefficients is standardised normal. For both series, the estimated coefficients on the constant, the post-break dummy variable and the trend are significantly different from zero. A limitation of these tests is that the dummy variables associated with the time break are exogenous and so the results are conditional on the imposed shift in the trend function. Also, the same exogenous time break for all of the series is used; a complementary approach is to let the data select the break date.

The Perron (1997) tests select T_b endogenously by minimising the t-statistic for testing $H_0: \alpha = 1$. The results are reported in Table 6.6. The unit root null hypothesis is rejected for three series: the returns indices for Hong Kong and Indonesia (confirming the findings of the previous test) and Malaysia. For these series, the estimated coefficients on the constant, the post-break dummy variable and the trend are significantly different from zero. The empirically determined time break is clearly associated with the 1997 crises in financial markets. The selected dates are 3 September 1997 for Hong Kong, 17 September 1997 for Indonesia and 25 June 1997 (one week before black Wednesday on the Bangkok Stock Exchange) for Malaysia.[20]

After allowing for a single downward shift in the trend function, these three series are described by stationary fluctuations around a deterministic trend; that is, they are characterised by deterministic nonstationary. Random shocks have only a temporary effect because fluctuations in these total return indices are transitory around a relatively stable trend path. This contrasts with the other series: under the unit root hypothesis, random shocks have a permanent effect on the system.

6.5 Empirical Results

Tests of cointegration on the postulated long-run relationship between domestic and

[20] The use of total returns indices, rather than the more-widely used stock price indices, is not the reason for the trend stationary. Using Datastream Total Market stock price indices, the unit root hypothesis is again rejected (with the same endogenous break dates) for Hong Kong, Indonesia and Malaysia. Additionally, the series for Taiwan is trend stationary; the time break is 28 march 1990 and the test statistic for $H_0: \alpha = 1$ is –5.19 which is less than the 0.05 critical value of –4.80.

world returns given by equation (6.4) for the period prior to Black Wednesday on the Bangkok Stock Exchange are reported in Table 6.7. For each country, four test statistics are reported: Engle Granger (1987) cointegrating regression ADF for regressions including (i) a contrast and (ii) a constant and a time trend; the error-correction model *t*-statistic and the Johansen trace statistic for the null of zero cointegrating vectors against the alternative of at least one. The Schwarz Bayesian criterion was used to select the order of the CRADF statistic. For the trace statistic, tests are based upon the underlying VAR(k). The order of the VAR is determined by first estimating in levels VAR(12) and then using the Schwarz Bayesian criterion and an adjusted likelihood ratio test to establish the appropriate order. The equations of the resulting VAR were then examined and, where necessary, the VAR order was increased until there was no autocorrelation.

In the pre-crash period, there is compelling evidence for not rejecting the null of no cointegration. The only exception is the ECM *t*-statistic for New Zealand. However, this result is not supported by the other three tests. This evidence of no cointegration is further supported by tests for the full sample reported in Table 6.8: not one of the test statistics rejects the no cointegration hypothesis. The result is not affected by the Asian financial market crisis.

A set of tests of bivariate cointegration between all I(1) country returns indices was also carried out. Almost all of our results, not reported here, found no cointegration either in the pre-crash or entire sample period. In particular, based on a common currency, the US$, we find no cointegration between Korea and Taiwan and Singapore and Taiwan. This contrasts with the work of Kwan, Sim and Cotsomitis (1995) who, using stock market price indices in local currency, find cointegrating vectors. However, some evidence of cointegration involving Japan and is found

Korea (see Table 6.9). Since the Korean stock market was opened up in January 1992 we also carried out the same set of four tests of bivariate cointegration between Korea and Japan for pre- and post-opening periods. As shown in Table 6.10, although some evidence of cointegration for the pre-opening period is found the results show noncointegration between the two markets in the post-opening period. One of the reasons might be the fact that since the opening up of the Korean stock market in 1992 the trading activity by foreign investors accounts for approximately 10% in terms of trading value and volume. Among foreign investors registered on the Korean Stock Exchange (KSE), Japanese investors including institutional investors and funds are accounts around 7 to 8% of the total number of foreign investors. This proportion is considerably small compared to those of the US and the UK, which account for a half of the foreign investors on the KSE, although Korea and Japan are adjacently located (see section 3.4.5 of Chapter 3 for further details). This finding implies that long-run portfolio diversification among these two markets is not beneficial because stock prices in the markets are not independent of each other. Subsequently, the so-called contagion effect might be exist, i.e. there is a danger that shocks in Japanese stock market might spill over to Korean stock market. The results could be interpreted as evidence contrasting the claim by Eun and Shim (1989) and Cheung and Mak (1992) that Japanese market is not influential even at regional level. Almost all of the results, not reported here, found no cointegration either in the pre-crash or entire sample period.

Besides, the same set of four tests of bivariate cointegration between Korea and Australia, New Zealand, the Philippines, Singapore, Taiwan, and Thailand are carried out for pre- and post-opening periods. All of the results, not reported here, show that there is no stationary long-run relationship between the equity markets of

Korea and each of the markets. This means that investing for long-term on those markets by Korean investors could be beneficial and vice versa. Overall, except some evidence involving Japan and Korea, the benefits of international diversification in this region are valid even if after the Southeast Asian financial market crisis. This suggests that the consequences of the Asian crisis for long-run equilibria between stock markets in the region are insignificant.

In addition, mutivariate cointegration in which all seven I(1) series are included together with the World total returns index is tested. The results are reported in Table 6.11. For the pre-crash period, evidence from trace tests suggests that there is at most one cointegrating vector and hence seven stochastic common trends driving the system. Including the post-period of the Asian financial crisis does change the results. There are now two cointegrating vectors and, therefore six common trends. Further we carried out two sets cointegration tests including only the developed markets or emerging markets along with the World total returns index for the pre-crash and entire periods. However the results, not reported here, found no cointegrating vector in either set.

In summary, given the number of variables, the number of cointegrating vectors is small and this general result is largely unaffected by the Asian financial crisis. This is highlighted by focusing on the number of trends. With n number of I(1) series and z number of cointegrating vectors, if $z = 0$ there are n trends and no shared trends. That is, the logarithms of the return indices are unrelated in the long-run. On the other hand, if $0 < z < n$ then there are $n - z$ shared trends. If $0 < z = n - 1$ there is one shared trend and the set of stock markets is integrated in a long-run statistical sense. If $0 < z < n - 1$ then there is more than one shared trend and the set of stock markets can be viewed as being partially integrated: the larger the number of shared trends the weaker the degree of market integration. As shown in Table 6.11, for the Pacific Basin as a whole, there are at least seven common stochastic trends in the pre-crash period whereas there are at least six shared trends in the entire period including the Asian crisis. Finding at least one cointegrating vector either in the pre-crash or in the entire periods, it is shown that stock markets in this region are collectively linked in the long-run.

All in all, integration of the stock markets in the Pacific Basin might be accelerated (i) more and more emerging markets are matured in terms of capitalisation, liquidity, deregulation on foreign ownership, institutional features; (ii) liberalisation on financial markets including foreign exchange markets are accelerated; (iii) mergers and strategic alliances among stock exchanges in different countries happen; and (iv) cyber stock trading on the internet readily available to international investors because this new generation of stock trading method provide real time information on other stock markets and remote stock trading as long as the internet is connected.

6.6 Conclusions

This chapter investigates long-term equilibrium among eleven emerging and developed stock markets in the Pacific Basin over the period starting in March 1988 and ending in April 2000, a period spanning the Asian financial market crises. For the analysis total returns indices, which included dividends paid and reinvested, are used. The results of unit root tests, which allow for a possible crash, find that four of our series, those for Australia, Hong Kong, Indonesia and Malaysia are trend stationary and so random shocks only have a temporary effect on these returns. Based on a common currency, the US$, no cointegration between world returns and each of the remaining I(1) series is found. Further test results of pair-wise cointegration between all I(1) country returns indices found no cointegration except some evidence of cointegration involving Japan and Korea. The results are not affected by the Asian financial market crisis. However, the test results of mutivariate cointegration, in which all I(1) series are included together with the World total returns index, indicate that there are two cointegrating vectors when the Asian crisis is included in the sample period, whereas there is at most a single cointegrating vector in the pre-crash period. This implies that the total return index of one country can be predicted by using a linear combination of stock prices from other countries in the region.

Overall, the findings on pair-wise cointegration tests suggest that stock markets in the Pacific Basin are not pair-wise cointegrated even after the Southeast Asian financial market crisis. Therefore, international diversification of investment portfolios by investors from one of the countries to another single country could be justified and beneficial because gaining abnormal profits in these markets by diversifying investment portfolios is possible and country-specific risk can be reduced. However, the results of mutivariate cointegration tests exhibit that there is one cointegrating vector in the pre-crash period whereas two cointegrating vectors are exhibited when the Asian crisis is included. Therefore, stock markets in this region are collectively linked in the long-run. Further investigation on cyber stock trading and foreign stock investors in this region could provide a positive and practical step in the direction for future research.

Table 6.1 Comparison of Stock Market Capitalisation

	1988			1998		
Market	US$ million	% of World Capitalisation	Turnover	US$ million	% of World Capitalisation	Turnover
Australia	138,283	1.421	27.1	874,283	3.184	51.9
Hong Kong	74,377	0.765	31.5	343,394	1.250	54.4
Indonesia	253	0.003	2.5	22,104	0.080	37.9
Japan	2,802,952	28.812	66.5	2,495,757	9.088	40.3
Korea	94,238	0.969	128.1	114,593	0.417	176.2
Malaysia	23,318	0.240	12.5	98,557	0.359	30.0
New Zealand	13,163	0.135	8.5	89,373	0.325	56.2
Philippines	4,280	0.044	24.4	35,314	0.129	30.0
Singapore	24,049	0.247	18.6	94,469	0.344	50.5
Taiwan	120,017	1.234	330.1	260,015	0.947	323.0
Thailand	8,811	0.091	78.6	34,903	0.138	71.0
UK	771,206	7.927	75.1	2,374,273	8.646	53.4
US	2,793.816	28.718	61.6	13,451,352	48.981	106.2
World	*9,728,497*	*100.000*			*100.000*	

Source: International Finance Corporation, *Emerging Stock Markets Factbooks* 1997, 1999.

Table 6.2 Correlation Coefficients: Period before Bangkok SE Black Wednesday 2 July 1997

	Market										
	AU	HK	ID	JP	KO	MY	NZ	PH	SG	TW	TH
HK	0.33										
ID	0.16	0.33									
JP	0.19	0.16	0.14								
KO	0.09	0.21	0.12	0.16							
MY	0.23	0.50	0.35	0.18	0.24						
NZ	0.53	0.28	0.16	0.24	0.10	0.24					
PH	-0.05	-0.05	-0.01	-0.09	-0.02	-0.01	-0.04				
SG	0.22	0.49	0.35	0.33	0.27	0.69	0.26	-0.07			
TW	-0.01	0.02	-0.02	0.01	0.02	-0.03	0.01	0.03	-0.04		
TH	0.16	0.33	0.33	0.10	0.19	0.45	0.15	-0.03	0.44	-0.07	
WD	0.38	0.38	0.26	0.81	0.25	0.38	0.39	-0.10	0.51	-0.04	0.25

Table 6.3 Correlation Coefficients: Entire Period

	Market										
	AU	HK	ID	JP	KO	MY	NZ	PH	SG	TW	TH
HK	0.38										
ID	0.21	0.36									
JP	0.25	0.24	0.15								
KO	0.18	0.32	0.18	0.25							
MY	0.21	0.42	0.42	0.19	0.21						
NZ	0.56	0.33	0.23	0.25	0.19	0.24					
PH	-0.04	-0.05	0.04	-0.09	-0.03	0.02	-0.02				
SG	0.30	0.56	0.41	0.29	0.27	0.57	0.31	-0.07			
TW	-0.01	0.02	0.02	0.02	0.01	0.01	0.00	0.01	0.01		
TH	0.25	0.41	0.43	0.17	0.31	0.45	0.25	-0.02	0.53	-0.03	
WD	0.44	0.46	0.23	0.72	0.32	0.30	0.42	-0.10	0.46	-0.03	0.32

Table 6.4 Phillips-Perron Unit Root Tests

Market	Equation (6.9) with **drift and trend**						Equation (6.10) with **drift** but not trend				Equation (6.11) without drift and trend		
	$Z(\tilde{\alpha})$	$Z(t_{\tilde{\alpha}})$	$Z(t_{\tilde{\beta}})$	$Z(t_{\tilde{\mu}})$	$Z(\Phi_3)$	$Z(\Phi_2)$	$Z(\alpha^*)$	$Z(t_{\alpha^*})$	$Z(t_{\mu^*})$	$Z(\Phi_1)$	$Z(\hat{\alpha})$	$Z(t_{\hat{\alpha}})$	
Australia	-24.60	-3.52	3.38	3.55	6.22	5.64	-1.49	-0.99	1.14	2.86	0.24	2.11	TS
Hong Kong	-8.27	-2.02	1.82	2.11	2.06	2.92	-1.25	-0.88	1.14	2.74	0.35	2.04	I(1)
Indonesia	-6.27	-1.79	-0.51	1.70	1.60	1.22	-5.65	-1.71	1.62	1.70	-0.34	-0.88	I(1)
Japan	-7.64	-1.72	1.69	1.73	2.15	1.44	-8.49	-1.96	1.97	1.94	0.01	0.06	I(1)
Korea	-7.24	-1.82	0.09	1.83	1.71	1.17	-7.29	-1.85	1.87	1.76	0.05	0.16	I(1)
Malaysia	-3.98	-1.54	-0.15	1.62	1.67	1.47	-4.17	-1.82	1.91	2.20	0.19	0.86	I(1)
New Zealand	-6.58	-1.76	1.38	1.80	1.58	1.48	-2.13	-1.11	1.20	1.28	0.16	1.06	I(1)
Philippines	-3.04	-0.99	-0.04	1.06	1.45	1.34	-3.14	-1.70	1.82	2.00	0.19	0.84	I(1)
Singapore	-6.45	-1.95	0.76	2.01	2.43	2.33	-4.55	-2.07	2.16	3.21	0.19	1.32	I(1)
Taiwan	-13.81	-2.72	1.13	2.76	3.74	3.74	-10.82	-2.48	2.53	3.40	0.19	0.64	I(1)
Thailand	-3.23	-1.27	-1.00	1.32	1.91	1.91	-4.08	-1.69	1.73	1.53	0.07	0.27	I(1)
World	-8.21	-1.95	2.26	2.01	2.86	2.86	0.94	0.81	-0.59	4.69	0.26	2.99	I(1)
	(-21.5)	(-3.42)	(±3.11)	(±3.38)	(6.30)	(4.71)	(-14.0)	(-2.87)	(±2.83)	(4.61)	(-8.0)	(-1.95)	

The estimation period is from 4 may 1988 until 12 April 2000 except for Indonesia which starts on 4 April 1990.
The results reported are for a lag window of 5; they are invariant for the range used for *l* from 5 to 17.

For the general model in equation (6.9), $Z(\tilde{\alpha})$ and $Z(t_{\tilde{\alpha}})$ test $H_0:\tilde{\alpha}=1$; $Z(t_{\tilde{\beta}})$ tests $H_0:\tilde{\beta}=0$; $Z(t_{\tilde{\mu}})$ tests $H_0:\tilde{\mu}=0$;

$Z(\Phi_3)$ tests $H_0:\tilde{\alpha}=1,\tilde{\beta}=0$; $Z(\Phi_2)$ tests $H_0:\tilde{\alpha}=1,\tilde{\beta}=0,\tilde{\mu}=0$.

For the model in equation (6.10), $Z(\alpha^*)$ and $Z(t_{\alpha^*})$ test $H_0:\alpha^*=1$; $Z(t_{\mu^*})$ tests $H_0:\mu^*=0$; $Z(\Phi_1)$ tests $H_0:\mu^*=0,\alpha^*=1$.

For the model in equation (6.11), $Z(\hat{\alpha})$ and $Z(t_{\hat{\alpha}})$ test $H_0:\hat{\alpha}=1$.

Table 6.5 Perron Unit Root Tests with Exogenous T_b at 3 September 1 997

	Test statistics													
Market	$\hat{\mu}$	$t_{\hat{\mu}}$	$\hat{\theta}$	$t_{\hat{\theta}}$	$\hat{\beta}$	$t_{\hat{\beta}}$	$\hat{\delta}$	$t_{\hat{\delta}}$	$\hat{\alpha}$	$t_{\hat{\alpha}}$	$t_{\hat{\alpha}-1}$	k	λ	
Australia	0.176	3.54	-0.004	-1.08	0.00009	3.40	0.025	1.03	0.962	89.16	-3.50	0	0.780	I(1)
Hong Kong	0.180	4.49	-0.033	-4.26	0.00020	4.50	0.040	1.11	0.960	105.65	-4.45	0	0.780	TS
Indonesia	0.179	4.60	-0.079	-4.60	0.00013	3.48	0.244	3.91	0.948	90.98	-4.94	18	0.739	TS
Japan	0.042	1.40	0.001	0.13	0.00000	0.50	0.007	0.24	0.990	147.14	-1.47	0	0.780	I(1)
Korea	0.063	2.13	-0.004	-0.16	0.00001	0.49	0.008	0.15	0.986	154.66	-2.16	3	0.780	I(1)
Malaysia	0.151	3.34	-0.043	-2.80	0.00010	2.63	0.197	4.11	0.969	100.87	-3.23	3	0.780	I(1)
New Zealand	0.070	2.57	-0.011	-2.43	0.00005	2.78	0.010	0.35	0.984	160.42	-2.61	12	0.780	I(1)
Philippines	0.047	2.02	-0.020	-2.64	0.00005	1.74	-0.013	-0.30	0.990	195.02	-1.90	0	0.771	I(1)
Singapore	0.080	2.12	-0.008	-1.17	0.00003	1.26	0.081	2.84	0.984	123.38	-1.99	0	0.780	I(1)
Taiwan	0.104	2.64	0.006	0.74	0.00001	0.32	0.006	0.11	0.980	128.42	-2.58	0	0.780	I(1)
Thailand	0.027	0.77	0.000	0.01	-0.00002	-0.50	0.135	2.56	0.996	133.95	-0.50	0	0.780	I(1)
World	0.077	2.16	0.003	1.09	0.00003	2.42	-0.004	-0.20	0.983	123.59	-2.15	0	0.780	I(1)

0.05 critical values for $H_0: \alpha = 1: -3.759$ if $\lambda = 0.780, -3.765$ if $\lambda = 0.739$ and -3.761 if $\lambda = 0.771$.

Table 6.6 Perron Unit Root Tests Using the Innovational Outlier Model

Regression model: $y_t = \hat{\mu} + \hat{\theta}DU_t + \hat{\beta}t + \hat{\delta}D(T_b)_t + \hat{\alpha}y_{t-1} + \sum_{i=1}^{k}\hat{c}_i\Delta y_{t-i} + e_t$

Market	T_b	k	$\hat{\mu}$	$t_{\hat{\mu}}$	$\hat{\theta}$	$t_{\hat{\theta}}$	$\hat{\beta}$	$t_{\hat{\beta}}$	$\hat{\delta}$	$t_{\hat{\delta}}$	$\hat{\alpha}$	$t_{\hat{\alpha}}$	$t^*_{\alpha}(1)$	
Australia	08:09:93	2	0.231	4.26	0.009	2.33	0.00008	3.45	-0.046	-1.96	0.951	81.63	-4.21	I(1)
Hong Kong	03:09:97	9	0.200	4.91	-0.035	-4.46	0.00022	4.90	0.053	1.45	0.955	103.02	-4.89	TS
Indonesia	17:09:97	11	0.193	4.76	-0.081	-4.89	0.00013	3.75	0.132	2.09	0.948	92.12	-5.00	TS
Japan	24:02:99	2	0.093	2.86	0.017	3.21	-0.00001	-1.33	-0.028	-0.91	0.979	136.29	-2.88	I(1)
Korea	17:02:99	9	0.083	2.73	0.020	2.38	-0.00002	-1.18	-0.145	-2.87	0.983	158.92	-2.73	I(1)
Malaysia	25:06:97	8	0.197	5.12	-0.064	-4.90	0.00016	4.67	0.061	1.30	0.958	117.93	-5.11	TS
New Zealand	23:06:93	8	0.117	3.36	0.018	3.10	0.00000	0.17	-0.020	-0.72	0.975	128.86	-3.29	I(1)
Philippines	19:08:98	11	0.143	4.35	-0.043	-4.09	0.00014	3.76	0.014	0.33	0.970	135.56	-4.23	I(1)
Singapore	12:02:97	9	0.137	3.91	-0.020	-3.34	0.00007	3.42	0.016	0.55	0.972	132.27	-3.86	I(1)
Taiwan	12:12:90	4	0.198	4.22	-0.035	-3.66	0.00010	3.85	0.073	1.32	0.963	108.88	-4.18	I(1)
Thailand	13:11:96	12	0.110	3.76	-0.047	-3.69	0.00010	3.04	0.036	0.67	0.977	158.40	-3.70	I(1)
World	31:01:90	12	0.164	3.65	-0.013	-3.70	0.00009	4.01	0.022	1.26	0.965	97.83	-3.59	I(1)

T_b is chosen by minimising the t-statistic for $H_0: \alpha = 1$.

The 0.05 critical value for $H_0: \alpha = 1$, $t^*_{\alpha}(1)$, is –4.80.

Table 6.7 Tests of Noncointegration with World Returns, May 1988 – June 1997

	Engle-Granger CRADF		ECM t	λ_{trace} H_0: $r = 0$
	Constant	Constant + Trend		
Japan	-1.9908	-1.1873	-1.4376	8.2201
Korea	-1.4832	-1.6588	-1.4968	8.7416
New Zealand	-3.0671	-3.5327	-3.3494*	20.989
Philippines	-2.4947	-1.9526	-0.81939	7.8252
Singapore	-0.35486	-1.2666	-1.3817	20.135
Taiwan	-2.2220	-2.4149	-2.4839	14.071
Thailand	0.84735	0.07794	-0.80046	17.235
.05 critical value	-3.3475	-3.8000	-3.28	25.77

Table 6.8 Tests of Noncointegration with World Returns, May 1988 – April 2000

	Engle-Granger CRADF		ECM t	λ_{trace} H_0: $r = 0$
	Constant	Constant + Trend		
Japan	-1.6310	-1.4437	-1.3790	8.2036
Korea	-2.1392	-2.0069	-1.7003	8.9934
New Zealand	-1.0446	-1.2811	-1.1168	8.5810
Philippines	-1.3993	-1.8771	-0.84124	10.758
Singapore	-1.5744	-2.1258	-1.9007	14.758
Taiwan	-2.5345	-2.7173	-2.8073	16.217
Thailand	-1.2520	-2.2671	-1.4303	16.348
.05 critical value	-3.3475	-3.8000	-3.28	25.77

Table 6.9 Tests of Noncointegration Between Returns of Japan and Korea

	Sample Periods	Engle-Granger CRADF		ECM t	$\lambda_{trace} H_0 : r = 0$
		Constant	Constant + Trend		
Entire period	May 1988 – April 2000	-3.5100*	-3.3585	-3.9636*	21.0324
Pre-crash period	May 1988 – June 1997	-3.6305*	-3.9023*	-3.4272*	19.8860
Pre-opening period	May 1988 – December 1991	-3.5437*	-3.6015	2.5388	21.3030
Post-opening period	January 1992 – April 2000	-2.6570	-2.8640	3.1028	15.4636
Post-opening period† (excluding Asian Crisis)	January 1992 – June 1997	-2.6902	-2.6891	2.5415	9.5079
.05 critical value		-3.3475	-3.8000	-3.28	25.77

* significant at the .05 level.

Table 6.10 Tests of Noncointegration Between Returns of Korea and Japan

	Sample Periods	Engle-Granger CRADF		ECM t	$\lambda_{trace} H_0 : r = 0$
		Constant	Constant + Trend		
Entire period	May 1988 – April 2000	-3.3979*	-3.3709	-2.9316	21.0324
Pre-crash period	May 1988 – June 1997	-3.3874*	-3.7068	-2.7824	19.8860
Pre-opening period	May 1988 – December 1991	-3.4392*	-3.5122	-3.1775	21.3030
Post-opening period	January 1992 – April 2000	-2.6682	-2.8553	-2.2323	15.4636
Post-opening period† (excluding Asian Crisis)	January 1992 – June 1997	-2.4625	-2.2686	-1.9788	9.5079
.05 critical value		-3.3475	-3.8000	-3.28	25.77

* significant at the .05 level

Table 6.11 Tests of Multivariate Cointegration Between JP, KO, NZ, PH, SG, TW, TH and WD

	Pre-crash		Entire	
	λ_{trace}	.95 critical values	λ_{trace}	.95 critical values
$z = 0$	205.42 *	182.99	221.82 *	182.99
$z \leq 1$	147.02	147.27	160.52 *	147.27
$z \leq 2$	104.54	115.85	111.66	115.85
$z \leq 3$	73.87	87.17	70.51	87.17
$z \leq 4$	46.68	63.00	46.29	63.00
$z \leq 5$	26.89	42.34	26.68	42.34
$z \leq 6$	12.82	25.77	13.68	25.77
$z \leq 7$	5.21	12.39	5.29	12.39

Notes: Pre-crash period starts 9 November 1988 and ends 26 June 1997 to exclude the Asian financial market crisis whereas entire period ends 12 April 2000.
SBC criteria for selecting the order of the VAR model suggests lag order one.
* significant at the .05 level.

Appendix 6.1 Degree of Market Openness as the End of 1997

	Availability of listed stocks to foreign investors / Regulations for exiting markets	Investment ceilings
Indonesia	Relatively free entry / Some restrictions	100% in general, 49% banks, 85% for securities companies
Korea	Relatively free entry / Free exit	55% in general, 25% for KEPCO & POSCO, 33% for SK Telecom
Malaysia	Free entry / Free exit (liberalised from 1987)	100% in general, 30% for lease and securities company, 30% for Bank Negara and banks
Philippines	Special classes of shares / Free exit	40% in general and 30% for banks through B shares, industries reserved for Filipinos: retail trade, mass media and rural banks
Taiwan	Authorised investors only / Some restrictions	30% foreign ownership limit for any single company
Thailand	Relatively free entry / Free exit (liberalised in spring 1990)	10%-49% foreign ownership limit depending on company by laws, 25% for commercial banks and finance companies
Australia	Free entry / Free exit	
Hong Kong	Free entry / Free exit	
Japan	Free entry / Free exit	
New Zealand	Free entry / Free exit	

Singapore	Free entry / Free exit	finance, newspaper, airline
UK	Free entry / Free exit	
US	Free entry / Free exit	

Source: International Finance Corporation, *Emerging Stock Markets Factbook* 1998.
* In September 1998, exchange regimes in Malaysia has changed to pegged to US dollar system from managed floating system.
Key to access:
(a) Relatively Free: Some registration procedures required to ensure re-participation rights, or significant limits on foreign ownership
(b) Special Classes of Shares: Foreigners restricted to certain classes of stocks, designated for foreign investors.
(c) Authorised Investors Only: Only approved foreign investors may buy stocks.
(d) Some restrictions: Typically, requires some registration with or permission of central bank, Ministry of finance, or an Office of exchange Controls

7 Do Stock Prices Follow a Random Walk under Price Limits? An Empirical Analysis Using Multiple Variance Ratio Tests

7.1 Introduction

The East Asian financial crisis of 1997 has generated a surge of interest in the stability of financial markets. Although the cause of the crisis are complex,[21] a common theme is the tremendous shocks to the region's economies and, in particular, large declines in stock prices together with the meltdown of currency markets. In several countries, for example Korea, Thailand and Indonesia, the crises in financial markets resulted in intervention in their economies by the International Monetary Fund (IMF). These economies were required to accept extensive deregulation of their financial markets in response to the requirements of the IMF bailout programmes, which require a wide range of financial market liberalisation. Although most stock markets in the region have had market stabilisation systems, they did not seem to prevent a great degree of market fluctuation due to largely unanticipated events like the East Asian financial market crashes.[22]

There are several forms of market stabilisation system but one of the most

[21] Among many others, for instance, Frankel (1998) argues that the main problem in East Asia was not macroeconomic, but structural. In particular, deep flaws afflicted the financial system that include excessive leverage, a banking system which was based excessively on directed lending, connected lending and other collusive personal relationships.
[22] Corsetti, Pesenti and Roubini (1998) point out that 'unusual suspects' often observed as indicators of crisis such as low growth, high budget deficits, high inflation, low savings rates, low investment rates are not observed in Asia.

widely used in emerging markets is price limits which are an important feature of many stock markets, including those of Korea, Malaysia, Taiwan and Thailand (Rhee and Chang, 1992). Most of the early literature on the effects of price limits tended to focus on futures markets, for example, Brennan (1986), Ma, Rao and Sears (1989), Morgan and Trevor (1997), and Berkman and Steenbeek (1998). In the context of stock markets, much of the research focuses on how useful price limits are in preventing excess volatility and thus stabilising the price mechanism. These hypotheses are succinctly discussed by Kim and Rhee (1997): the volatility spillover, delayed price discovery and trading inference hypotheses. Their empirical evidence supports all three hypotheses for the Tokyo Stock Exchange, implying price limits are ineffective. For Korean stock market, the evidence on price limits and volatility is inconclusive. Chung (1991) finds no evidence that price limits decrease volatility over the period January 1980 – August 1980. However, Lee and Kim (1995) find that price limits slow down price changes and reduce stock price volatility for the period 1980 – 1989. Lee and Chung (1996) find that price limits are an important feature affecting price movements and the stock market appears to be inefficient because of biased price movements due to price limits.

In fact, there have been contradictory views regarding the usefulness of price limits in a stock market. Yet, there seems to be no agreement on this issue. Those who insist on the positive effectiveness of price limits believe that this system could reduce unnecessary price fluctuations, which tend to deviate tremendously from their intrinsic values or equilibrium prices, i.e., a cooling-off effect. Thus, it can protect individual investors from huge losses in trading by providing them with a period to settle up for next trading especially when stock prices fell rapidly. The system also appeared to be accompanied by reductions in volatility and the minimisation of transaction costs. In contrast, it is often argued that price limits negatively affect the market as means of prolonging the price discovery process. Consequently, price limits prevent the operation of the natural market mechanism. This, in turn, brings liquidity problems, which can result in potential prevention of participation of buyer/seller due to further anticipated price movement. In other words, the information flows of the market could be inefficient.

This chapter focuses on a different aspect—although one that is related to the delayed price discovery hypothesis in which equity prices are prevented from efficiently reaching their equilibrium levels. We address the question: Do price limits prevent stock prices from following a random walk process? The time paths of stock prices under price limits might not coincide with the time paths that would prevail in the absence of price limits. With daily price limits, the movement of stock prices is bounded both upwards and downwards on a particular day. When a price limits is reached, any trading is at the limit price and equity prices may not reach their equilibrium levels on that day. According to Black (1971, p. 32)

> 'Randomness means that a series of small upward movements (or small downward movements) is very unlikely. If the price is going to move up, it should move up all at once, rather than in a series of small steps.'

Consider 'news' which changes the equilibrium price of an equity. In an efficient market the price immediately adjusts to the new equilibrium value; if it did not then resulting, profitable arbitrage opportunity would be immediately exploited. That is, stock market efficiency is associated with the rapid adjustment of equity prices to their equilibrium values. Slow adjustment of prices results in distortions in the pricing of capital and risk with implications for the allocation of capital within an economy. Fama (1989) conjectures that price limits delay the adjustment of prices but do not affect the size of the adjustment. In these circumstances, some stocks are traded at disequilibrium prices, price limits are inefficient and markets, which have them, will loose out to those that do not.

Whilst there have been numerous studies of the efficient markets hypothesis, none of them has investigated the consequences of price limits for weak-form efficiency. This paper differs from previous studies in several ways. Since the price limits in the Korea Stock Exchange have been modified several times as the bands have widened, the random walk hypothesis is tested under the different regimes of price limits. First, the multiple variance ratio (MVR) test developed by Chow and Denning (1993) is used to examine whether prices of individual stocks follow a random walk process under price limits. Secondly, the data cover a longer time span- over ten years of daily observations.[23] In order to avoid the problem of missing observations, some of which are associated with price limits, all six trading days in the week are included in our data. Thirdly, we consider the effects of the relaxation of price limits: as price limits are relaxed do some equity prices follow a random walk process? Finally, the impact of the Korean financial crisis on the weak-form efficiency of the stock market is noted.

The remainder of this chapter is organised as follows. The next section discussed the empirical test methodology. Section 8.3 describes the characteristics of, and changes in, the system of price limits in the Korean stock market. The data and their properties are described in section 8.4. In section 8.5, the empirical results are presented. The final section provides brief conclusions and suggestions for further research.

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[23] Shiller and Perron (1985) find that a long span of data increases the power of tests of the random walk hypothesis.

7.2 Methodology: Multiple Variance Ratio Tests

A frequently used test of market efficiency is to examine whether a price follows a random walk. Under the random walk hypothesis

$$p_t = p_{t-1} + \mu + \varepsilon_t, \tag{7.1}$$

or $$\Delta p_t = \mu + \varepsilon_t \tag{7.2}$$

in which p_t is the natural logarithm of a stock price, μ is an arbitrary drift parameter and ε_t is a random disturbance term. The ε_t satisfy $E[\varepsilon_t] = 0$ and $E[\varepsilon_t \varepsilon_{t-g}] = 0$, $g \neq 0$, for all t. The random walk implies uncorrelated residuals and hence uncorrelated returns, Δp_t. A number of factors can induce autocorrelation including some aspects of the market's microstructure-the bid-ask spread and nonsynchronous trading. It can readily be shown that effective price limits also induce autocorrelation and so result in inefficient markets. Consider the arrival of news at time t which reduces the equilibrium price of the equity. The actual price decreases but suppose adjustment to the equilibrium is incomplete within the unit period because the price adjustment is constrained by the price limit. Writing the random walk hypothesis out for successive time periods we have

$$p_t = p_{t-1} + \mu + \varepsilon_t, \tag{7.3}$$

$$p_{t+1} = p_t + \mu + \varepsilon_{t+1}, \tag{7.4}$$

$$p_{t+2} = p_{t+1} + \mu + \varepsilon_{t+2}, \tag{7.5}$$

and so on.

The disturbance ε_t will be negative and since p_t does not immediately adjust to the new equilibrium, the disturbance ε_{t+1} will be negative and $p_{t+1} < p_t$. If adjustment is again constrained by the price limit then ε_{t+2} will be negative. With the effective daily price limits and daily data, news has effects in a number of periods after it arrives and so successive disturbances are autocorrelated. If price limits result in an equity price departing from a random walk then we expect positive autocorrelation.

Since the pioneering work by Lo and MacKinlay (1988) variance ratio tests have been widely used for testing the random walk hypothesis. These tests are particularly useful for investigating asset prices such as stock prices in which returns are frequently not normally distributed. If stock prices are found to follow a random walk processes then equity markets are weak-form efficient (Fama, 1970). In this case, all information contained in historical stock prices is fully reflected in current stock prices and so returns on shares would not be predictable. Since future returns cannot be predicted from past returns, trading rules based on the examination of the sequence of past prices are worthless. Hence the past information contains nothing about the magnitude of the deviation of today's return from the expected return.

Consider a random walk with a drift process

$$p_t = \mu + p_{t-1} + \varepsilon_t, \tag{7.6}$$

or

$$r_t \equiv \Delta p_t = \mu + \varepsilon_t \tag{7.7}$$

where p_t the natural logarithm of stock prices, μ is an arbitrary drift parameter and ε_t is a random disturbance term. The ε_t satisfy $E[\varepsilon_t] = 0$ and $E[\varepsilon_t \, \varepsilon_{t-g}] = 0$, $g \neq 0$, for all t, and r_t is continuously compounded returns. With uncorrelated residuals and hence uncorrelated increments in p_t the variance of these increments increases linearly in the observation interval,

$$\mathrm{Var}(p_t - p_{t-q}) = q \, \mathrm{Var}(p_t - p_{t-1}) \tag{7.8}$$

in which q is any positive integer. The variance ratio is given by

$$VR(q) \equiv \frac{\frac{1}{q} Var\,[R_t(q)]}{Var\,[R_t]} = \frac{\sigma^2(q)}{\sigma^2(1)} \tag{7.9}$$

in which $R_t(q)$ is a q period continuously compounded return

$$R_t(q) \equiv r_t + r_{t-1} + \ldots + r_{t-q+1} = p_t - p_{t-q} \tag{7.10}$$

and under the null hypothesis VR(q) = 1.

Under the null hypothesis of heteroscedastic increments random walk, Lo and MacKinlay (1988) consider a sample of size $nq + 1$ observations $(p_0, p_1, \cdots, p_{nq})$ and derive the test statistic

$$Z^*(q) = \frac{\sqrt{nq}\hat{M}(q)}{\hat{\sigma}_e(q)} \tag{7.11}$$

where $\hat{M}(q)$ is asymptotically equal to a weighted sum of autocorrelation coefficient estimates,

$$\hat{M}(q) \overset{a}{=} 2\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)\hat{\rho}(k), \tag{7.12}$$

and $$\hat{\sigma}_e(q) = \left(4\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2 \hat{\sigma}_k\right)^{1/2} \tag{7.13}$$

where $$\hat{\sigma}_k = \frac{nq\sum_{j=k+1}^{nq}(p_j - p_{j-1} - \hat{\mu})^2(p_{j-k} - p_{j-k-1} - \hat{\mu})^2}{\left[\sum_{j=1}^{nq}(p_j - p_{j-1} - \hat{\mu})^2\right]^2} \tag{7.14}$$

and $\hat{\mu}$ is the sample mean of $(p_t - p_{t-1})$.

If the null hypothesis is true then the associated test statistic has an asymptotic standard normal distribution. A weakness of the Lo and MacKinlay variance ratio tests is that they focus on testing one variance ratio at a time for a single aggregation interval, q, and so they are essentially *individual* hypothesis tests. However, the random walk hypothesis requires that VR(q) =1 and hence M(q) ≡ VR(q) -1 = 0 *for* *all q*. The multiple variance ratio (MVR) test facilitates cases of the multiple comparison of a set of estimated variance ratios with unity by way of a joint test in which size is controlled (Chow and Denning, 1993).

The MVR test uses Lo and MacKinlay test statistics but with critical values appropriate for the joint test. Consider a set of m variance ratio tests $\{M(q_i)|i = 1, 2, \ldots, m\}$ associated with the set of aggregation intervals $\{q_i\,|i = 1, 2, \ldots, m\}$. Under the random walk null hypothesis there are multiple sub-hypotheses

$$H_{0i}\text{: } M(q_i) = 0 \text{ for } i = 1, 2, \ldots, m$$

$$H_{1i}\text{: } M(q_i) \neq 0 \text{ for any } i = 1, 2, \ldots, m \qquad (7.15)$$

If one or more H_{0i} is rejected then the random walk hypothesis is rejected. Consider a set of Lo and MacKinlay test statistics, $\{\, Z^*(q_i)|i = 1, 2, \ldots, m\}$. Since the random walk null hypothesis is rejected if any of the estimated variance ratios is significantly differently different from one, it is only necessary to focus on the maximum absolute value in the set of test statistics. Chow and Denning's MVR test is based on the result

$$PR[\max(|Z(q_1)|,|Z(q_2)|, \ldots,|Z(q_m)|) \leq SMM(\alpha; m; T)] \geq (1\text{-}\alpha) \qquad (7.16)$$

in which SMM(α; m; T) is the upper α point of the Studentized Maximum Modulus (SMM) distribution with parameters m (number of variance ratios) and T (sample size) degrees of freedom. Asymptotically, when T is infinite,

$$SMM(\alpha; m; \infty) = Z_{\alpha^*/2} \quad \text{in which } \alpha^* = 1 - (1 - \alpha)^{1/m}. \qquad (7.17)$$

The size of a MVR test is controlled by comparing the calculated values of the standardised test statistic with the SMM critical values available in, for example, Miller (1981, pp. 239 and 278). For large samples, they can also be generated from the standard normal distribution using equation (7.17). If the maximum absolute value of $Z^*(q_i)$ is greater than the SMM critical value at a predetermined significance level then the random walk hypothesis is rejected.

7.3 Price Limits in the Korean Stock Market

There have been price limits on the Korea Stock Exchange since 1963. Following a massive collapse of stock prices in May 1962, they were introduced as a mechanism to stabilise the market by eliminating excessive volatility and limiting potential daily losses. The price limits have been modified several times and their structure and changes from 1988 are summarised in Table 7.1. The base price is defined as the closing price on the previous trading day. The first column of this table identifies ranges of base prices and subsequent columns report the associated price limits. Before April 1995, these price limits were expressed as *absolute* changes for specified ranges of base prices. For example, suppose on a particular day between 2 March and 7 June 1992 the previous trading day's closing price for a particular equity was 3,000 Korean won. That day's price limits were +200 won and –200 won- the maximum the share price could go up or go down. Under this system of *absolute* changes, as the average equity price has increased over time, the set of ranges of base prices has increased. From the beginning of April 1995, price limits have been expressed as a *fixed* percentage rate. Under this system, for a given period, the price limits are the same percentage change of the base price, whatever that base price. Initially, the daily limits were price changes of ±6%, these were relaxed to ±8% from 25 November 1996 and again to ±12% from 2 March 1998. From 7 December 1998 the limits were widened to ±15% of the base price and circuit breakers were also introduced. With the latter, if the KOSPI falls by more than 10% from the previous day's closing price for more than one minute then trading is suspended for 30 minutes so transactions can re-access the market before further trading. Saturday trading was also abolished.

7.4 The Data and Their Properties

The random walk hypothesis can be tested with either market indices or the prices of individual equities. However, the limits are set on the prices of individual equities and not the KOSPI. An aggregate index might be used to investigate the possible effects of price limits if most of the constituent prices frequently hit the limits. This is the rarely the case. It is quite possible, therefore, the KOSPI may follow a random walk-but not the majority of its constituents. A sample of 55 stocks listed on the KSE is used. Stocks were selected across a wide range of industries (no more than six stocks in any one sector) that are actively traded and have a marked number of limits moves. The sample includes eleven of the twenty largest companies and nine of the twenty most actively traded stocks, both in 1996. Since the analysis focuses on the consequences of price limits and these depend on the closing price on the previous trading day, it is important not to omit any trading days from the empirical analysis. Therefore the data are daily and cover all six trading day each week, beginning on 2 March 1988 and ending on 5 December 1998 (3,159 observations).[24] They enable us to use five subperiods associated with the first five price limit regimes identified in Table 8.1. They are: Period 1, They are: Period 1, 2 March 1988 – 7 June 1992 (1,245 observations); Period 2, 8 June 1992 – 31 March 1995 (831 observations); Period 3, 1 April 1995 – 24 November 1996 (486 observations); Period 4, 25 November 1996 – 1

[24] Five series start later due to late inception of stock trading on the KSE: Isu Chemical, 28 April 1988; POSCO, 10 June 1988; KEPCO, 10 August 1989; SK Telecom, 7 November 1989 and Shinhan Bank 28 November 1989. Two series finish earlier: Commercial Bank, 26 September 1998 and Korea Long Term Credit Bank, 4 December 1998, because they merged with other banks.

March 1998 (366 observations); and Period 5, 2 March 1998 – 5 December 1998 (231 observations). The sources of the data are: March 1988 – December 1995 the KSE Database, January 1996 – March 1997 the Korea Securities Computer Corporation (KOSCOM) and April 1997 – December 1998 *Datastream* and *The Korea Economic Daily*.

Table 7.2 classifies the companies by sector and reports descriptive statistics of daily returns. For 45 of the 55 equities, the average daily return is negative. The standard deviations of returns do not appear to fluctuate much across stocks which may be a consequence of price limits. Not surprisingly, not one of the daily returns is normally distributed: twenty five are skewed to the left, thirty skewed to the right and all are leptokurtic, that is, more-sharply peaked about the mean than the normal distribution. These distributional characteristics are entirely consistent with a system of daily price limits. Daily returns are continuous random variables only between the upper and lower limits. If market forces are taking the 'true' daily return on a stock above the upper limit or below the lower limit then the actual return recorded is the upper or lower limit and not the 'true' market-determined return; both tails of the distribution of returns are censored. For example, the price limits regime in subperiod 3 was ±6% of the base price. If a stock return at a certain time exceeded the upper limit, i.e. $r_t^* \geq 6\%$, then the return was simply expressed as the upper limit ($r_t = 6\%$). Contrarily, when a true stock return is below than the lower limit, i.e. $r_t^* \leq 6\%$, the value was recorded at the lower limit ($r_t = -6\%$). In other words, although we observe a set of random variables for a certain period we only get continuous random variables for $|r_t| < 6\%$ and discrete random variables for $r_t = 6\%$ or $r_t = -6\%$. Therefore, the stock returns in the Korean market should be regarded as variables censored in both tails. This reconciles the fact that none of the stock returns in our data exhibits the normal distribution.[25]

As presented in Table 7.3, we also calculate the average standard deviation of daily returns was calculated for each subperiod. This is relatively stable for the first three subperiods at 0.0196, 0.0224 and 0.0213 respectively. However, volatility increased markedly in period 4, when price limits were ±8%, with average standard deviation 0.0390 and, again, in period 5, when price limits were relaxed to ±12% and average standard deviation is 0.0475. This suggests that volatility increases as price limits are relaxed. This is consistent with the work of Ma (1993) and Lee and Kim (1995) although Wu, Naughton and Chung (1995) found that when price limits on the Taiwan Stock Market were tightened from 5% to 3% in 1987 volatility significantly increased.

Table 7.4 reports for each equity price the number of limit moves for each subperiod and the full sample. Over the entire sample period, the average number of limit moves is 301.3 and with 3,195 observations this gives an average rate of limit moves of 9.4%—approximately 10% of trading days are affected by price limits. This ranges considerably for individual equities from 169 (5.3%) for Shinhan Bank to 587 (18.4%) for Taekwang Industrial. The average rate also varies across subperiods and this is illustrated in Figure 7.1. The average number of up- and down-limit moves is similar in periods 1 and 2 then clearly declined, increased in period 4 and declined once more in period 5. It is greatest for period 2 (16.0%) and smallest for periods 3 and 5 both of which are associated with the market as a whole declining. In period 3, two of our stocks have zero limit moves, LG Electronics Inc and Korea Long Term Credit Bank. We shall see in section 5 that the stock price of the latter follows a

[25] One explicit method of dealing this issue is by the so-called Tobit model, which is developed by Tobin (1958) and frequently referred as the censored regression model. In this chapter, however, we do not apply the model to our data since we are mainly interested in whether the random walk hypothesis can be hold even under price limits.

random walk in this period.

Table 7.5 reports the frequencies of successive days of limit-constrained price changes. These frequently occur in clusters of two, three, four, or more consecutive days in the same direction. One of the striking findings is that a few stocks hit the price limits over ten successive trading days in the same direction and in an extreme case this occurred over twenty-eight successive trading days, which is equivalent to over six weeks period.[26] Over the full sample, all stock returns are limit-constrained. Successive price limits are hit more frequently when prices are rising than when they are falling. Also, many more stock returns are limit-constrained over a larger number of consecutive days when returns are positive than when they are negative. Figure 7.2 illustrates the average number of successive days of limit-constrained price changes under each price limit regime. To the extent that successive limit moves indicate ineffectiveness of the price limits system, it is ineffective in all subperiods. There are, however, clear differences. The average number of successive days of limit moves was 39.0 in period 1, increased in period 2 then clearly declined, increased in period 4 and declined again in period 5. When examined by sector, the results tell us that the returns of banks are less affected by price limits which, in turn, implies their equity prices fluctuate less than those in other industries, at least until the East Asian crises. This may be partially explained by more conservative, or risk averse, investors preferring the stocks of banks to those of other industries because many investors in the Korean stock market have perceived investing in bank stocks as much safer than buying those of other sectors. However, following IMF action in December 1997 and despite strong criticism that intervention would prevent free market capitalism, the Korean government injected a total of US$2 billion into two of the weakest

[26] The details of results are not reported here.

commercial banks, First Korea Bank and Seoul Bank—both leading creditors of several bankrupt *Chebols*, in exchange for a 59% shareholding.

7.5 Empirical Results

The random walk hypothesis is tested for each of the 55 stock prices for the five periods associated with the five price limit regimes. The variance ratio tests are based upon 6 observations per week and a set of five aggregation intervals $\{q_i | i = 2, 6, 12, 18, 24\}$, that is, spanning 2 days and 1–4 weeks inclusive. Empirical evidence finds that returns have variable volatility, Corhay and Rad (1993), Huang, Liu and Yang (1995) and Ryoo (1997). Consequently, with our MVR tests we use the Lo and MacKinlay heteroscedasticity-robust test statistics, $Z^*(q_i)$, and compare their calculated values with the SMM critical values. At the .05 significance level, from equation (7.17) with $m = 5$ the corresponding critical value is 2.57. The full results of our tests of the heteroscedastic random walk null hypothesis are reported in Table 7.6 through 7.11. For each stock price, we report the estimated variance ratios for the set of aggregation intervals $\{q_i | i = 2, 6, 12, 18, 24\}$ together with their associated test statistics $\{Z^*(q_i) | i = 2, 6, 12, 18, 24\}$. Since the full results are quite lengthy the summarised results are also reported in Tables 7.12 and 7.13.

The cross-sectional means of the variance ratios together with their standard deviations are reported for each period in Table 7.12. These standard deviations provide an indication of the cross-sectional dispersion of the variance ratios but, since the variance ratios are not cross-sectionally independent, these standard deviations cannot be used to carry out the usual significance tests. For all periods, the average variance ratio for $q = 2$, $V\hat{R}(2)$, > 1. Lo and MacKinlay (1988) show that for $q = 2$, estimates of the variance ratio minus one and the first-order autocorrelation coefficient are asymptotically equal, $\hat{\rho}_1 \overset{a}{=} \hat{VR}(2)-1$. Hence, on average, the first-order autocorrelation coefficient is positive and close to zero. Our finding of *positive* autocorrelation in individual stock returns is consistent with the effect of price limits and contrasts with empirical evidence for more-advanced stock markets such as the US where negative serial correlation is found in individual stock returns. Here, differences in market microstructure are important. In the US market, there are no price limits for stock trading and the existence of a bid-ask spread (and possibly also nonsynchronous trading) induces *negative* serial correlation in observed individual security returns (Campbell, Lo and MacKinlay, 1997).

Although autocorrelation can arise in various reasons, one of the obvious causes in our analysis seems to be the existence of price limits in the Korean stock market. The price limits prevent equity prices from following a random walk process and so results in the market being inefficient. Some studies, for instance Liu and He (1991) and Theerathorn, Charoenwong, and Ding (1993), argue that the rejection of a random walk process does not necessarily mean inefficiency and accuse the government intervention as one of the reasons. However, these studies do not correctly observe the impacts of price limits. As argued in Chou (1997), if a shock occurs such that a stock price his a limit then some excess demand or supply remains unreflected, thus, the returns of the following trading days would absorb the residual shock. Therefore, if consecutive limit moves are persisted, then the observed returns are autocorrelated. This reconciles the fact that, under price limits, stock returns often deviate from a random walk, hence, an informationally inefficient market.

The extent to which the sets of variance ratios for individual stocks are significant is summarised in Table 7.13 which reports the frequency of rejection for each of the price limit regimes. In period 1, the hypothesis is rejected for 33 of the 55 (60%) stock prices. When expressed in percentage terms, the ranges of price limits for periods 1 and 2 are very similar. It is not surprising, therefore, that our results show a similar number of rejections of the hypothesis, 31 out of 55 (56.4%), for the latter period. Of these period 2 rejections, 22 involve the same companies whose share prices did not follow a random walk process in period 1.

Period 3 is associated with uniform price limits of ±6% and represents a relaxation of the limits from the previous regime which, when expressed in percentage terms, range from approximately ±2% to ±6.7%. Under this regime, only 15 of the 55 stocks (27.3%) reject the heteroscedastic random walk null hypothesis—half the number of rejections found in the previous period. The transition from period 3 to period 4 involves a relaxation of price limits from ±6% to ±8%. The results of our tests for period 4 are interesting in that 44 of the 55 stock returns reject the random walk hypothesis. This period is associated with an average price limit hit rate of 12.74% (the sum of lower and upper limit rates of 5.57% and 7.17%, respectively). One possible explanation of this relatively higher limit hit rate given the ±8% range for price limits is the Korean financial market crisis which was associated with highly volatile stock returns. In order to separate the potential effects of price limits from those of the financial market crisis, we excluded from period 4 the subperiod from one month before the IMF bailout on 3 December 1997 to the end of the period. Eliminating in this way the observations associated with major financial market turbulence, we aim to pick-up the effects of the relaxed price limits. When the period of the Korean financial market crisis is excluded, the results are striking. Only 12 stock prices reject the random walk hypothesis—that is, 78.2% of our sample of 55 stocks follow a random walk process. This implies that 34 stocks, which do not follow a random walk process in the original subperiod 4, become informationally efficient. One of the reasons for this is that even before the actual IMF bail-out programs, large institutional and foreign investors anticipated a bearish market in the nearer future so that they tended to sell shares rather buying them. Subsequently, shortly after the outbreak of the IMF bailout programs, the overall stock market became more volatile thus more consecutive down limits occurred. This might prevent subperiod 4, in which the Korean financial market crisis period is included, to be informationally efficient. It reconciles the fact that there are more stocks, which follow a random walk process, in new subperiod 4 than in the original subperiod 4. For period 5, with price limits of ±12%, only 10 of the stock prices do not follow a random walk.

In summary: excluding the period of the Korean financial market crisis, as price limits on the Korean stock market are relaxed, the proportion of stock prices in our sample which follow a random walk increases. In the early part of our sample period, when price limits were expressed as absolute changes for specified ranges of base prices and were equivalent to a range from ±2.0% to ±6.7%, approximately 40% of the stock prices in our sample followed a random walk process. By the end of our sample period, when price limits had been relaxed to ±12%, the proportion of stock prices following a random walk had doubled. That is, as price limits are relaxed, the stock market as a whole approaches a random walk.

7.6 Conclusions

This chapter investigated whether stock prices under price limits follow a random walk. The multiple variance ratio tests are implemented to examine the random walk hypothesis for the Korean stock market under five regimes of daily price limits from March 1988 to December 1998. Using a sample of 55 actively traded stocks selected to cover a wide range of sectors, the hypothesis is tested under each price limit regime.

The results show several striking findings. First, the results generally support the idea that price limits do impact on volatility. It is found that stock price volatility increased when the price limits were widened its bands from ±6% to ±8% and further to ±12%. This suggests that impose of tightened price limits can affect for reducing volatility although less volatile market is not necessarily to be desirable. Second, in general, approximately 10% of returns for the entire sample period in our data has been affected by the price limits. This implies that neglecting the presence of price limits could result in misleading empirical evidence because price limits can be a crucial factor affecting stock price movement. It can be quite problematic because the time paths of stock prices under price limits might not coincide with the time paths which would prevail in the absence of price limits. Thus equity prices are prevented from efficiently reaching equilibrium levels. That is, having limits move for a particular stock price on previous trading day can distort an equilibrium level since unabsorbed demand/supply on the following day, which has not been fully reflected into today's price due to price limits, might affect the following day's corresponding true return in terms of a leftover term. Finally, excluding the unusual period of the Korean financial market crisis, as price limits are relaxed, the proportion of stock prices in the sample which follow a random walk increases. That is, the stock market as a whole approaches a random walk. With price limits of ±15% from 7 December 1998 and expectations of them being relaxed further in the short term, it seems that these wider limits are likely to have relatively little influence on whether or not stock prices follow a random walk. As more data become available it will be useful test other hypotheses. For example, it is sometimes argued that there is more information available for large capitalisation stocks. Do the prices of large capitalisation stocks follow a random walk while those of small capitalisation stocks do not?

Overall, the evidence indicates that price limits can prevent stock price evolving from a random walk process and hence the stock market is inefficient. In spite of the price limits in Korean Stock Exchange have been modified several times as the bands have widened, they have played a role in hindering the Korean stock market from becoming informationally efficient. Consequently, whatever the pros and cons of price limits are, one should not ignore the fact that the behaviour of stock prices is not likely to be efficient as long as price limits remain as rule in stock market.

Table 7.1 Modification of Daily Price Limits

	Date regime introduced					
Base Price	2 Dec 88	8 Jun 92	1 Apr 95	25 Nov 96	2 Mar 98	7 Dec 98
≤ 2,999	100 (3.3%-5.0%)	100				
3,000 - 4,999	200 (4.0%-6.7%)	200				
5,000 - 6,999	300 (4.3%-6.0%)	300				
7,000 - 9,999	400 (4.0%-5.7%)	400				
10,000 - 14,999	600 (4.0%-6.0%)	600	± **6%** of *base prices	± **8%** of base prices	± **12%** of base prices	± **15%** of base prices
15,000 - 19,999	800 (4.0%-5.3%)	800				
20,000 - 29,999	1,000 (3.3%-5.0%)	1,000				
30,000 - 39,999	1,300 (3.3%-4.3%)	1,300				
40,000 - 49,999	1,600 (3.2%-4.0%)	1,600				
50,000 - 69,999	2,000 (2.9%-4.0%)	2,000				
70,000 - 99,999	2,500 (2.5%-3.6%)	2,500				
100,000-149,999	3,000 (2.0%-3.0%)	3,000				
150,000-199,999	4,000 (2.0%-2.7%)	4,000				
200,000-299,999		6,000 (2.0%-3.0%)				
300,000-399,999		8,000 (2.0%-2.7%)				
400,000-499,999		10,000 (2.0%-2.5%)				
500,000≤		12,000 (- 2.4%)				

Sources: Korea Stock Exchange, *Korean Stock Market*, 1996; *The Korea Economic Daily*, various issues.
*Base Prices are the previous trading day's closing prices in Korean won.
Price limits in columns 2 and 3 are maximum deviations either upwards or downwards in Korean won.
For rates in column 3, refer column 2 unless the rates are indicated in the parentheses.
Up until March 1995, as in shaded columns, price limits had been expressed as an *absolute* changes system. From April 1995 they were expressed as a *percentage* of the base price.

Table 7.2 Descriptive Statistics and Autocorrelation Test Results for the Entire Sample Period (March 1988 – May 1998)

Company code	Company	Mean	St. Dev.	Skewness	Kurtosis	Jarque-Bera
KR7000140004	Hite Brewery	-0.00011	0.0254	0.07	5.47	804.0
KR7005180005	Bingrae Co.	-0.00004	0.0303	-0.18	5.10	598.0
KR7005300009	Lotte Chillsung Beverage	0.00027	0.0234	-0.06	5.39	754.2
KR7002020006	Kolon Ind.	-0.00044	0.0247	-0.07	6.79	1893.8
KR7001460005	BYC	0.00019	0.0219	0.03	5.27	677.9
KR7004460002	Kohab Ltd.	-0.00070	0.0294	-0.03	6.56	1663.5
KR7003240009	Taekwang Industrial	0.00056	0.0225	-0.06	7.18	2297.4
KR7009830001	Hanwha	-0.00048	0.0291	0.11	5.36	739.8
KR7005950001	Isu Chemical	-0.00010	0.0279	0.17	4.09	170.2
KR7003550001	LG Chemical Ltd.	-0.00011	0.0240	0.05	5.99	1176.1
KR7011780004	Korea Kumho Petro.	-0.00055	0.0263	-0.01	5.96	1151.3
KR7003600004	SK	-0.00025	0.0226	-0.02	8.10	3427.7
KR7010950004	Ssangyong Oil Ref.	-0.00005	0.0227	0.02	6.95	2051.2
KR7000020008	Dongwha Pharm.	-0.00003	0.0290	0.06	5.14	605.7
KR7001060003	Choongwae Pharm.	-0.00002	0.0265	-0.14	5.27	686.8
KR7002000008	Hankook Glass	0.00008	0.0238	0.10	5.32	711.8
KR7005930003	Samsung Electronics	0.00029	0.0242	-0.55	15.08	19364.1
KR7002610004	LG Electronics Inc.	-0.00001	0.0252	0.10	6.27	1408.4
KR7007410004	Daewoo Electronics	-0.00035	0.0254	0.35	5.50	884.3
KR7001830009	Anam Eletronics	-0.00060	0.0305	-0.002	5.53	844.8
KR7006400006	Samsung Display Device	0.00006	0.0237	0.03	8.55	4049.7
KR7009150004	Samsung Electric-Mech.	-0.00016	0.0253	0.15	6.35	1487.0
KR7005380001	Hyundai Motor	-0.00001	0.0232	0.25	5.94	1168.5
KR7000270009	Kia Motors	-0.00071	0.0295	-0.21	7.58	2787.8
KR7003620002	Ssangyong Motor	-0.00054	0.0291	0.19	4.73	412.4
KR7008400004	Jindo Corp.	-0.00085	0.0316	0.01	5.91	1116.4
KR7005790001	Mando Machinery	-0.00035	0.0264	-1.36	21.58	46405.9
KR7000720003	Hyundai Construction	-0.00026	0.0250	0.19	4.90	493.3
KR7000280008	Dongah Construction	-0.00066	0.0278	-0.06	6.97	2072.4
KR7000210005	Daelim Ind.	-0.00060	0.0264	0.13	5.23	668.3
KR7003810009	Daewoo Corp.	-0.00053	0.0254	0.12	5.50	827.1
KR7000830000	Samsung Corp.	-0.00041	0.0246	0.14	5.76	1011.5
KR7001120005	LG International Corp.	-0.00053	0.0264	0.16	5.18	636.0
KR7004060000	Segye Corp.	-0.00063	0.0322	-0.04	5.10	581.8
KR7015580004	Shinhan Bank	-0.00053	0.0256	0.20	6.59	1442.4
KR7000010009	Choheung Bank	-0.00081	0.0291	0.36	15.58	20883.0
KR7000030007	Comercial Bank	-0.00107	0.0267	-0.26	8.60	4084.2
KR7008890006	Boram Bank	-0.00074	0.0286	-1.73	38.94	171502.7
KR7005020003	Korea L T Credit Bank	-0.00071	0.0275	-0.92	35.87	142604.8
KR7006800007	Daewoo Securities	-0.00039	0.0273	-0.09	8.01	3312.1
KR7003540002	Daishin Securities	-0.00047	0.0284	0.01	7.53	2701.0
KR7005740002	LG Secutities	-0.00042	0.0282	-0.08	7.74	2957.1
KR7000810002	Samsung F&M Insurance	0.00006	0.0237	0.03	8.55	4049.7
KR7000060004	Oriental F&M Insurance	-0.00056	0.0292	-1.00	18.47	32019.4
KR7000540005	Ssangyong F&M Insurance	-0.00054	0.0302	0.02	4.99	519.2
KR7003690005	Korea Reinsurance	-0.00046	0.0263	-0.53	11.07	8719.8
KR7005490008	POSCO	0.00012	0.0211	0.12	7.04	2095.6
KR7000200006	Daewoo Heavy Ind.	-0.00034	0.0270	-0.45	13.33	14143.2
KR7015760002	KEPCO	0.00003	0.0227	0.10	5.75	865.1
KR7017670001	SK Telecom	0.00125	0.0238	0.003	6.10	1065.8
KR7003490000	KAL	-0.00030	0.0250	-0.25	10.75	7936.3
KR7001150002	STC Corp.	-0.00040	0.0295	0.03	4.06	337.3
KR7007190002	Sinho Paper Mfg.	-0.00064	0.0334	-0.53	9.64	5938.3
KR7006570006	Daelim Trading	-0.00002	0.0294	-0.02	3.91	109.1
KR7004170007	Shinsegye Dpt.	-0.00011	0.0237	0.04	6.55	1657.7

The .05 critical value for the Jarque-Bera test is 5.99.

Table 7.3 Standard Deviations of Daily Stock Returns for Subperiods

Company code	*Absolute* changes system		*Fixed percentage* rates system		
	Subperiod 1 (Price limits: ±2.0 ~ ±6.7%)	Subperiod 2 (Price limits: ±2.0 ~ ±6.7%)	Subperiod 3 (Price limits: ±6%)	Subperiod 4 (Price limits: ±8%)	Subperiod 5 (Price limits: ±12%)
KR7000140004	0.0179	0.0249	0.0197	0.0378	0.0404
KR7005180005	0.0234	0.0262	0.0296	0.0438	0.0513
KR7005300009	0.0146	0.0217	0.0274	0.0346	0.0268
KR7002020006	0.0183	0.0212	0.0211	0.0372	0.0474
KR7001460005	0.0146	0.0201	0.0245	0.0323	0.0307
KR7004460002	0.0215	0.0244	0.0199	0.0342	0.0663
KR7003240009	0.0127	0.0171	0.0268	0.0345	0.0425
KR7009830001	0.0196	0.0253	0.0229	0.0435	0.0639
KR7005950001	0.0219	0.0265	0.0240	0.0411	0.0491
KR7003550001	0.0185	0.0215	0.0190	0.0377	0.0397
KR7011780004	0.0220	0.0239	0.0189	0.0379	0.0490
KR7003600004	0.0165	0.0203	0.0185	0.0344	0.0326
KR7010950004	0.0168	0.0197	0.0147	0.0388	0.0369
KR7000020008	0.0198	0.0242	0.0272	0.0425	0.0589
KR7001060003	0.0194	0.0246	0.0241	0.0416	0.0454
KR7002000008	0.0179	0.0216	0.0195	0.0399	0.0366
KR7005930003	0.0149	0.0185	0.0273	0.0356	0.0420
KR7002610004	0.0198	0.0214	0.0198	0.0367	0.0512
KR7007410004	0.0198	0.0227	0.0196	0.0370	0.0411
KR7001830009	0.0208	0.0223	0.0273	0.0439	0.0639
KR7006400006	0.0169	0.0183	0.0199	0.0342	0.0512
KR7009150004	0.0180	0.0209	0.0208	0.0378	0.0549
KR7005380001	0.0178	0.0195	0.0157	0.0358	0.0407
KR7000270009	0.0182	0.0204	0.0175	0.0444	0.0604
KR7003620002	0.0197	0.0246	0.0247	0.0489	0.0475
KR7008400004	0.0206	0.0262	0.0210	0.0472	0.0699
KR7005790001	0.0199	0.0202	0.0208	0.0431	0.0523
KR7000720003	0.0207	0.0216	0.0163	0.0375	0.0417
KR7000280008	0.0195	0.0217	0.0183	0.0393	0.0635
KR7000210005	0.0192	0.0236	0.0211	0.0385	0.0560

KR7003810009	0.0213	0.0229	0.0203	0.0370	0.0408
KR7000830000	0.0170	0.0216	0.0210	0.0384	0.0430
KR7001120005	0.0198	0.0240	0.0222	0.0378	0.0440
KR7004060000	0.0263	0.0293	0.0260	0.0433	0.0535
KR7015580004	0.0215	0.0206	0.0160	0.0350	0.0468
KR7000010009	0.0191	0.0215	0.0174	0.0384	0.0784
KR7000030007	0.0197	0.0205	0.0171	0.0373	0.0618
KR7008890006	0.0259	0.0212	0.0221	0.0377	0.0471
KR7005020003	0.0204	0.0204	0.0148	0.0349	0.0839
KR7006800007	0.0223	0.0205	0.0205	0.0431	0.0495
KR7003540002	0.0220	0.0206	0.0227	0.0431	0.0528
KR7005740002	0.0225	0.0211	0.0230	0.0432	0.0556
KR7000810002	0.0197	0.0195	0.0235	0.0361	0.0392
KR7000060004	0.0241	0.0256	0.0246	0.0394	0.0516
KR7000540005	0.0215	0.0257	0.0256	0.0429	0.0568
KR7003690005	0.0218	0.0225	0.0217	0.0383	0.0418
KR7005490008	0.0158	0.0190	0.0156	0.0324	0.0330
KR7000200006	0.0202	0.0273	0.0203	0.0396	0.0476
KR7015760002	0.0183	0.0204	0.0150	0.0311	0.0298
KR7017670001	0.0170	0.0179	0.0214	0.0365	0.0289
KR7003490000	0.0175	0.0208	0.0157	0.0393	0.0525
KR7001150002	0.0224	0.0263	0.0242	0.0412	0.0577
KR7007190002	0.0191	0.0297	0.0264	0.0506	0.0767
KR7006570006	0.0239	0.0281	0.0258	0.0397	0.0590
KR7004170007	0.0155	0.0196	0.0212	0.0385	0.0451
Average	*0.0196*	*0.0224*	*0.0213*	*0.0390*	*0.0475*

Table 7.4 Number of Days of Up- and Down-Limit Moves

Company	Period 1	Period 2	Period 3	Period 4	Period 5	*Total*
Hite Brewery	68	142	13	43	7	*273*
Bingrae Co.	150	160	23	58	9	*400*
Lotte Chillsung Beverage	57	274	15	25	1	*372*
Kolon Ind.	83	114	11	27	8	*243*
BYC	136	336	8	14	2	*496*
Kohab Ltd.	96	100	3	31	46	*276*
Taekwang Industrial	136	406	26	14	5	*587*
Hanwha	86	104	12	65	21	*288*
Isu Chemical	106	122	12	46	7	*293*
LG Chemical Ltd.	76	75	8	19	2	*180*
Korea Kumho Petro.	97	73	9	69	10	*258*
SK	69	127	9	39	7	*251*
Ssangyong Oil Ref.	54	65	4	54	4	*181*
Dongwha Pharm.	95	132	42	60	23	*352*
Choongwae Pharm.	76	204	26	60	5	*371*
Hankook Glass	75	99	5	48	3	*230*
Samsung Electronics	58	175	17	40	10	*300*
LG Electronics Inc.	82	71	0	52	12	*217*
Daewoo Electronics	94	88	6	40	11	*239*
Anam Eletronics	97	67	12	68	39	*283*
Samsung Display Device	70	146	7	34	11	*268*
Samsung Electric-Mech.	119	123	21	37	14	*314*
Hyundai Motor	92	102	1	32	8	*235*
Kia Motors	72	62	8	69	47	*258*
Ssangyong Motor	81	106	37	87	11	*322*
Jindo Corp.	85	123	6	75	46	*335*
Mando Machinery	99	94	12	55	9	*269*
Hyundai Construction	132	122	9	26	5	*294*
Dongah Construction	102	123	9	51	36	*321*
Daelim Ind.	109	105	5	73	9	*301*
Daewoo Corp.	109	85	10	44	2	*250*
Samsung Corp.	70	127	8	36	6	*247*
LG International Corp.	92	91	2	40	9	*234*
Segye Corp.	192	170	16	69	21	*468*
Shinhan Bank	58	68	1	32	10	*169*
Choheung Bank	72	68	2	44	33	*219*
Comercial Bank	77	50	6	36	26	*195*
Boram Bank	112	54	7	42	16	*231*
Korea L T Credit Bank	82	91	0	28	14	*215*
Daewoo Securities	143	93	14	43	6	*299*
Daishin Securities	126	71	8	65	15	*285*
LG Secutities	134	83	2	46	12	*277*
Samsung F&M Insurance	136	297	25	32	5	*495*

Oriental F&M Insurance	132	185	29	40	12	*398*
Ssangyong F&M Insurance	136	137	26	56	17	*372*
Korea Reinsurance	138	120	18	32	5	*313*
POSCO	70	132	4	32	3	*241*
Daewoo Heavy Ind.	77	101	6	54	7	*245*
KEPCO	53	97	4	30	4	*188*
SK Telecom	125	367	21	34	6	*553*
KAL	77	75	3	33	12	*200*
STC Corp.	127	158	15	49	18	*367*
Sinho Paper Mfg.	51	195	24	108	50	*428*
Daelim Trading	140	173	4	46	10	*373*
Shinsegye Dpt.	70	174	12	35	7	*298*
Average	*97.3*	*132.8*	*11.7*	*45.8*	*13.7*	*301.3*
Average Percentage Rate	*7.8*	*16.0*	*2.4*	*12.5*	*5.1*	*9.4*

Figure 7.1 Average Number of Days of Limit Moves

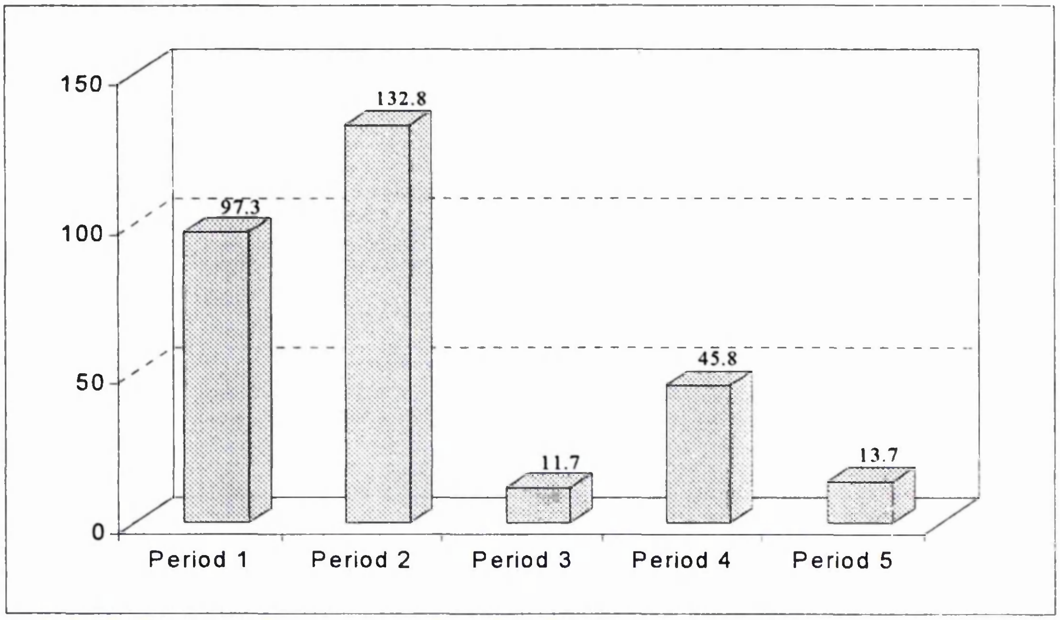

Figure 7.2 Average Number of Successive Days of Limit Moves

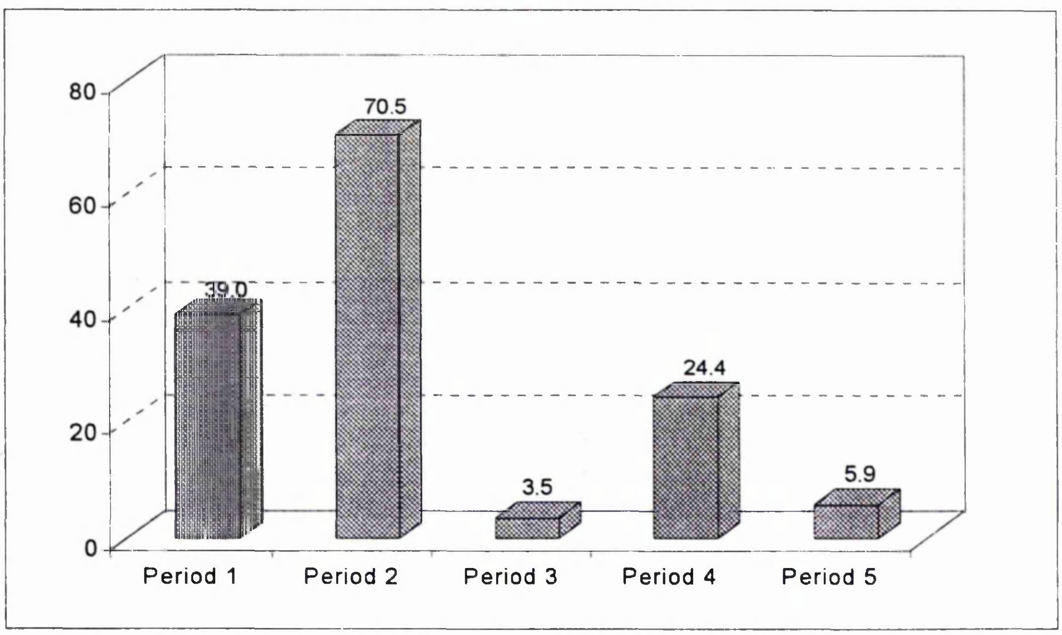

Table 7.5 Frequency of Successive Days of Up- and Down-Limit Moves

	Frequency of successive downs				Frequency of successive ups			
Company	2	3	4	≥ 5	2	3	4	≥ 5
Hite Brewery	11	2		1	21	5	1	3
Bingrae Co.	21	1	2	3	26	8	3	6
Lotte Chillsung Beverage	23	3	3	3	21	5	6	7
Kolon Ind.	14	1		1	12	5	2	3
BYC	26	6	4	8	15	19	7	13
Kohab Ltd.	13	1		2	23	5	4	1
Taekwang Industrial	23	9	6	8	27	18	7	19
Hanwha	9	4	2		24	8	1	1
Isu Chemical	11	1		3	21	10	1	3
LG Chemical Ltd.	5				17	2		
Korea Kumho Petro.	9	3		1	19	3		2
SK	8	3			23	4	2	1
Ssangyong Oil Ref.	6	4			13	2	3	2
Dongwha Pharm.	18	6		1	22	7	5	3
Choongwae Pharm.	20	5	1	3	21	10	6	5
Hankook Glass	12		1		20	8	1	
Samsung Electronics	11	2	3		20	8	3	3
LG Electronics Inc.	9	1			14	5	1	
Daewoo Electronics	9				15	5	4	
Anam Eletronics	8	5		2	15	5	2	3
Samsung Display Device	15	2	1		21	8	4	
Samsung Electric-Mech.	15	4	1		28	10	1	1
Hyundai Motor	10	2	1		22	5	1	
Kia Motors	15	3		1	22	5	3	
Ssangyong Motor	13	4		1	17	8	5	4
Jindo Corp.	12	7	5	1	22	9	6	3
Mando Machinery	16		1	1	18	7	2	1
Hyundai Construction	8	1	3		24	10	3	1
Dongah Construction	19	1	2	2	22	4	5	3
Daelim Ind.	11	2		1	17	5	3	1
Daewoo Corp.	12				18	6	4	1
Samsung Corp.	11	1		1	15	11	3	2
LG International Corp.	9				14	7	1	2
Segye Corp.	28	3	2	2	27	15	5	6
Shinhan Bank	8			1	12	6	1	
Choheung Bank	4				16	7		1
Commercial Bank	3	1	1		11	3	1	2
Boram Bank	6				17	5	3	1
Korea Long Term Credit Bank	8				15	7		3
Daewoo Securities	8			1	19	6	4	2
Daishin Securities	7	1		1	18	10	1	4
LG Securities	7			1	13	12	2	2
Samsung F&M Insurance	31	6	4	3	32	8	1	14
Oriental F&M Insurance	25	2	1	1	30	15	3	3
Ssangyong F&M Insurance	19	2		1	29	14	5	2
Korea Reinsurance	12	2	1		20	10	3	1
POSCO	9	2			24	6	4	1
Daewoo Heavy Ind.	16				17	5	2	1
KEPCO	13				14	9		2
SK Telecom	24	14	7	6	22	14	11	16
KAL	6	4			12	6	2	1
STC Corp.	20	2	3	1	23	7	2	7
Sinho Paper Mfg.	18	8	3	2	27	9	4	7
Daelim Trading	18	7	1	1	28	6	3	3
Shinsegye Dpt.	12	4			23	6	2	6

Table 7.6 Variance Ratio Tests for Period 1 (2 March 1988 - 7 June 1992)

Industry	Company code	Aggregation interval				
		q = 2	*q = 6*	*q = 12*	*q = 18*	*q = 24*
Foods & Beverage	KR7000140004	1.056 (2.58)*	0.925 (-1.04)	0.813 (-1.22)	0.739 (-1.06)	0.711 (-0.88)
	KR7005180005	1.115 (5.33)*	1.187 (1.60)	1.291 (1.89)	1.340 (1.53)	1.326 (1.02)
	KR7005300009	1.170 (7.94)*	1.430 (5.70)	1.623 (3.84)	1.728 (2.57)	1.804 (2.27)
Textiles & Wearing Apparel	KR7002020006	1.113 (4.59)*	1.101 (1.22)	1.030 (0.18)	1.040 (0.16)	1.037 (0.10)
	KR7001460005	1.294 (14.23)*	1.751 (10.27)	2.171 (7.32)	2.484 (6.60)	2.718 (5.61)
	KR7004460002	1.052 (2.37)	0.953 (-0.66)	0.875 (-0.83)	0.889 (-0.46)	0.846 (-0.50)
	KR7003240009	1.322 (17.21)*	2.009 (16.29)	2.374 (10.04)	2.671 (8.29)	2.973 (7.15)
Chemicals & Chemical Products	KR7009830001	1.030 (1.42)	1.014 (0.20)	0.984 (-0.11)	1.043 (0.18)	1.038 (0.11)
	KR7005950001	1.060 (2.73)*	1.125 (1.73)	1.179 (1.21)	1.223 (0.96)	1.166 (0.50)
	KR7003550001	0.9934 (-0.32)	0.874 (-1.65)	0.791 (-1.28)	0.811 (-0.72)	0.801 (-0.63)
	KR7011780004	1.080 (3.83)*	1.056 (0.77)	1.068 (0.35)	1.081 (0.35)	1.074 (0.23)
	KR7003600004	1.070 (3.00)*	1.096 (1.17)	1.044 (0.26)	1.054 (0.19)	1.017 (0.05)
	KR7010950004	0.999 (-0.03)	0.873 (-1.61)	0.764 (-1.45)	0.745 (-0.97)	0.724 (-0.90)
Medicine	KR7000020008	1.029 (1.24)	1.033 (0.44)	1.010 (0.06)	1.007 (0.03)	0.986 (-0.04)
	KR7001060003	1.051 (2.27)	0.983 (-0.22)	0.931 (-0.45)	0.891 (-0.30)	0.897 (-0.30)
Non-metallic Mineral Products	KR7002000008	1.052 (2.37)	0.968 (-0.42)	0.875 (-0.82)	0.868 (-0.55)	0.871 (-0.36)
Electrical & Electronic Products	KR7005930003	1.110 (4.63)*	1.109 (1.41)	1.036 (0.21)	1.088 (0.32)	1.104 (0.30)
	KR7002610004	0.997 (-0.12)	0.958 (-0.56)	0.875 (-0.75)	0.877 (-0.48)	0.862 (-0.44)
	KR7007410004	0.992 (-0.33)	0.954 (-0.65)	0.867 (-0.85)	0.862 (-0.56)	0.876 (-0.38)
	KR7001830009	1.044 (1.99)	1.065 (0.88)	1.005 (0.04)	1.018 (0.08)	0.939 (-0.20)
	KR7006400006	1.115 (4.85)*	1.182 (1.92)	1.178 (0.90)	1.205 (0.67)	1.174 (0.48)
	KR7009150004	1.110 (4.66)*	1.168 (2.12)	1.189 (1.10)	1.252 (1.03)	1.238 (0.75)
Transport Equipment	KR7005380001	1.143 (6.36)*	1.288 (4.05)	1.268 (1.71)	1.315 (1.30)	1.288 (0.87)
	KR7000270009	1.082	1.111	1.029	1.077	1.101

		(3.66)*	(1.51)	(0.18)	(0.30)	(0.30)
	KR7003620002	1.038 (1.63)	1.004 (0.05)	0.914 (-0.55)	0.936 (-0.26)	0.935 (-0.22)
	KR7008400004	1.051 (2.26)	1.108 (1.42)	1.169 (1.35)	1.193 (0.83)	1.161 (0.50)
	KR7005790001	1.022 (1.09)	0.873 (-1.61)	0.781 (-1.23)	0.764 (-0.70)	0.748 (-0.50)
Construction	KR7000720003	1.138 (6.43)*	1.267 (3.80)	1.329 (2.25)	1.367 (1.62)	1.333 (1.06)
	KR7000280008	1.097 (4.36)*	1.281 (3.81)	1.354 (2.28)	1.423 (1.69)	1.397 (1.23)
	KR7000210005	1.067 (2.98)*	1.021 (0.27)	0.951 (-0.30)	0.993 (-0.03)	0.974 (-0.08)
Wholesale Trade	KR7003810009	1.063 (2.88)*	1.139 (1.83)	1.132 (0.93)	1.120 (0.48)	1.115 (0.33)
	KR7000830000	1.063 (2.67)*	1.064 (0.86)	0.915 (-0.52)	0.921 (-0.32)	0.889 (-0.33)
	KR7001120005	1.051 (2.28)	1.061 (0.83)	0.968 (-0.20)	0.977 (-0.09)	0.981 (-0.06)
	KR7004060000	1.142 (6.64)*	1.810 (1.13)	1.008 (0.06)	0.970 (-0.13)	0.960 (-0.12)
Banks	KR7015580004	1.027 (0.94)	1.018 (0.17)	0.910 (-0.41)	0.937 (-0.18)	0.972 (-0.08)
	KR7000010009	1.022 (1.05)	0.997 (-0.04)	0.952 (-0.30)	0.996 (-0.02)	1.027 (0.08)
	KR7000030007	1.031 (0.67)	0.957 (-0.57)	0.894 (-0.64)	0.930 (-0.26)	0.942 (-0.16)
	KR7008890006	1.047 (1.68)	1.134 (1.22)	1.099 (0.77)	1.071 (0.20)	1.066 (0.14)
	KR7005020003	1.052 (2.10)	1.063 (0.87)	1.029 (0.16)	1.083 (0.29)	1.110 (0.29)
Securities	KR7006800007	1.084 (3.36)*	1.225 (2.90)	1.222 (1.31)	1.263 (0.99)	1.295 (0.74)
	KR7003540002	1.053 (2.23)	1.126 (1.52)	1.121 (0.70)	1.165 (0.61)	1.214 (0.60)
	KR7005740002	1.102 (3.96)*	1.196 (2.33)	1.209 (1.21)	1.280 (0.98)	1.357 (1.09)
Insurance	KR7000810002	1.142 (5.43)*	1.291 (3.25)	1.467 (2.98)	1.614 (2.53)	1.713 (2.08)
	KR7000060004	1.064 (2.78)*	1.149 (1.69)	1.234 (1.71)	1.290 (1.09)	1.363 (0.75)
	KR7000540005	1.133 (5.59)*	1.198 (2.41)	1.180 (1.12)	1.226 (0.94)	1.287 (0.81)
	KR7003690005	1.075 (2.94)*	1.141 (1.51)	1.249 (1.38)	1.322 (1.07)	1.380 (1.49)
Basic Metal Industries	KR7005490008	1.127 (6.01)*	1.097 (1.27)	1.001 (0.01)	1.019 (0.07)	1.028 (0.08)
Machinery	KR7000200006	1.013 (0.54)	1.013 (0.17)	0.972 (-0.19)	0.992 (-0.03)	1.030 (0.09)
Electricity	KR7015760002	1.033 (1.41)	0.916 (-1.05)	0.814 (-0.99)	0.802 (-0.99)	0.811 (-0.42)

Communication	KR7017670001	1.302 (10.52)*	1.756 (7.63)	2.177 (5.80)	2.329 (4.01)	2.366 (2.93)
Air Transport	KR7003490000	1.067 (3.06)*	1.130 (1.93)	1.205 (1.27)	1.253 (1.03)	1.271 (0.86)
Rubber & Plastics	KR7001150002	1.097 (4.61)*	1.226 (3.39)	1.244 (1.75)	1.296 (1.33)	1.304 (1.03)
Paper & Paper Products	KR7007190002	1.200 (8.21)*	1.595 (7.69)	1.744 (4.82)	1.750 (2.89)	1.704 (2.05)
Fabricated Metal Products	KR7006570006	1.091 (4.03)*	1.069 (0.97)	1.063 (0.40)	1.063 (0.27)	1.078 (0.26)
Retail Trade	KR7004170007	1.147 (6.01)*	1.368 (5.10)	1.431 (3.04)	1.448 (1.87)	1.378 (1.16)

For each company and each aggregation interval the table reports the estimated variance ratio together with the Lo and MacKinlay $Z(q)^*$ statistics under the heteroscedasticity assumption in parentheses.
* indicates where the maximum absolute value in the set of tests statistics exceeds the .05 critical value of the SMM (0.05; 5; 1245) distribution of 2.57 and hence the variance ratio is significantly different from 1.0.

Table 7.7 Variance Ratio Tests for Period 2 (8 June 1992 – 31 March 1995)

Industry	Company code	Aggregation interval				
		$q = 2$	$q = 6$	$q = 12$	$q = 18$	$q = 24$
Foods & Beverage	KR7000140004	1.073 (2.37)	1.015 (0.15)	0.908 (-0.46)	0.847 (-0.50)	0.860 (-0.35)
	KR7005180005	1.098 (3.06)*	1.152 (1.50)	1.070 (0.33)	1.042 (0.13)	0.985 (-0.03)
	KR7005300009	1.272 (9.02)*	1.797 (8.44)	2.228 (6.59)	2.524 (5.27)	2.738 (4.31)
Textiles & Wearing Apparel	KR7002020006	1.073 (2.48)	1.027 (0.34)	0.934 (-0.37)	0.932 (-0.22)	0.915 (-0.23)
	KR7001460005	1.301 (9.61)*	1.723 (7.23)	1.695 (3.39)	1.557 (1.84)	1.490 (1.16)
	KR7004460002	1.020 (0.68)	0.915 (-0.91)	0.875 (-0.62)	0.851 (-0.47)	0.770 (-0.55)
	KR7003240009	1.424 (13.45)*	2.088 (10.59)	2.414 (6.71)	2.637 (5.20)	2.735 (4.09)
Chemicals & Chemical Products	KR7009830001	1.043 (1.38)	0.937 (-0.64)	1.001 (0.00)	1.063 (0.20)	1.061 (0.14)
	KR7005950001	1.035 (1.17)	0.918 (-0.87)	0.859 (-0.72)	0.841 (-0.54)	0.822 (-0.42)
	KR7003550001	1.040 (1.35)	0.932 (-0.73)	0.907 (-0.46)	0.875 (-0.39)	0.882 (-0.29)
	KR7011780004	0.984 (-0.54)	0.784 (-2.29)	0.711 (-1.39)	0.671 (-1.06)	0.645 (-0.85)
	KR7003600004	1.143 (4.99)*	1.170 (1.87)	1.253 (1.38)	1.260 (0.94)	1.308 (0.81)
	KR7010950004	1.087 (2.92)*	1.026 (0.27)	0.874 (-0.61)	0.767 (-0.77)	0.729 (-0.64)
Medicine	KR7000020008	1.109 (3.50)*	1.102 (1.06)	1.048 (0.25)	1.009 (0.03)	1.018 (0.04)
	KR7001060003	1.192 (6.29)*	1.506 (4.88)	1.625 (2.96)	1.634 (1.97)	1.605 (1.48)
Non-metallic Mineral Products	KR7002000008	1.109 (3.47)*	1.011 (0.11)	0.974 (-0.14)	0.964 (-0.12)	1.004 (0.01)
Electrical & Electronic Products	KR7005930003	1.178 (6.02)*	1.327 (3.50)	1.303 (1.62)	1.311 (0.91)	1.418 (0.90)
	KR7002610004	1.080 (2.80)*	0.972 (-0.31)	0.996 (-0.02)	1.008 (0.03)	1.038 (0.10)
	KR7007410004	1.039 (1.36)	0.933 (-0.73)	0.892 (-0.59)	0.893 (-0.35)	0.867 (-0.31)
	KR7001830009	0.997 (-0.11)	0.816 (-1.91)	0.663 (-1.72)	0.611 (-1.27)	0.603 (-0.98)
	KR7006400006	1.208 (7.32)*	1.279 (2.99)	1.275 (1.38)	1.291 (0.97)	1.338 (0.86)
	KR7009150004	1.173 (5.78)*	1.144 (1.38)	0.991 (-0.04)	0.920 (-0.25)	0.945 (-0.14)
Transport Equipment	KR7005380001	1.158 (5.45)*	1.219 (2.44)	1.092 (0.48)	1.045 (0.15)	1.069 (0.17)
	KR7000270009	1.031	0.929	0.795	0.747	0.749

		(1.07)	(-0.80)	(-1.01)	(-0.82)	(-0.61)
	KR7003620002	1.085 (2.91)*	1.074 (0.80)	1.124 (0.65)	1.139 (0.44)	1.105 (0.26)
	KR7008400004	1.095 (3.12)*	1.165 (1.78)	1.021 (0.10)	0.980 (-0.06)	0.994 (-0.01)
	KR7005790001	1.032 (1.04)	0.928 (-0.72)	0.801 (-0.99)	0.731 (-0.89)	0.696 (-0.72)
Construction	KR7000720003	1.146 (5.12)*	1.306 (3.48)	1.266 (1.46)	1.259 (1.92)	1.283 (0.73)
	KR7000280008	1.176 (5.92)*	1.245 (2.70)	1.143 (0.77)	1.079 (0.27)	1.092 (0.23)
	KR7000210005	1.048 (1.61)	0.999 (-0.02)	0.936 (-0.32)	0.910 (-0.30)	0.892 (-0.26)
Wholesale Trade	KR7003810009	0.993 (-0.23)	0.873 (-1.44)	0.806 (-1.11)	0.798 (-0.68)	0.809 (0.48)
	KR7000830000	1.147 (4.93)*	1.127 (1.32)	1.032 (0.16)	1.047 (0.16)	1.090 (0.21)
	KR7001120005	0.998 (-0.08)	0.882 (-1.22)	0.722 (-1.41)	0.651 (-1.12)	0.630 (-0.92)
	KR7004060000	1.051 (1.66)	1.093 (0.98)	1.195 (1.01)	1.245 (0.79)	1.203 (0.50)
Banks	KR7015580004	1.016 (0.59)	0.945 (-0.57)	0.852 (-0.77)	0.874 (-0.43)	0.898 (-0.26)
	KR7000010009	1.047 (1.62)	0.965 (-0.37)	0.915 (-0.43)	0.920 (-0.26)	0.909 (-0.23)
	KR7000030007	1.020 (0.70)	0.985 (-0.17)	0.827 (-0.94)	0.803 (-0.63)	0.794 (-0.50)
	KR7008890006	0.971 (-0.98)	0.892 (-1.18)	0.704 (-0.90)	0.621 (-0.90)	0.621 (-0.89)
	KR7005020003	1.109 (3.96)*	1.101 (1.11)	1.081 (0.43)	1.025 (0.08)	0.969 (-0.08)
Securities	KR7006800007	1.092 (3.33)*	1.153 (1.81)	1.037 (0.20)	1.084 (0.29)	1.171 (0.43)
	KR7003540002	0.999 (-0.03)	0.967 (-0.37)	0.870 (-0.66)	0.882 (-0.38)	0.896 (-0.27)
	KR7005740002	1.042 (1.42)	1.073 (0.78)	0.991 (-0.05)	1.009 (0.03)	1.049 (0.12)
Insurance	KR7000810002	1.335 (10.76)	2.124 (11.48)*	2.675 (8.07)	2.974 (6.44)	3.113 (5.24)
	KR7000060004	1.131 (4.42)*	1.181 (1.86)	1.244 (1.19)	1.290 (0.97)	1.256 (0.66)
	KR7000540005	1.130 (4.15)*	1.108 (1.14)	1.024 (0.12)	0.996 (-0.01)	0.951 (0.12)
	KR7003690005	1.095 (3.28)*	1.135 (1.49)	1.055 (0.28)	1.001 (0.00)	0.946 (-0.14)
Basic Metal Industries	KR7005490008	1.210 (6.77)*	1.382 (4.12)	1.562 (2.85)	1.693 (2.26)	1.813 (2.07)
Machinery	KR7000200006	1.040 (1.13)	1.116 (1.01)	1.075 (0.34)	1.054 (0.19)	1.085 (0.24)
Electricity	KR7015760002	1.175 (6.28)*	1.482 (5.58)	1.672 (3.75)	1.757 (2.58)	1.841 (2.25)

Communication	KR7017670001	1.441 (14.17)*	2.250 (13.07)	2.821 (9.31)	3.181 (7.29)	3.505 (6.19)
Air Transport	KR7003490000	1.078 (2.68)*	1.113 (1.22)	1.097 (0.50)	1.116 (0.38)	1.162 (0.39)
Rubber & Plastics	KR7001150002	1.047 (1.48)	1.080 (0.85)	1.101 (0.52)	1.137 (0.46)	1.212 (0.54)
Paper & Paper Products	KR7007190002	1.047 (1.51)	1.092 (0.98)	1.023 (0.12)	1.054 (0.17)	1.058 (0.14)
Fabricated Metal Products	KR7006570006	1.149 (4.73)*	1.175 (1.82)	1.092 (0.46)	1.163 (0.54)	1.222 (0.54)
Retail Trade	KR7004170007	1.250 (8.67)*	1.560 (6.04)	1.652 (3.56)	1.648 (2.37)*	1.630 (1.66)

For each company and each aggregation interval the table reports the estimated variance ratio together with the Lo and MacKinlay $Z(q)$* statistics under the heteroscedasticity assumption in parentheses.
* indicates where the maximum absolute value in the set of tests statistics exceeds the .05 critical value of the SMM (0.05; 5; 831) distribution of 2.57 and hence the variance ratio is significantly different from 1.0.

Table 7.8 Variance Ratio Tests for Period 3 (1 April 1995 – 24 November 1996)

Industry	Company code	Aggregation interval				
		$q = 2$	$q = 6$	$q = 12$	$q = 18$	$q = 24$
Foods & Beverage	KR7000140004	0.987 (-0.34)	0.924 (-0.56)	0.846 (-0.49)	0.819 (-0.44)	0.832 (-0.27)
	KR7005180005	1.061 (1.32)	1.126 (0.84)	1.068 (0.22)	0.983 (-0.04)	0.961 (-0.09)
	KR7005300009	1.068 (1.84)	0.959 (-0.31)	0.888 (-0.44)	0.908 (-0.19)	0.928 (-0.13)
Textiles & Wearing Apparel	KR7002020006	1.086 (1.95)	1.033 (0.27)	0.878 (-0.39)	0.872 (-0.30)	0.792 (-0.36)
	KR7001460005	0.930 (-1.68)	0.632 (-2.72)*	0.518 (-1.89)	0.490 (-1.26)	0.456 (-0.98)
	KR7004460002	0.927 (-1.66)	0.807 (-1.56)	0.698 (-1.06)	0.650 (-0.83)	0.627 (-0.73)
	KR7003240009	0.991 (-0.23)	0.786 (-1.59)	0.615 (-1.31)	0.597 (-1.03)	0.546 (-0.80)
Chemicals & Chemical Products	KR7009830001	1.020 (0.50)	1.027 (0.23)	0.971 (-0.11)	0.897 (-0.25)	0.861 (-0.27)
	KR7005950001	1.068 (1.75)	1.080 (0.63)	0.896 (-0.35)	0.847 (-0.36)	0.807 (-0.34)
	KR7003550001	1.122 (2.86)*	1.095 (0.69)	1.038 (0.14)	0.902 (-0.22)	0.807 (-0.36)
	KR7011780004	0.935 (-1.92)	0.832 (-1.36)	0.792 (-0.72)	0.704 (-0.72)	0.635 (-0.69)
	KR7003600004	1.036 (1.07)	1.031 (0.25)	0.925 (-0.28)	0.950 (-0.10)	0.894 (-0.20)
	KR7010950004	0.992 (-0.22)	0.866 (-0.90)	0.737 (-0.92)	0.716 (-0.66)	0.650 (-0.58)
Medicine	KR7000020008	1.137 (3.78)*	1.156 (1.31)	1.123 (0.52)	1.157 (0.45)	1.100 (0.21)
	KR7001060003	1.032 (0.89)	0.969 (-0.23)	0.889 (-0.42)	0.900 (-0.26)	0.795 (-0.38)
Non-metallic Mineral Products	KR7002000008	0.993 (-0.17)	0.979 (-0.15)	0.938 (-0.24)	0.919 (-0.20)	0.873 (0.24)
Electrical & Electronic Products	KR7005930003	1.177 (5.58)*	1.319 (2.34)	1.215 (0.56)	1.290 (0.64)	1.255 (0.35)
	KR7002610004	1.147 (3.74)*	1.080 (0.60)	1.109 (0.34)	1.190 (0.44)	1.268 (0.45)
	KR7007410004	0.931 (-1.86)	0.875 (-1.04)	0.735 (-0.95)	0.707 (-0.72)	0.601 (-0.73)
	KR7001830009	1.198 (5.41)*	1.458 (3.94)	1.400 (1.55)	1.308 (0.79)	1.223 (0.40)
	KR7006400006	1.105 (2.24)	1.066 (0.46)	1.116 (0.39)	1.150 (0.36)	1.094 (0.15)
	KR7009150004	1.063 (1.57)	1.107 (0.86)	1.107 (0.38)	1.080 (0.22)	0.973 (-0.05)
Transport Equipment	KR7005380001	1.091 (1.90)	1.037 (0.25)	1.012 (0.04)	1.075 (0.19)	1.089 (0.16)
	KR7000270009	1.051	0.949	0.860	0.858	0.823

		(1.36)	(-0.40)	(-0.52)	(-0.34)	(-0.30)
	KR7003620002	1.023 (0.73)	1.155 (1.51)	1.197 (0.82)	1.270 (0.72)	1.293 (0.59)
	KR7008400004	0.967 (-0.83)	0.876 (-1.00)	0.655 (-1.20)	0.587 (-0.98)	0.562 (-0.72)
	KR7005790001	0.938 (-1.54)	0.856 (-1.06)	0.821 (-0.66)	0.816 (-0.43)	0.788 (-0.38)
Construction	KR7000720003	1.100 (2.74)*	1.134 (1.26)	1.059 (0.26)	0.919 (-0.22)	0.799 (-0.47)
	KR7000280008	1.098 (2.61)*	1.106 (0.88)	1.052 (0.19)	0.956 (-0.11)	0.922 (-0.14)
	KR7000210005	1.047 (1.09)	0.924 (-0.57)	0.783 (-0.75)	0.799 (-0.50)	0.796 (-0.36)
Wholesale Trade	KR7003810009	0.921 (-2.14)	0.787 (-1.68)	0.730 (-0.94)	0.675 (-0.79)	0.605 (0.70)
	KR7000830000	1.098 (2.23)	1.012 (0.10)	0.935 (-0.23)	0.960 (-0.09)	0.987 (-0.02)
	KR7001120005	0.979 (-0.47)	0.803 (-1.45)	0.696 (-1.14)	0.633 (-0.81)	0.594 (-0.68)
	KR7004060000	1.049 (1.18)	1.055 (0.43)	0.842 (-0.61)	0.836 (-0.38)	0.736 (-0.47)
Banks	KR7015580004	0.980 (-0.49)	0.833 (-1.50)	0.716 (-1.06)	0.632 (-0.90)	0.567 (-0.75)
	KR7000010009	1.013 (0.29)	0.931 (-0.59)	0.805 (-0.67)	0.820 (-0.39)	0.723 (-0.45)
	KR7000030007	1.005 (0.12)	0.958 (-0.35)	0.845 (-0.48)	0.862 (-0.28)	0.806 (-0.32)
	KR7008890006	0.996 (-0.10)	1.030 (0.25)	0.975 (-0.10)	0.967 (-0.08)	0.924 (-0.14)
	KR7005020003	0.977 (-0.54)	0.897 (-0.54)	0.854 (-0.54)	0.815 (-0.42)	0.681 (-0.59)
Securities	KR7006800007	1.120 (3.15)*	1.177 (1.38)	1.132 (0.49)	1.115 (0.27)	1.018 (0.03)
	KR7003540002	1.028 (0.68)	1.119 (0.93)	1.186 (0.67)	1.157 (0.38)	1.071 (0.13)
	KR7005740002	1.059 (1.52)	1.184 (1.37)	1.244 (0.91)	1.195 (0.44)	1.096 (0.16)
Insurance	KR7000810002	1.154 (4.00)*	1.316 (2.37)	1.220 (0.74)	1.346 (0.80)	1.334 (0.60)
	KR7000060004	1.039 (0.86)	1.025 (0.18)	0.977 (-0.09)	0.887 (-0.27)	0.751 (-0.45)
	KR7000540005	1.078 (1.88)	1.058 (0.41)	0.983 (-0.06)	0.990 (-0.02)	0.935 (0.11)
	KR7003690005	1.128 (3.54)*	1.213 (1.86)	1.220 (0.79)	1.206 (0.53)	1.160 (0.27)
Basic Metal Industries	KR7005490008	1.130 (3.23)*	0.981 (-0.15)	0.875 (-0.41)	0.945 (-0.12)	0.948 (-0.10)
Machinery	KR7000200006	0.965 (-0.88)	0.916 (-0.68)	0.846 (-0.53)	0.806 (-0.96)	0.705 (-0.55)
Electricity	KR7015760002	1.125 (3.61)*	1.062 (0.57)	0.913 (-0.29)	0.757 (-0.61)	0.671 (-0.66)

Communication	KR7017670001	1.199 (5.57)*	1.229 (1.82)	1.228 (0.84)	1.265 (0.64)	1.228 (0.40)
Air Transport	KR7003490000	1.062 (1.61)	0.995 (-0.04)	0.893 (-0.38)	0.922 (-0.20)	0.932 (-0.12)
Rubber & Plastics	KR7001150002	1.051 (1.21)	1.025 (0.18)	0.974 (-0.10)	1.035 (0.09)	0.988 (-0.02)
Paper & Paper Products	KR7007190002	1.043 (1.08)	1.106 (0.85)	0.993 (-0.03)	0.915 (-0.21)	0.832 (-0.29)
Fabricated Metal Products	KR7006570006	1.013 (0.29)	1.034 (0.27)	1.037 (0.13)	1.005 (0.01)	0.945 (-0.09)
Retail Trade	KR7004170007	1.117 (2.67)*	1.074 (0.56)	1.063 (0.23)	1.157 (0.35)	1.149 (0.32)

For each company and each aggregation interval the table reports the estimated variance ratio together with the Lo and MacKinlay $Z(q)^*$ statistics under the heteroscedasticity assumption in parentheses.

* indicates where the maximum absolute value in the set of tests statistics exceeds the .05 critical value of the SMM (0.05; 5; 486) distribution of 2.57 and hence the variance ratio is significantly different from 1.0

Table 7.9 Variance Ratio Tests for Period 4 (25 November 1996 – 1 March 1998)

Industry	Company code	Aggregation interval				
		q = 2	*q = 6*	*q = 12*	*q = 18*	*q = 24*
Foods & Beverage	KR7000140004	1.316 (9.16)	1.997 (9.40)*	2.354 (7.04)	3.008 (6.06)	3.116 (4.62)
	KR7005180005	1.306 (7.60)	2.049 (8.49)*	2.816 (7.00)	3.207 (5.46)	3.238 (4.03)
	KR7005300009	1.094 (2.42)	1.095 (0.81)	0.989 (-0.05)	0.996 (-0.01)	1.154 (0.31)
Textiles & Wearing Apparel	KR7002020006	1.140 (3.60)*	1.071 (0.60)	0.946 (-0.22)	0.856 (-0.37)	0.907 (-0.18)
	KR7001460005	0.954 (-1.15)	0.699 (-2.42)	0.623 (-1.40)	0.592 (-0.92)	0.533 (-0.76)
	KR7004460002	1.201 (6.07)*	1.249 (2.22)	1.061 (0.27)	0.917 (-0.23)	0.960 (-0.08)
	KR7003240009	0.945 (-1.27)	0.677 (-2.43)	0.541 (-1.42)	0.490 (-1.09)	0.495 (-0.81)
Chemicals & Chemical Products	KR7009830001	1.208 (5.44)*	1.474 (3.96)	1.413 (1.67)	1.394 (1.00)	1.265 (0.51)
	KR7005950001	1.099 (2.37)	1.247 (1.93)	1.024 (0.09)	0.954 (-0.11)	0.960 (-0.07)
	KR7003550001	1.148 (3.36)*	0.898 (-0.77)	0.843 (-0.60)	0.843 (-0.38)	0.881 (-0.21)
	KR7011780004	1.187 (5.60)*	1.543 (4.94)	1.455 (2.09)	1.490 (1.43)	1.601 (1.22)
	KR7003600004	1.093 (2.18)	0.965 (-0.29)	0.863 (-0.55)	0.899 (-0.24)	0.982 (-0.03)
	KR7010950004	1.243 (6.74)*	1.676 (5.98)	1.934 (3.83)	1.997 (2.71)	2.137 (2.27)
Medicine	KR7000020008	1.359 (9.51)*	2.023 (8.85)	2.725 (7.07)	2.977 (5.33)	3.002 (3.86)
	KR7001060003	1.192 (4.94)*	1.177 (1.47)	1.267 (1.05)	1.215 (0.56)	1.229 (0.44)
Non-metallic Mineral Products	KR7002000008	1.115 (2.60)*	1.096 (0.69)	1.029 (0.11)	0.970 (-0.07)	0.922 (-0.14)
Electrical & Electronic Products	KR7005930003	1.262 (6.84)*	1.255 (2.17)	1.301 (1.25)	1.475 (1.19)	1.595 (1.14)
	KR7002610004	1.136 (3.31)*	1.021 (0.16)	0.915 (-0.33)	0.863 (-0.33)	0.929 (-0.12)
	KR7007410004	1.158 (3.93)*	1.094 (0.77)	1.086 (0.34)	1.103 (0.26)	1.185 (0.34)
	KR7001830009	1.336 (8.42)*	1.779 (6.23)	1.977 (3.74)	2.225 (3.00)	2.367 (2.43)
	KR7006400006	1.265 (7.58)*	1.298 (2.76)	1.249 (1.07)	1.442 (1.23)	1.650 (1.32)
	KR7009150004	1.236 (5.90)*	1.277 (2.31)	1.231 (0.89)	1.250 (0.37)	1.406 (0.73)
Transport Equipment	KR7005380001	1.211 (5.43)*	1.102 (0.83)	0.871 (-0.50)	0.808 (-0.51)	0.817 (-0.35)
	KR7000270009	1.159	0.999	0.814	0.749	0.747

		(4.20)*	(-0.01)	(-0.72)	(-0.64)	(-0.48)
	KR7003620002	1.127 (2.90)*	1.147 (1.05)	1.125 (0.45)	1.108 (0.26)	1.059 (0.10)
	KR7008400004	1.256 (6.22)*	1.637 (4.79)	1.905 (3.43)	2.018 (2.52)	2.035 (1.83)
	KR7005790001	1.255 (7.53)	2.075 (10.07)*	2.700 (6.96)	2.862 (4.84)	2.517 (3.01)
Construction	KR7000720003	1.167 (4.24)*	1.296 (2.33)	1.183 (0.72)	1.046 (0.12)	0.923 (-0.15)
	KR7000280008	1.169 (4.65)*	1.230 (2.07)	1.215 (0.88)	1.161 (0.43)	1.083 (0.16)
	KR7000210005	1.175 (4.48)*	1.211 (1.74)	1.260 (1.01)	1.305 (0.80)	1.349 (0.65)
Wholesale Trade	KR7003810009	1.212 (5.35)*	1.233 (2.01)	1.075 (0.30)	1.010 (0.03)	1.002 (0.00)
	KR7000830000	1.121 (3.04)*	1.066 (0.57)	0.935 (-0.26)	0.874 (-0.33)	0.883 (-0.22)
	KR7001120005	1.123 (3.03)*	1.001 (0.07)	0.844 (-0.62)	0.764 (-0.62)	0.771 (-0.42)
	KR7004060000	1.273 (7.21)*	1.691 (5.80)	1.814 (3.43)	2.020 (2.65)	2.124 (2.17)
Banks	KR7015580004	1.101 (2.76)*	0.846 (-1.36)	0.527 (-1.78)	0.454 (-1.42)	0.432 (-1.07)
	KR7000010009	1.053 (1.28)	0.878 (-0.96)	0.701 (-0.06)	0.650 (-0.86)	0.644 (-0.58)
	KR7000030007	1.112 (2.81)*	1.087 (0.72)	1.004 (0.02)	0.846 (-0.37)	0.780 (-0.38)
	KR7008890006	1.084 (2.22)	0.962 (-0.34)	0.930 (-0.29)	0.865 (-0.37)	0.858 (-0.27)
	KR7005020003	1.068 (1.68)	0.880 (-0.98)	0.697 (-1.26)	0.787 (-0.59)	0.836 (-0.32)
Securities	KR7006800007	1.163 (3.78)*	1.338 (2.61)	1.425 (1.62)	1.506 (1.23)	1.541 (0.94)
	KR7003540002	1.184 (4.44)*	1.412 (3.24)	1.268 (1.03)	1.318 (0.80)	1.328 (0.60)
	KR7005740002	1.173 (4.11)*	1.426 (3.33)*	1.579 (2.14)*	1.650 (1.60)	1.646 (1.13)
Insurance	KR7000810002	1.312 (8.27)*	1.442 (3.81)	1.220 (0.88)	1.209 (0.56)	1.227 (0.44)
	KR7000060004	1.179 (4.20)*	1.256 (2.01)	1.251 (0.98)	1.250 (0.59)	1.211 (0.39)
	KR7000540005	1.175 (4.39)*	1.357 (2.91)	1.427 (1.63)	1.326 (0.80)	1.265 (0.50)
	KR7003690005	1.109 (2.72)*	0.854 (-1.25)	0.773 (-0.88)	0.734 (-0.66)	0.713 (-0.54)
Basic Metal Industries	KR7005490008	1.058 (1.52)	0.840 (-1.39)	0.647 (-1.24)	0.621 (-0.94)	0.636 (-0.68)
Machinery	KR7000200006	1.163 (3.76)*	1.072 (0.58)	1.065 (0.23)	1.080 (0.19)	1.162 (0.28)
Electricity	KR7015760002	1.057 (1.56)	0.848 (-1.41)	0.745 (-1.05)	0.792 (-0.58)	0.903 (-0.20)

Communication	KR7017670001	1.145 (3.56)*	1.055 (0.46)	0.845 (-0.59)	0.810 (-0.48)	0.829 (-0.32)
Air Transport	KR7003490000	1.233 (6.04)*	1.353 (3.02)	1.365 (1.47)	1.214 (0.54)	1.275 (0.52)
Rubber & Plastics	KR7001150002	1.205 (5.43)	1.682 (5.76)*	2.006 (4.12)	2.125 (2.94)	2.037 (2.05)
Paper & Paper Products	KR7007190002	1.203 (4.71)*	1.390 (2.92)	1.455 (1.63)	1.616 (1.46)	1.798 (1.38)
Fabricated Metal Products	KR7006570006	1.093 (2.19)	1.122 (0.81)	0.850 (-0.49)	0.781 (-0.47)	0.729 (-0.44)
Retail Trade	KR7004170007	1.191 (5.04)*	1.328 (2.85)	1.346 (1.49)	1.487 (1.32)	1.668 (1.32)

For each company and each aggregation interval the table reports the estimated variance ratio together with the Lo and MacKinlay $Z(q)^*$ statistics under the heteroscedasticity assumption in parentheses.
* indicates where the maximum absolute value in the set of tests statistics exceeds the .05 critical value of the SMM (0.05; 5; 366) distribution of 2.57 and hence the variance ratio is significantly different from 1.0

Table 7.10 Variance Ratio Tests for New Period 4 (25 November 1996 – 31 October 1997) Excluded the Korean Financial Market Crisis

Industry	Company code	Aggregation interval				
		$q = 2$	$q = 6$	$q = 12$	$q = 18$	$q = 24$
Foods & Beverage	KR7000140004	1.101 (2.49)	1.278 (1.48)	1.087 (0.21)	0.996 (-0.01)	0.980 (-0.03)
	KR7005180005	1.105 (2.22)	1.240 (1.45)	1.283 (0.73)	1.237 -0.380	1.374 -0.440
	KR7005300009	0.957 (-1.00)	0.790 (-1.29)	0.591 (-1.47)	0.557 (-0.83)	0.610 (-0.57)
Textiles & Wearing Apparel	KR7002020006	1.001 (0.02)	1.042 (0.25)	0.820 (-0.53)	0.657 (-0.63)	0.707 (-0.34)
	KR7001460005	0.925 (-1.47)	0.687 (-2.26)	0.565 (-1.22)	0.523 (-0.77)	0.514 (-0.51)
	KR7004460002	0.884 (-1.89)	0.689 (-2.00)	0.717 (-0.94)	0.739 (-0.36)	0.773 (-0.24)
	KR7003240009	0.925 (-1.60)	0.729 (-1.67)	0.554 (-1.32)	0.490 (-0.90)	0.528 (-0.56)
Chemicals & Chemical Products	KR7009830001	0.940 (-1.35)	0.791 (-1.32)	0.764 (-0.58)	0.691 (-0.49)	0.583 (-0.53)
	KR7005950001	0.974 (-0.43)	0.978 (-0.13)	0.854 (-0.39)	0.760 (-0.43)	0.804 (-0.28)
	KR7003550001	1.014 (0.27)	0.838 (-0.92)	0.629 (-1.00)	0.566 (-0.72)	0.584 (-1.52)
	KR7011780004	1.057 (1.38)	0.762 (-1.57)	0.567 (-1.09)	0.457 (-0.91)	0.463 (-0.64)
	KR7003600004	1.138 (2.94)*	1.203 (1.25)	1.012 (0.03)	1.100 (0.14)	1.209 (0.23)
	KR7010950004	0.988 (-0.27)	1.057 (0.32)	0.964 (-0.09)	0.852 (-0.26)	0.723 (-0.35)
Medicine	KR7000020008	1.186 (3.88)*	1.209 (1.36)	1.211 (0.58)	1.061 (0.11)	1.010 (0.01)
	KR7001060003	1.112 (2.29)	1.180 (1.09)	1.105 (0.30)	0.864 (-0.25)	0.830 (-0.22)
Non-metallic Mineral Products	KR7002000008	1.140 (2.60)*	1.280 (1.61)	1.191 (0.56)	1.154 (0.30)	1.179 (0.23)
Electrical & Electronic Products	KR7005930003	1.267 (5.93)*	1.430 (3.27)	1.230 (0.68)	1.370 (0.66)	1.434 (0.54)
	KR7002610004	1.101 (2.15)	1.137 (0.89)	1.122 (0.36)	1.195 (0.34)	1.289 (0.31)
	KR7007410004	1.065 (1.38)	1.018 (0.12)	0.859 (-0.41)	0.839 (-0.25)	0.981 (-0.02)
	KR7001830009	1.146 (3.00)*	1.178 (1.10)	1.148 (0.42)	1.041 (0.06)	0.974 (-0.03)
	KR7006400006	1.171 (4.10)*	1.228 (1.45)	0.768 (-0.74)	0.758 (-0.41)	0.779 (-0.27)
	KR7009150004	1.088 (1.81)	1.036 (0.23)	0.972 (-0.08)	1.078 (0.14)	1.213 (0.22)
Transport Equipment	KR7005380001	1.123 (2.35)	1.117 (0.74)	0.931 (-0.20)	0.939 (-0.10)	0.927 (-0.09)

	KR7000270009	1.132 (3.29)*	1.264 (1.98)	0.986 (-0.05)	0.956 (-0.09)	0.971 (-0.05)
	KR7003620002	1.076 (1.43)	0.994 (-0.03)	0.822 (-0.48)	0.710 (-0.53)	0.620 (-0.48)
	KR7008400004	1.161 (3.35)*	1.381 (2.24)	1.416 (1.17)	1.352 (0.58)	1.243 (0.30)
	KR7005790001	0.977 (-0.53)	0.861 (-0.93)	0.712 (-0.75)	0.625 (-0.75)	0.632 (-0.40)
Construction	KR7000720003	1.173 (3.40)*	1.157 (0.88)	1.010 (0.03)	0.994 (-0.01)	0.936 (-0.07)
	KR7000280008	1.222 (4.96)*	1.217 (1.42)	1.093 (0.28)	0.994 (-0.01)	0.858 (-0.16)
	KR7000210005	1.033 (0.62)	0.863 (-0.78)	0.708 (-0.74)	0.563 (-0.70)	0.491 (-0.59)
Wholesale Trade	KR7003810009	1.114 (2.33)	1.066 (0.45)	0.866 (-0.37)	0.809 (-0.31)	0.820 (-0.23)
	KR7000830000	1.033 (0.69)	0.991 (-0.06)	0.789 (-0.06)	0.776 (-0.39)	0.739 (-0.33)
	KR7001120005	1.140 (2.64)*	1.137 (0.81)	0.824 (-0.42)	0.734 (-0.46)	0.754 (-0.30)
	KR7004060000	1.080 (1.51)	0.874 (-0.71)	0.747 (-0.70)	0.618 (-0.62)	0.586 (-0.56)
Banks	KR7015580004	1.032 (0.72)	0.800 (-1.27)	0.604 (-0.97)	0.543 (-0.80)	0.543 (-0.66)
	KR7000010009	1.067 (1.29)	1.034 (0.20)	1.021 (0.06)	0.970 (-0.06)	1.030 (0.03)
	KR7000030007	1.105 (2.03)	1.016 (0.09)	1.038 (0.11)	1.016 (0.03)	1.081 (0.10)
	KR7008890006	0.949 (-0.90)	0.716 (-1.54)	0.658 (-0.86)	0.585 (-0.83)	0.519 (-0.52)
	KR7005020003	0.981 (-0.33)	0.786 (-1.25)	0.674 (-0.92)	0.693 (-0.50)	0.701 (-0.35)
Securities	KR7006800007	1.119 (2.07)	1.349 (2.04)	1.495 (1.51)	1.676 (1.20)	1.837 (1.10)
	KR7003540002	1.049 (0.83)	1.018 (0.06)	1.018 (0.06)	1.027 (0.05)	1.060 (0.07)
	KR7005740002	1.086 (1.47)	1.336 (1.52)	1.508 (1.52)	1.617 (1.15)	1.701 (0.91)
Insurance	KR7000810002	1.220 (4.92)*	1.317 (1.80)	0.801 (-0.52)	0.698 (-0.50)	0.668 (-0.47)
	KR7000060004	1.078 (1.42)	1.101 (0.58)	0.876 (-0.33)	0.743 (-0.42)	0.722 (-0.32)
	KR7000540005	1.010 (0.21)	0.897 (-0.58)	0.783 (-0.51)	0.754 (-0.38)	0.686 (-0.41)
	KR7003690005	1.018 -0.390	0.854 (-0.91)	0.729 (-0.68)	0.666 (-0.58)	0.579 (-0.58)
Basic Metal Industries	KR7005490008	1.060 (1.47)	1.067 (0.43)	0.723 (-0.67)	0.705 (-0.59)	0.793 (-0.21)
Machinery	KR7000200006	1.082 (1.73)	1.173 (1.20)	1.312 (0.93)	1.435 (0.77)	1.594 (0.75)
Electricity	KR7015760002	0.962 (-0.84)	0.885 (-0.74)	0.802 (-0.52)	0.883 (-0.22)	1.013 (0.02)

Communication	KR7017670001	1.121 (2.21)	1.137 (0.81)	0.929 (-0.16)	0.971 (-0.05)	1.022 (0.03)
Air Transport	KR7003490000	1.088 (1.79)	0.936 (-0.43)	0.791 (-0.58)	0.804 (-0.36)	0.880 (-0.13)
Rubber & Plastics	KR7001150002	1.035 (0.65)	1.074 (0.46)	1.042 (0.10)	0.859 (-0.23)	0.759 (-0.28)
Paper & Paper Products	KR7007190002	1.065 (1.30)	0.984 (-0.10)	0.905 (-0.26)	0.784 (-0.38)	0.778 (-0.30)
Fabricated Metal Products	KR7006570006	0.990 (-0.21)	1.032 (0.17)	0.739 (-0.70)	0.670 (-0.56)	0.673 (-0.42)
Retail Trade	KR7004170007	1.076 (1.65)	1.208 (1.43)	0.918 (-0.27)	0.895 (-0.18)	0.907 (-0.11)

For each company and each aggregation interval the table reports the estimated variance ratio together with the Lo and MacKinlay $Z(q)^*$ statistics under the heteroscedasticity assumption in parentheses.
* indicates where the maximum absolute value in the set of tests statistics exceeds the .05 critical value of the SMM (0.05; 5; 273) distribution of 2.57 and hence the variance ratio is significantly different from 1.0

Table 7.11 Variance Ratio Tests for Period 5 (2 March 1998 – 5 December 1998)

Industry	Company code	Aggregation interval				
		q = *2*	*q* = *6*	*q* = *12*	*q* = *18*	*q* = *24*
Foods & Beverage	KR7000140004	1.026 (0.47)	0.765 (-1.27)	0.708 (-0.77)	0.729 (-0.50)	0.728 (-0.31)
	KR7005180005	1.035 (0.67)	0.974 (-0.13)	0.975 (-0.06)	0.975 (-0.04)	0.770 (-0.30)
	KR7005300009	0.980 (-0.40)	0.969 (-0.21)	0.990 (-0.03)	1.114 (0.27)	1.095 (0.11)
Textiles & Wearing Apparel	KR7002020006	1.050 (0.97)	0.878 (-0.59)	0.799 (-0.64)	0.861 (-0.24)	0.834 (-0.21)
	KR7001460005	0.932 (-1.22)	0.742 (-1.32)	0.858 (-0.35)	1.004 (0.01)	1.099 (0.10)
	KR7004460002	1.221 (4.00)*	1.307 (1.77)	0.984 (-0.04)	1.026 (0.04)	1.062 (0.07)
	KR7003240009	1.040 (0.81)	0.867 (-0.73)	0.625 (-0.89)	0.630 (-0.73)	0.619 (-0.43)
Chemicals & Chemical Products	KR7009830001	1.151 (3.10)*	1.183 (1.03)	1.085 (0.22)	1.337 (0.51)	1.501 (0.52)
	KR7005950001	1.063 (1.16)	0.793 (-1.09)	0.652 (-1.04)	0.697 (-0.52)	0.742 (-0.28)
	KR7003550001	1.103 (1.82)	0.973 (-0.13)	0.788 (-0.48)	0.820 (-0.26)	0.840 (-0.16)
	KR7011780004	0.852 (-3.45)*	0.782 (-1.27)	0.615 (-0.90)	0.608 (-0.61)	0.651 (-0.41)
	KR7003600004	0.811 (-4.32)*	0.755 (-1.34)	0.735 (-0.58)	0.749 (-0.36)	0.779 (-0.24)
	KR7010950004	1.064 (1.04)	0.983 (-0.08)	0.988 (-0.03)	1.046 (0.08)	1.123 (0.15)
Medicine	KR7000020008	1.094 (1.79)	1.393 (2.35)	1.699 (1.75)	1.950 (1.81)	1.953 (1.33)
	KR7001060003	1.110 (2.09)	0.956 (-0.23)	0.802 (-0.49)	0.773 (-0.42)	0.622 (-0.46)
Non-metallic Mineral Products	KR7002000008	0.951 (-1.01)	0.839 (-0.73)	0.708 (-0.67)	0.785 (-0.31)	0.802 (-0.29)
Electrical & Electronic Products	KR7005930003	1.203 (3.14)*	1.163 (0.99)	1.005 (0.01)	1.199 (0.28)	1.250 (0.31)
	KR7002610004	1.062 (1.10)	0.942 (-0.26)	0.737 (-0.65)	0.744 (-0.40)	0.707 (-0.29)
	KR7007410004	0.980 (-0.42)	0.823 (-0.83)	0.551 (-0.99)	0.541 (-0.73)	0.529 (-0.47)
	KR7001830009	1.185 (3.38)*	0.989 (-0.07)	0.910 (-0.25)	0.935 (-0.12)	0.958 (-0.06)
	KR7006400006	1.129 (2.27)	1.237 (1.20)	1.132 (0.32)	1.312 (0.47)	1.316 (0.36)
	KR7009150004	1.032 (0.59)	1.038 (0.19)	0.791 (-0.48)	0.901 (-0.15)	0.888 (-0.12)
Transport Equipment	KR7005380001	1.121 (2.36)	0.907 (-0.43)	0.658 (-0.68)	0.595 (-0.63)	0.597 (-0.48)
	KR7000270009	1.200	1.580	0.145	1.494	1.751

		(3.75)*	(3.01)	(1.26)	(0.86)	(0.91)
	KR7003620002	1.124 (2.24)	1.132 (0.64)	1.101 (0.22)	1.095 (0.15)	1.130 (0.16)
	KR7008400004	1.173 (3.04)*	1.269 (1.37)	0.916 (-0.21)	0.872 (-0.20)	0.945 (-0.07)
	KR7005790001	0.970 (-0.52)	0.786 (-1.05)	0.813 (-0.49)	0.827 (-0.30)	0.851 (-0.18)
Construction	KR7000720003	0.849 (-2.51)	0.719 (-1.32)	0.763 (-0.57)	0.897 (-0.17)	1.011 (0.01)
	KR7000280008	1.263 (5.16)*	1.280 (1.64)	1.069 (0.19)	1.082 (0.14)	1.101 (0.12)
	KR7000210005	1.070 (1.12)	0.967 (-0.15)	0.868 (-0.32)	0.986 (-0.02)	1.117 (0.14)
Wholesale Trade	KR7003810009	0.912 (-1.45)	0.807 (-0.94)	0.660 (-0.81)	0.612 (-0.61)	0.581 (-0.44)
	KR7000830000	0.930 (-1.23)	0.833 (-0.69)	0.858 (-0.30)	0.890 (-0.18)	0.861 (-0.16)
	KR7001120005	1.093 (1.53)	1.057 (0.29)	1.122 (0.26)	1.286 (0.49)	1.415 (0.53)
	KR7004060000	1.050 (0.87)	0.919 (-0.41)	0.783 (-0.52)	0.816 (-0.34)	0.868 (-0.15)
Banks	KR7015580004	1.019 (0.35)	1.108 (0.50)	1.192 (0.50)	1.233 (0.39)	1.226 (0.24)
	KR7000010009	1.041 (1.06)	1.079 (0.37)	1.181 (0.53)	1.336 (0.60)	1.385 (0.55)
	KR7000030007	1.122 (2.18)	1.263 (1.43)	1.299 (0.79)	1.428 (0.81)	1.464 (0.62)
	KR7008890006	1.101 (1.86)	1.098 (0.51)	1.115 (0.29)	1.252 (0.42)	1.205 (0.25)
	KR7005020003	0.949 (-2.02)	0.870 (-0.72)	0.804 (-0.52)	0.834 (-0.33)	0.870 (-0.15)
Securities	KR7006800007	1.006 (0.10)	0.997 (-0.02)	0.752 (-0.55)	0.829 (-0.30)	0.828 (-0.21)
	KR7003540002	1.113 (1.92)	1.123 (0.66)	1.215 (0.52)	1.456 (0.78)	1.502 (0.63)
	KR7005740002	1.049 (0.84)	1.128 (0.68)	1.168 (0.38)	1.331 (0.56)	1.320 (0.38)
Insurance	KR7000810002	1.041 (0.81)	0.975 (-0.14)	0.824 (-0.49)	0.922 (-0.13)	0.923 (-0.13)
	KR7000060004	1.062 (1.25)	1.128 (0.74)	1.175 (0.45)	1.261 (0.45)	1.344 (0.48)
	KR7000540005	1.030 (0.50)	1.151 (0.79)	1.161 (0.37)	1.186 (0.31)	1.135 (0.18)
	KR7003690005	1.032 (0.50)	0.939 (-0.37)	1.085 (0.22)	1.131 (0.20)	1.144 (0.17)
Basic Metal Industries	KR7005490008	1.021 (0.47)	0.953 (-0.25)	0.813 (-0.44)	0.997 (-0.01)	0.994 (-0.01)
Machinery	KR7000200006	0.948 (-0.87)	0.759 (-0.90)	0.576 (-0.92)	0.631 (-0.53)	0.613 (-0.43)
Electricity	KR7015760002	0.899 (-2.05)	0.708 (-1.43)	0.456 (-1.50)	0.470 (-0.88)	0.579 (-0.45)

Communication	KR7017670001	0.992 (-0.18)	0.806 (-1.33)	0.694 (-0.87)	0.781 (-0.35)	0.823 (-0.18)
Air Transport	KR7003490000	1.026 (0.38)	0.859 (-0.68)	0.833 (-0.39)	0.982 (-0.04)	1.051 (0.05)
Rubber & Plastics	KR7001150002	0.939 (-1.01)	0.831 (-0.99)	0.821 (-0.48)	0.943 (-0.10)	1.029 (0.04)
Paper & Paper Products	KR7007190002	1.216 (3.87)*	1.290 (1.58)	1.109 (0.27)	1.081 (0.12)	1.105 (0.12)
Fabricated Metal Products	KR7006570006	1.065 (1.41)	0.990 (-0.06)	0.978 (-0.06)	1.107 (0.16)	1.140 (0.19)
Retail Trade	KR7004170007	1.033 (0.61)	0.994 (-0.03)	0.906 (-0.24)	1.005 (0.01)	1.004 (0.00)

For each company and each aggregation interval the table reports the estimated variance ratio together with the Lo and MacKinlay $Z(q)^*$ statistics under the heteroscedasticity assumption in parentheses.
* indicates where the maximum absolute value in the set of tests statistics exceeds the .05 critical value of the SMM (0.05; 5; 231) distribution of 2.57 and hence the variance ratio is significantly different from 1.0

Table 7.12 Average Variance Ratios

	Aggregation interval				
	$q=2$	$q=6$	$q=12$	$q=18$	$q=24$
Period 1	1.086 (0.070)	1.155 (0.239)	1.146 (0.335)	1.184 (0.392)	1.196 (0.436)
Period 2	1.110 (0.103)	1.169 (0.317)	1.160 (0.460)	1.171 (0.540)	1.191 (0.593)
Period 3	1.046 (0.071)	1.019 (0.149)	0.931 (0.184)	0.931 (0.203)	0.881 (0.215)
Period 4	1.169 (0.085)	1.250 (0.355)	1.246 (0.533)	1.273 (0.642)	1.297 (0.650)
Period 4 excluding crisis	1.068 (0.081)	1.044 (0.190)	0.914 (0.232)	0.874 (0.271)	0.855 (0.307)
Period 5	1.046 (0.097)	0.994 (0.190)	0.892 (0.247)	0.989 (0.282)	1.014 (0.304)

Figures in parentheses are standard deviations of the cross section of variance ratios. They provide an indication of the cross-sectional dispersion of the variance ratios but, since the variance ratios are not cross-sectionally independent, these standard deviations cannot be used to carry out the usual significance tests.

Table 7.13 Results Summary: The Heteroscedastic Random Walk Null Hypothesis

	Price limits	Number which reject	Proportion which accept
Period 1	Range from ± 2.0% to ±6.7%	33	40.0%
Period 2	Range from ±2.0% to ±6.7%	31	43.6%
Period 3	±6%	15	72.7%
Period 4	±8%	44	20.0%
Period 4 excluding crisis*	±8%	12	78.2%
Period 5	±12%	10	81.8%

* Excluding the period from one month before the IMF bail-out to the end of the subperiod, November 1997 – February 1998.

Appendix 7.1 GAUSS Program for Heteroscedasticity-Consistent Variance Ratio Test

```
/******************************************************************

                        File: Vratio.p

      Heteroscedasticity-consistent Variance Ratio Test

                 This version: 4th June 1998.
                  Written by Hyun-Jung Ryoo
                      hp6@soas.ac.uk

******************************************************************/
load p[]=a:samselc.dat;                     /*** data file ***/
output file=a:samselc.out reset;
format /m1 /ldn 16,4;
/******************************************************************

******************************************************************/
P[1:rows(p),1]=log(p[1:rows(P),1]);
R=P[2:rows(P)]-P[1:rows(P)-1];
q=2;
proc(3)=VRATIO (p,r,q);               /*** name of the procedure ***/
  local
mu,ssa,sa,devone,dev,sc,vr,psione,psitwo,psi,k,thone,thtwo,th,psista
r;

  MU=(P[rows(P)]-P[1])/(rows(P)-1);
  SSA=R[1:rows(P)-1]'*R[1:rows(P)-1];
  SA=SSA/(rows(P)-2);

  DEVONE=(P[q+1:rows(P)]-P[1:rows(P)-q])-q*MU*ones(rows(P)-q,1);
  DEV=DEVONE'*DEVONE;
  SC=DEV/(q*(rows(P)-q)*(1-(q/(rows(P)-1))));
  VR=SC/SA;                                 /*** variance ratio ***/

/******************************************************************
        Homoscedasticity-consistent variance ratio statistic
******************************************************************/

  PSIONE=(rows(p)-1)^(1/2)*(VR-1);
  PSITWO=((2*((2*q)-1)*(q-1))/(3*q))^(1/2);
  PSI=PSIONE/PSITWO;                         /***  PSI statistic ***/

/******************************************************************
      Heteroscedsticity-consistent variance ratio statistic
******************************************************************/

  k=1;
  do until k>(q-1);
      th=4*(1-k/q)^2*(rows(P)-1)/ssa^2*
      ((R[k+1:rows(P)-1]-MU*ones(rows(P)-1-k,1))^2)'*
      (R[1:rows(P)-1-k]-MU*ones(rows(P)-1-k,1))^2;
      k=k+1;
  endo;

PSISTAR=(rows(P)-1)^(1/2)*(VR-1)/TH^(-1/2); /***PSI(*)statistic ***/

retp(vr,psi,psistar);
```

```
endp;

{vr,psi,psistar}=VRATIO (p,r,q);

print;"< samselc >";
print;"(q=2)";
print;;"VR    ";;VR;"PSI   ";;PSI;"PSI* ";;PSISTAR;

/******************************************************************
Lag(q)=6
******************************************************************/
{vr,psi,psistar}=VRATIO (p,r,6);

print;"(q=6)";
print;;"VR    ";;VR;"PSI   ";;PSI;"PSI* ";;PSISTAR;

/******************************************************************
Lag(q)=12
******************************************************************/
{vr,psi,psistar}=VRATIO(p,r,12);

print;"(q=12)";
print;;"VR    ";;VR;"PSI   ";;PSI;"PSI* ";;PSISTAR;

/******************************************************************
Lag(q)=18
******************************************************************/
{vr,psi,psistar}=VRATIO (p,r,18);

print;"(q=18)";
print;;"VR    ";;VR;"PSI   ";;PSI;"PSI* ";;PSISTAR;

/******************************************************************
Lag(q)=24
******************************************************************/
{vr,psi,psistar}=VRATIO (p,r,24);

print;"(q=24)";
print;;"VR    ";;VR;"PSI   ";;PSI;"PSI* ";;PSISTAR;


output off;
```

8 The Impact of Stock Index Futures on the Korean Stock Market

8.1 Introduction

Stock index futures are perceived as one of the most successful financial innovations of the 1980s. Trading in them was first introduced in February 1982 by the Kansas City Board of Trade in the US and other developed markets soon followed. In the Pacific Basin, for example, a futures contract based on the Australian All Ordinaries Index started trading on the Sydney Futures Exchange in February 1983. Index futures were listed in Hong Kong in May 1986 and in Singapore four months later. New Zealand followed in January 1987 when Barclays Share Price Index Futures were listed on the New Zealand Futures and Options Exchange. Trading in Nikkei 225 Index Futures were introduced on the Osaka Securities Exchange in September 1988 (see Table 8.1). In contrast, much of the futures trading in emerging markets is a relatively recent phenomenon. Although Korea is one of the fastest growing emerging markets, it was not until 3 May 1996 that a futures contract based on the Korea Stock Price Index 200 (KOSPI 200) was introduced on the Korea Stock Exchange (KSE). Trading in these stock index futures has grown remarkably. By the end of 1998, average daily trading volume was 61,279 contracts (value 1.39 million won). According to FIBV (1999), by December 1998 the stock index futures market in

Korea had become the second largest in the world in terms of average trading volume, after the Chicago Mercantile Exchange (CME).

The impact of derivative trading on spot price volatility has been widely investigated for developed markets. For stock index futures, research has focused on comparing spot price volatility in periods before and after the introduction of futures (for example: Edwards, 1988; Harris, 1989b; and Antoniou and Holmes, 1995). In particular, one of the primary concerns of previous studies has been the issue of whether futures trading destabilises the underlying spot market. Although some studies find increased volatility, the *weight* of the empirical evidence shows no increase in volatility following the introduction of trading in stock index futures. Among others, Freris (1990) examines the impact effect of Hang Seng Index Futures on the behaviour of the Hang Seng Index using data for the period from 1984 to 1987 and finds that the introduction of stock index futures trading had no measurable effect on the volatility of the stock price index. Lee and Ohk (1992) examine the effect of introducing index futures trading on stock market volatility in Australia, Hong Kong, Japan, the UK and the US using daily index data for periods of approximately four years spanning the start of trade in index futures. They find that for the three largest markets, return volatility increased significantly after the stock index futures were listed on the underlying index, but for the Australian market there was no significant difference and stock return volatility actually decreased in Hong Kong. Using international portfolios, they further found that although the creation of stock index futures generally exerts a volatility-increasing influence on the behaviour of cash market stock returns, it makes the stock market relatively more efficient because volatility shocks are more quickly assimilated in that market. Kamara, Miler and Siegel (1992) investigate the effect of futures trading on the S&P 500 on the stability of the underlying index. Their results suggest that, although the volatility of monthly returns remained unchanged, the volatility of daily returns in the post-futures period was higher than in the pre-futures period.

A group of papers focus on extreme volatility. Becketti and Sellon (1989) distinguish normal volatility and jump volatility. The former refers to the ordinary ups and downs in stock prices and the latter to occasional and sudden extreme changes in prices, such as the market collapse in October 1987. They find no evidence of an increase in normal volatility in the 1980s although there is some evidence that jump volatility did increase. Further evidence is provided by Becketti and Roberts (1990). Their empirical findings on the introduction of the S&P 500 stock index futures in 1982 suggest that there is little or no relationship between stock market volatility and either the existence of, or the level of activity in, the stock index futures market. Darrat and Rahman (1995) also focus on jump volatility which is based on a method for identifying outliers. Using Granger causality tests on stationary series, they find that trading of S&P500 futures does not cause volatility in stock prices. Schwert (1990) finds little evidence that the introduction of stock index futures is associated with an upward trend in stock volatility except for the period from October 1987 to October 1989.

One of the important roles attributed to futures markets is that of 'price discovery'; that is, the futures market reflects new information before the spot market. If new market information disseminates in the futures market before the stock market, then the introduction of a futures market increases the amount of information reflected in the spot price. In brief, empirical evidence suggests that market information tends to disseminate in futures prices prior to, and at greater speed than, in the stock prices (see Kawalle, Koch and Koch, 1987, and Chan, 1992). This might be explained by the fact that trading futures has the advantages of a highly liquid market, low transaction costs, easily available short positions, low margins and rapid execution. Thus, informed traders may find that they can act faster and at lower cost in the futures market than the cash, resulting in a lead-lad relationship between futures and spot prices.

The lead-lag relation between movements of spot and futures prices has been widely investigated with the methods used varying across studies. For example, Kawaller, Koch and Koch (1987), Abhyankar (1998) and Tang, Mak and Choi (1992) use modified/non-modifed granger causality tests. Whereas Wahab and Lashgari (1993), Fleming, Ostdiek and Whaley (1996) and Pizzi, Economopoulos and O'Neill (1998) use cointegration and error correction models. However, irrespective of methodology, the results can be summarised concisely: market information tends to disseminate in futures prices prior to, and at greater speed than, in stock prices.

Much of the extensive research including those papers discussed so far, focuses on developed markets (see Harris, 1989b; Morris, 1989; Yau, Schneeweiss and Yung, 1990; Bailey, 1991; and Hiraki, Maberly and Taube, 1998 for further details). Very little work has investigated the impact of stock index futures trading in emerging markets. This chapter contributes to this sparse literature; it is the first to examine the impact on the Korean spot market of trading in futures. It focuses on three aspects. First, the impact of futures trading on price volatility in the spot market is examined. Secondly, long-run equilibrium and short-run adjustment are discussed using tests of cointegration and causality. Thirdly, lead-lag relationships are analysed. This chapter differs from previous studies which use closing prices for futures and spot prices, by using data with matched closing times. This is desirable because in Korea trading in index futures and trading in stocks finish at different times. By using matched closing times, the comparison of nonsynchronous closing prices of the spot index and futures contract, which might lead to a significant source of error, is avoided.

The rest of this chapter is organised as follows. The next section presents the methodology. In section 8.3, we briefly introduce the KOSPI 200 futures contract and discuss the data. Results are presented and discussed in section 8.4. Finally, section 8.5 provides conclusions.

8.2 Methodology

The impact of futures trading on price volatility in the underlying spot market index is examined by adopting the generalized ARCH (GARCH) process in which the conditional variance of u at time t is dependent not only on past squared disturbances but also on past conditional variances. Empirical evidence, for example, Bollerslev, Chou and Kroner (1992), Huang, Liu and Yang (1995) and Ryoo (1997), finds that returns in stock markets exhibit heteroscedasticity. Therefore, following Holmes (1996), a GARCH representation would seem to be an appropriate means by which to capture market-wide price volatility. Consider the model

$$R_{s,t} = a_0 + a_1 R_{p,t} + u_t \tag{8.1}$$

$$u_t \mid \Psi_{t-1} \sim N(0,\ h_t) \tag{8.2}$$

in which $R_{s,t}$ is spot price returns, the change in the logarithm of the spot price index in period t, $R_{p,t}$ is returns on the market proxy variable (for which there is no associated futures index), u_t is an error term representing unexplained price changes and Ψ_t is the information set available at time t. Since the proxy variable covers market-wide influences on price changes, the error term captures the impact of factors specific to the market on which the futures contract is written and its variance provides a measure of market-wide price volatility

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} \qquad (8.3)$$

The impact of new information or 'news' is captured by the coefficient α_1. An increase in α_1 after the introduction of futures trading suggests news is impounded into prices more rapidly. In contrast, a fall in α_1 implies news is impounded more slowly.

Engle and Bollerslev (1986) and Engle and Mustafa (1992) show for the GARCH(1,1) model, that the persistence of volatility shocks depends primarily on $\alpha_1 + \beta_1$. Consequently, by estimating the model for the periods pre- and post-futures trading and comparing the parameters of the variance equations we are able to determine how futures trading impacts on volatility. An increase in $\alpha_1 + \beta_1$ following the introduction of futures trading indicates increased persistence of volatility shocks.

The Engle-Granger approach is used to test for the existence of a long-run equilibrium relationship between stock and futures prices based on the relationship

$$s_t = \alpha_0 + \beta_0 f_t + z_t \qquad (8.4)$$

where s_t and f_t are the logarithms of contemporaneous spot and futures prices at time t and z_t is the disequilibrium error, the deviation from long-run equilibrium.

Following Engle and Granger (1987), if both s_t and f_t are cointegrated then they are generated by Error Correction Models (ECMs) of the form

$$R_{s,t} = \alpha_1 + \sum_{j=1}^{n} \beta_{1j} R_{s,t-j} + \sum_{j=1}^{n} \gamma_{1j} R_{f,t-j} + \lambda_1 z_{s,t-1} + v_{s,t} \qquad (8.5)$$

and

$$R_{f,t} = \alpha_2 + \sum_{j=1}^{n} \beta_{2j} R_{f,t-j} + \sum_{j=1}^{n} \gamma_{2j} R_{s,t-j} + \lambda_2 z_{f,t-1} + v_{f,t} \tag{8.6}$$

in which $R_{s,t} = s_t - s_{t-1}$, $R_{f,t} = f_t - f_{t-1}$, v_t is a stationary disturbance and z_{t-1} the correction term. The ECMs are useful because short- and long-run effects are separate and both can be estimated. The coefficients on lagged returns in equations (8.5) and (8.6), β_{1j} and β_{2j}, represent the short-run elasticities of $R_{s,t}$ and $R_{f,t}$ with respect to $R_{f,t}$ and $R_{s,t}$ respectively. The respective long-run elasticities are obtained from cointegrating regressions. The coefficients on the disequilibrium errors, λ_1 and λ_2, measure the speed of adjustment of s_t and f_t respectively to the error in the previous period. With cointegration, at least one of the $\lambda_i \neq 0$.

Using the ECMs, three casality tests, Granger (1969), Sims (1972), and Geweke, Meese and Dent (1983) Granger (1969), are carried out between the stock index spot and futures markets. While these testing procedures are theoretically equivalent, they are different in practice, because they must be estimated using finite parameterisations of the autoregression (for Granger), distributed lags (for Sims) and two-sided distributed lag augmented with lagged dependent variables) (for Geweke, Meese and Dent), which do not directly corresponded.

For example, in equation (8.5), if λ_1 is zero and all γ_{1j} are zero, then $R_{f,t}$ does not Granger cause $R_{s,t}$. The test equation is

$$R_{s,t} = \alpha_1 + \sum_{j=1}^{\infty} \beta_{1j} R_{s,t-j} + \sum_{j=1}^{\infty} \gamma_{1j} R_{f,t-j} + \lambda_1 \hat{z}_{s,t-1} + v_{s,t} \tag{8.7}$$

with H$_0$: $\lambda_1 = 0$ and $\gamma_{1j} = 0$ for all j. Alternatively, the Sims test equation is

$$R_{s,t} = \alpha_1 + \sum_{j=-\infty}^{\infty} \gamma_{1j} R_{f,t-j} + \lambda_1 \hat{z}_{s,t-1} + v_{s,t} \tag{8.8}$$

and tests the null hypothesis, that is, H_0: $\lambda_l = 0$ and $\gamma_{lj} = 0$ for all $j < 0$. Similarly, the Geweke, Meese and Dent test equation is

$$R_{s,t} = \alpha_l + \sum_{j=l}^{\infty} \beta_{lj} R_{s,t-j} + \sum_{j=-\infty}^{\infty} \gamma_{lj} R_{f,t-j} + \lambda_l \hat{z}_{s,t-l} + v_{s,t} \tag{8.9}$$

with H_0: $\lambda_l = 0$ and $\gamma_{lj} = 0$ for all $j < 0$.

A lead-lag relation is described by the model

$$R_{s,t} = \alpha + \sum_{l=-n}^{l=+n} b_l R_{f,t+l} + \varepsilon_t \tag{8.10}$$

where $R_{s,t}$ are spot index returns and $R_{f,t}$ are returns on futures. The coefficients with positive subscripts, b_{+l}, are lead coefficients and those with negative subscripts, b_{-l}, are lag coefficients. If the lead coefficients are significant, spot index returns lead futures whereas if the lag coefficients are significant, futures returns lead spot index returns. Both Stoll and Whaley (1990) and Chan (1992) have noted that computed raw returns may suffer from infrequent trading bias and so misleading results from equation (8.10). Consequently, the lead-lag relation is estimated using return innovations where the portion of spot index price changes due to infrequent trading of component stocks is filtered out.

8.3 The Data and Their Properties

The Korea Stock Price Index 200 (KOSPI 200) is the underlying stock index for traded futures and options contracts on the KSE. The KOSPI 200 is a sampled, constituent market capitalisation-weighted index that tracks the continuous price performance of 200 actively traded, large capitalisation common stocks listed on the KSE. These shares account for approximately 70 to 80 percent of domestic market capitalisation so that the index reflects the overall market performance. In order to avoid unintended bias, the constituent stocks are rigorously revised over time. The base figure was set at 100.00 as of 3 January 1990.

Trading of KOSPI 200 futures is implemented under an order-driven, continuous trading system. Since trading is executed through a computerised system there is no physical trading floor. KOSPI 200 futures expire four times a year, in March, June, September and December. The last trading day is the second Thursday of each contract month. One index point equals 500,000 Korean won and settlement of the contract is in cash. There are two trading sessions, morning and afternoon. Until 5 December 1998, both stock and stock index futures contracts were traded on weekdays between 9:30 a.m. and 11:30 a.m. in the morning session. In the afternoon session, stocks were traded from 1:00 p.m. until 3:00 p.m. and index futures were traded between 1:00 p.m. and 3:15 p.m. except on the last day of each contract month, when futures trading closed at 2:50 p.m..[27] On Saturdays, both stock and index futures were traded from 9:30 a.m. until 11:30 a.m. and 11:45 a.m., respectively. Since 7 December 1998. There has been no Saturday trading and the morning session for weekdays has been extended from 9:00 a.m. until mid-day.

With the introduction of stock index futures trading, there were daily price limits for futures contracts of ±5% of the previous trading day's closing price. On 2 March 1998 this was relaxed to ±7% and on 7 December 1998 to ±10%. There is also a system of circuit breakers. When the price of the previous trading day's most active contract reaches ±5% of that day's closing price for one minute, the trading of all futures contracts is halted for the next five minutes. Also, when the KOSPI continues

[27] The last trading of each futures contract month is the second Thursday in March, June, September and December.

(for one minute) to lose 10% or more of its value compared to the previous day's closing price, futures trading is halted for twenty minutes. For the next ten minutes following the cooling-off period, orders are collected and then matched.

For our analyses, both daily and five-minute data are used. Actual daily closing and minute-by-minute data on KOSPI 200 and KOSPI 200 futures prices were obtained from the KSE. To examine the impact of futures trading on stock price volatility, daily closing price indices are used for the period beginning on 1 September 1993 and ending on 28 December 1998. The pre-futures period to 2 May 1996 consists of 785 observations and the post-futures period from 3 May 1996 has 779 observations.

To estimate the GARCH model in equation (8.1), a market proxy variable is required. The stock price index chosen should reflect general, market-wide fluctuations and be less affected by price volatility specific to the cash market. Although there are several potential indices, only a few are available for the entire sample period. The Arithmetic Stock Price Average (ASAP), collected from *Stocks* published by the KSE, is used.

For tests of cointegration and causality and the analysis of lead-lag relationships, this thesis uses five-minute data from the start of futures trading on 3 May 1996, to the end of December 1998. The data available from the KSE include minute-by-minute KOSPI 200 spot and futures series. Index futures data based on the *nearby contract* is used since this is the most active in terms of trading volume. Five-minute data are generated in order to minimise the effects of the errors-in-the-variables problem induced by the use of nonsynchronous data. Also, the first five minutes of trading is excluded. There are two principal reasons for this. First, overnight returns are measured over a longer time period than five-minute returns.

Secondly, the stale quote problem at the start of trading is avoided. If the calculated opening values for the stock index reflect mainly the closing price on the previous trading day, it is likely that stale prices are used in calculating the opening values of the spot index. Since spot market trading finishes 15 minutes earlier than futures market trading (except on the last trading day of each futures contract when the futures market closes 10 minutes earlier than spot market) our data are sampled by matching the closing times of the two markets. The five-minute, matched spot-futures series for the KOSPI 200 contains 35,087 observations: 8,751 in 1996, 13,054 in 1997, and 13,282 in 1998.

8.4 Results

8.4.1 Interday Returns

Table 8.2 provides descriptive statistics for daily KOSPI 200 spot returns for the entire, pre-futures and post-futures periods. For the entire and post-futures periods, the average daily return is negative in contrast to the pre-futures period when it is positive. Following the introduction of index futures the standard deviation of returns more than doubles. The third and fourth moments of daily returns series for all periods indicate that the empirical distributions are not normally distributed; they are skewed to the right and leptokurtic. This is also confirmed by the results of Jarque-Bera test of normality.[28] Spot returns have significant autocorrelation coefficients in all periods.

[28] The Jarque-Bera statistic is calculated as:

$$\frac{T}{6}\left(S^2 + \frac{(k-3)^2}{4}\right)$$

where T is the number of observations, S represents skewness and K is kurtosis.

Initially, the extent to which the movement of stock prices has altered since the introduction of the KOSPI 200 futures is examined. One possible way to identify abnormally small or large values, stock price jumps, is to measure the frequency of changes outside a band. Those changes are identified as jumps because they are considered abnormal, exceptional changes. Following Becketti and Roberts (1990), and others, we identify jumps in stock returns as outliers and use the method discussed in Hoaglin, Iglewicz and Tukey (1986). This involves constructing a band on a robust measure of the dispersion of price observations in the sample. Observations are defined as outliers or jumps if *either* they are less than $Q_L - 1.5\, D_Q$ *or* if they are greater than $Q_U + 1.5\, D_Q$, where Q_L and Q_U denote the first and third quartiles in the data set and $D_Q = Q_U - Q_L$, the interquartile range. Using this technique, a daily jump is defined as any day in which the KOSPI 200 rises more than 0.0339% or falls below –0.0343%. Our results are reported in Table 8.3. Over the entire period, 7.29% of daily returns are jumps but they are not uniformly distributed through the period. When the sample is divided into pre- and post-futures periods, the results are particularly interesting. For the pre-futures period, only 0.26% of daily returns were jumps whereas, surprisingly, 14.38% of daily returns were jumps for the post-futures period; there is a much higher frequency of outliers in the post-futures period than in the pre-futures period. However, it is not clear that the futures market is responsible for this increase in jump volatility. One way to examine this is to examine whether outliers are more frequent when futures trading is active than when it is not. If stock index futures are a major source of jump volatility, then volatility should be high when the volume of futures trading is high, and low when the volume of futures trading is generally low.

In order to examine the relationship between volume and volatility we first detrend futures trading volume. Following Andersen (1996), a trend component is estimated from which a 'normal' or expected volume series is derived. Each daily observation on futures trading volume is then divided by the 'normal' value for that day to obtain a detrended series. A two-month centred moving average is used to generate the 'normal' series. As expected given the method of normalisation, the mean of the detrended series is close to unity irrespective of sample period and the standard deviation is relatively stable except for the period of the Korean financial market crisis in the second half of 1997. Figure 8.1 provides graphs of the number of daily jumps in the KOSPI 200 spot index per month and the median detrended trading volume each month. From this figure, it seems that trading volume is unrelated to the frequency of outliers. This is confirmed by the sample correlation coefficient between the frequency of stock price outliers and detrended futures trading volume; this is 0.010 and not significantly different from zero. Also, the correlation between daily stock price volatility and daily detrended futures trading volume is 0.038 and also low. Previously, other factors have been found to affect volatility. For example, stock market volatility is often influenced by recent episodes of volatility and this volatility clustering is usually captured in ARCH models. Additionally, macroeconomic variables such as the growth rate of industrial production, inflation volatility, the volatility of the term structure of interest rates and the volatility of risk premia have all been proposed as potential determinants of stock prices (Chen, Roll and Ross, 1986). It seems therefore that futures trading does not increase jump volatility.

Although jump volatility is not affected, futures trading might affect general volatility in the stock market. To examine this, we estimate over the entire period a

GARCH(1,1) model which includes a dummy variable, D_t, in the variance equation where D_t takes the values zero and one for the pre- and post-futures periods respectively. The results are reported in Table 8.4. The estimated coefficient on the dummy variable, $\hat{\delta}_I$, is positive and significant implying that the introduction of stock index futures resulted in an increase in volatility in the stock market.

Results for separate GARCH(1,1) models for the pre- and post-futures periods are also reported in the second and third rows of Table 8.4. For both periods, the coefficients of the variance equations are significant and although the intercepts are very small they are nonzero. The estimated coefficient $\hat{\alpha}_1$ increases from 0.05436 to 0.08783 in the post-futures period, which confirms the result of the previous GARCH estimation of higher stock market volatility when futures are traded. The coefficient α_1 relates today's price changes to yesterday's market-specific price changes and as these depend on the arrival of information yesterday, α_1 can be viewed as a 'news' coefficient. Since α_1 increases following the introduction of futures trading, this suggests that futures trading results in information being impounded into spot prices more quickly. In these circumstances, an increase in spot market volatility following the introduction of stock index futures trading is not necessarily bad. The unconditional variance, given by $\alpha_0/(1-\alpha_1-\beta_1)$, increases from 0.00005 in the pre-futures period to 0.0004 in the post-futures period—further evidence that spot market volatility increased following the introduction of futures trading.

The persistence of volatility shocks depends primarily on $\alpha_I+\beta_I$. For the pre-futures period, we find $\alpha_I+\beta_I=0.9804$, implying high persistence of volatility, and increasing slightly to 0.9937 following the introduction of futures trading. This surprising result merits further investigation. If a market reflects information rapidly, the persistence should decrease. Our post-futures period includes the Korean financial market crisis, an unusually volatile period. The effects of this unusual period are removed by re-estimating the model over the period from 3 May 1996 until 31 October 1997. These are the last set of results reported in Table 8.4 and they are compared with those for the pre-futures period. Following the introduction of futures trading, the news coefficient, α_1, increases from 0.0544 to 0.1660; volatility persistence decreases from 0.9804 to 0.942 and the unconditional variance increases 0.00005 to 0.0001. That is, information is impounded into prices more quickly; the persistence of information is reduced, and spot market volatility increased.

8.4.2 Intraday Returns

Descriptive statistics for KOSPI 200 spot index and futures five-minute returns, together with autocorrelation coefficients up to the twelfth order (one hour), are reported in Table 8.5.1. For each period, the mean returns for spot and futures are of similar magnitude. However, futures returns are more volatile having greater standard deviation. The empirical distributions are not normally distributed but skewed and more-sharply peaked than the normal distribution. Given the large sample size, these measures of skewness and kurtosis result in large Jarque-Bera statistics. For example, for spot returns for the entire period this statistic is 1.2×10^7. The Ljung-Box statistics show that the returns series have significant autocorrelation coefficients in all periods. For the KOSPI 200 spot index, autocorrelation coefficients at lag one are significantly large and positive. The autocorrelation coefficient at lag one is 0.333 in 1996, falling to 0.277 in 1997 and 0.162 in 1998. This suggests that, over the sample period, either the problem of non-synchronous trading becomes relatively less important or the spot market processes market-wide information more efficiently as the market matures. Unlike the spot index, the magnitude of the KOSPI 200 futures autocorrelation coefficients is quite small, although Ljung-Box statistics indicate that they are significantly different from zero (see Table 8.5.2).

As presented in Table 8.6, Phillips-Perron unit root tests for the logarithm of the KOSPI 200 spot and futures series, s_t and f_t respectively, find the series are I(1) for the entire period and three subperiods. Engel-Granger cointegration tests are reported in Table 8.7. For each period, the forward and reverse regressions are presented, together with the cointegrating regression augmented Dickey-Fuller (CRADF) statistic and its associated lag order. This was selected by testing down to eliminate autocorrelation in the test regression. The null hypothesis of non-cointegration is rejected at the .05 level for all the periods considered. The prices in the two markets are linked in the long-run and the long-run coefficients are close to one, irrespective of the sample period.

Accepting that each pair of spot and futures prices forms a cointegrated system, ECMs are estimated for the entire period and three subperiods by the Engle-Granger two-step method and the results reported in Table 8.8.1. The Schwarz Bayesian criterion (SBC) and Hannan-Quinn criterion (HQC) were used to determine lag lengths.[29] Under certain regularity conditions it can be shown that the SBC and HQC are consistent in the sense that for large enough samples and assuming the true model belongs to the set of models over which one is searching, they lead to the correct model choice. These two criteria selected lag lengths of the same order: five for all periods except 1996 for which four was chosen. As expected, at least one of

[29] The SBC and HQC are computed as

$$\text{SBC} = T\ln(\sigma^2) + n\ln T$$
$$\text{HQC} = T\ln(\sigma^2) + 2n\ln(\ln T)$$

where T is the number of usable observations, σ^2 is the residual sum of squares and n is the number of parameters estimated.

the lagged disequilibrium errors has a significant coefficient in each period confirming that the spot and futures markets respond to the previous period's deviation from equilibrium. For the entire period, both coefficients on the lagged disequilibrium terms are significant. This implies that both markets adjust to long-run equilibrium. For the subperiods, the coefficients on disequilibrium errors are insignificant in 1997 in panel A and in 1996 and 1998 in panel B. This lack of significance indicates that the current period spot (futures) return does not respond to disequilibrium in the previous period. Consequently, any adjustment in the current period's spot (futures) return is caused by lagged spot and futures returns. Irrespective of sample period, Granger causality tests on ECMs do not support unidirectional causality from one market to another because F-statistics in both panel A and panel B reject the hypothesis that the coefficients jointly equal to zero. There is bidirectional causality, feedback between markets. As reported in Table 8.8.2 and 8.8.3, this is further supported by Sims (1972) tests and Geweke, Meese and Dent (1983) causality tests. The results indicate the rejection of the null hypothesis that the sets of coefficients are jointly equal to zero. Although bidirectional causality observed in our test, the magnitude of t-statistics suggests that the lead from futures to spot returns is mildly more robust than that from spot to futures returns.

Lead-lag relationships between the stock index and stock index futures markets, together with Wald tests of coefficient restrictions, are reported in Table 8.9.1 and 8.9.2. Since raw returns series can cause a spurious lead-lag relation because of infrequent trading of stocks within the index portfolio, consequently, misleading results from equation (8.10). To overcome this problem, our models use stock index return innovations, $I_{s,t}$, and the future return innovations, $I_{f,t}$. Initially, several ARMA(p,q) processes were estimated including the ARMA(2,3) model used by Stoll and Whaley (1990) and Fleming, Ostdiek and Whaley (1996). However, all of these were less successful at eliminating autocorrelation than a simple AR(1) process. The higher-order ARMA models resulted in low explanatory power and correlograms showed significant residual autocorrelation. Thus, the lead-lag relation is estimated with return innovations generated by an AR(1) process using the following model which is based on equation (8.10)

$$I_{s,t} = a + \sum_{l=-8}^{l=+8} b_l I_{f,t+1} + \varepsilon_t \qquad (8.11)$$

The choice of eight leads and lags for our models is based on preliminary evidence from cross-correlation coefficients which are small and insignificant at longer leads and lags. The dependent variable is KOSPI 200 spot return innovations. The independent variable is KOSPI 200 futures return innovations. Focusing first on the results using raw returns, as shown in Table 8.9.1, the contemporaneous relationships are found to be strong between the spot and futures markets in all subperiods. The estimated contemporaneous coefficients, b_0, are large (0.3990, 0.4203 and 0.4524 for 1996, 1997 and 1998, respectively) and significant at the 5% level (t-statistics of 70.99 for 1996, 81.14 for 1997 and 83.64 for 1998). The estimated coefficients on b_{-1}, associated with a futures market lead of five minutes, are also large and significant. The leading effect of futures market seems to persist even at lag 2, albeit at lower levels than at lag 1. Although the magnitude of the coefficients declines, the evidence suggests that futures price movements tend to lead price movements in the spot market by as much as 35 minutes. This issue, however, is re-examined with the use of KOSPI 200 return innovations and KOSPI 200 futures return innovations generated from AR(1) processes since raw returns series can cause a spurious lead-lag relation because of infrequent trading of stocks within the index portfolio.

As presented in Table 8.9.2, the results show that the futures market leads the spot market but the lead is not as long as indicated by raw returns. The contemporaneous coefficients are 0.4020, 0.4156 and 0.4475, with t-statistics of 71.41, 81.63 and 82.03 for 1996, 1997 and 1998, respectively. The increase on contemporaneous coefficient for KOSPI futures return innovations suggest that the integration of the index futures and the spot market has continuously been grown over the sample periods. The results for individual subperiods show that in successive years, the lead time has increased by five minutes each year but with the magnitude of the earliest significant coefficient declining. Some of the lead coefficients (b_{+l}) are significant, providing evidence of the spot market leading the futures market. The relations for successive years show this lead declining. Although the effect is small compared to the lead of futures returns it supports the notion that occasionally the spot leads the futures. The evidence indicates that the futures market tends to lead the spot market by as much as 30 minutes. In addition, the reported F-statistics, which test that all the lead coefficients, b_{+l}, and the all the lag coefficients, b_{+l}, are jointly zero, show that both of them have p-values smaller than 0.1% in all subperiods. Clearly, although there is weak evidence that the spot index leads the futures index, there is stronger evidence that the stock index futures market leads the stock market.

8.5 Conclusions

This chapter investigates the impact on the spot market of trading in stock index futures in Korea in May 1996 and several important results were found. First, the results show that futures trading increases the speed at which information is impounded into spot market prices. Secondly, there has been an increase in volatility and a decrease in the persistence of volatility following the introduction of stock index futures. Although the volatility increase might be due to destabilising effects of futures trading associated with speculation, stock index futures add a new dimension to the market by providing a new instrument to facilitate hedging. Thirdly, the evidence indicates that futures trading does not result in increased jump volatility, abnormally large increases or decreases in stock prices. Fourthly, there is a long-run equilibrium relationship between the KOSPI 200 spot and futures prices with bidirectional causality between spot and futures markets. This differs from most of the literature on developed markets which finds unidirectional causality from futures to spot markets. Fifthly, returns in these two markets are largely contemporaneous but with weak evidence that the spot market leads the futures market and stronger evidence that the stock index futures market leads the spot market. This suggests that news disseminates first in the futures market and then in the spot market. In summary, it would seem that the impact of futures trading has been beneficial for the Korean stock market.

Table 8.1 Introduction of Stock Index Futures Trading in the Pacific Basin

Country	Stock index futures	Exchange	Listing date
Australia	All Ordinaries Index Futures	The Sydney Futures Exchange	Feb. 1983
Hong Kong	Hang Seng Index Futures	The Hong Kong Futures Exchange	Jun. 1986
Japan	Nikkei Stock Average Futures	The Osaka Securities Exchange	Sep. 1988
	Topix Index Futures	The Tokyo Stock Exchange	Sep. 1988
Korea	Korea Composite Stock Price Index 200 Futures	The Korea Stock Exchange	May 1996
New Zealand	Barclays Shares Price Index Futures	The New Zealand Futures and Options Exchange	Jan. 1987
Singapore	Nikkei Stock Average Futures	The Singapore International Monetary Exchange	Sep. 1986

Table 8.2 Descriptive Statistics for Interday KOSPI 200 Spot Returns (September 1993 – December 1998)

Statistic	Entire Period	Pre-futures	Post-futures
Mean	–0.0001	0.0005	–0.0006
Standard Deviation	0.0187	0.0104	0.0243
Skewness	0.1619	0.1283	0.1938
Kurtosis	7.1618	3.4752	4.9023
Jarque-Bera	1134.84*	9.5253*	122.33*
Autocorrelation Coefficients (Ljung-Box Q Statistic)			
1	0.153 (36.79)*	0.113 (9.98)*	0.160 (20.02)*
2	–0.045 (40.01)*	–0.077 (14.67)*	–0.041 (21.33)*
3	–0.006 (40.08)*	0.055 (17.06)*	–0.018 (21.60)*
4	–0.042 (42.84)*	–0.004 (17.07)*	–0.049 (23.49)*
5	–0.089 (55.37)*	0.036 (18.11)*	–0.114 (33.75)*
6	–0.066 (62.13)*	0.023 (18.54)*	–0.085 (39.44)*
7	–0.013 (62.41)*	–0.101 (26.63)*	0.002 (39.44)*
8	0.018 (62.91)*	–0.062 (29.67)*	0.033 (40.29)*
9	0.085 (74.29)*	0.101 (37.84)*	0.081 (45.42)*
10	0.044 (77.28)*	0.037 (38.91)*	0.043 (46.90)*

* indicates significance at the 5% level.

Table 8.3 Outliers in Interday Returns on KOSPI 200 Spot

	Pre-futures	Post-futures
Sample Period	1 Sept 1993 – 2 May 1996	3 May 1996 – 28 Dec 1998
Observations	784	779
Low Outliers	1 (0.13%)	56 (7.19%)
High Outliers	1 (0.13%)	56 (7.19%)
All Outliers	2 (0.26%)	112 (14.38%)

Note: Low outlier and high outlier is defined as any day in which the KOSPI 200 falls below –0.0343% and rises more than 0.0339% compared to the previous trading day's KOSPI 200, respectively.

Figure 8.1 Frequency of Jumps in Stock Price Volatility and Detrended Futures Trading Volume

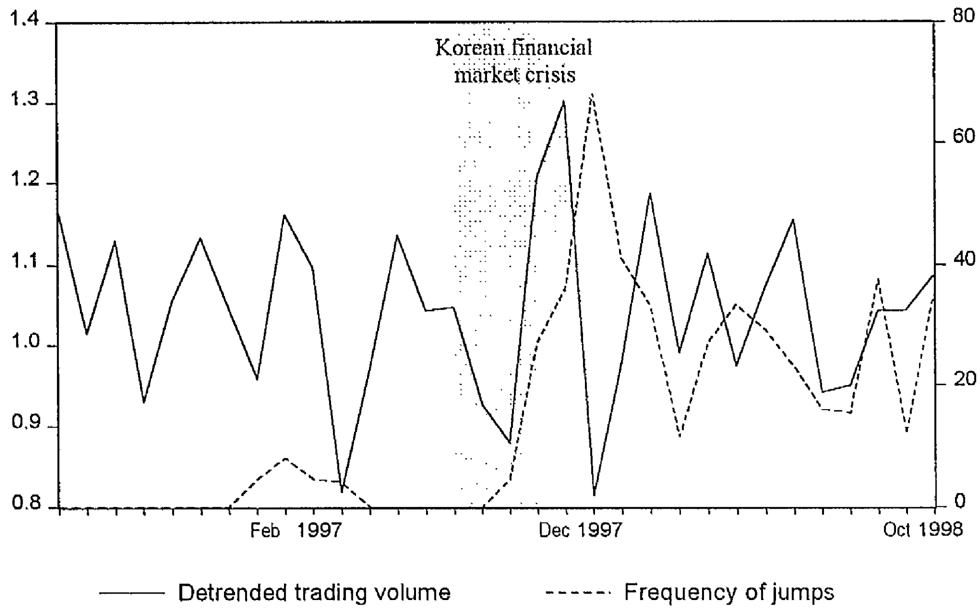

Table 8.4 GARCH (1,1) model

	$R_{s,t} = a_0 + a_1 R_{p,t} + u_t$		$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \delta_1 D_t$			
Period	$\hat{a}_0$	$\hat{a}_1$	$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\beta}_1$	$\hat{\delta}_1$
Entire	−0.00022	0.87047	0.000001	0.06933	0.91969	0.000002
	(−1.04)	(56.85)*	(2.93)*	(6.23)*	(79.92)*	(2.55)*
Pre-futures	−0.00005	0.86207	0.000001	0.05436	0.92604	
	(−0.21)	(35.40)*	(2.31)*	(3.15)*	(44.66)*	
Post-futures	−0.00068	0.86853	0.000003	0.08783	0.90590	
	(−1.50)	(42.15)*	(2.17)*	(5.73)*	(61.68)*	
New Post-futures [a]	-0.00147	0.70016	0.000008	0.16602	0.77604	
	(-3.09)*	(23.26)*	(2.18)*	(4.35)*	(14.17)*	

t-statistics are presented in parentheses.
* indicates significance at the 5% level.
[a] period ends 31 October 1997 to exclude the Korean financial market crisis .

Table 8.5.1 Descriptive Statistics for Intraday Five-Minute KOSPI 200 Spot and Futures Returns

	Entire		1996		1997		1998	
	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures
Mean	-0.000014	-0.000013	-0.000052	-0.000058	-0.000036	-0.000036	0.000033	0.000040
Standard Deviation	0.0034	0.0043	0.0013	0.0017	0.0033	0.0044	0.0043	0.0052
Skewness	0.995	-0.764	3.461	1.634	-0.678	-1.078	1.536	-0.523
Kurtosis	94.262	125.581	71.915	49.723	155.446	195.856	44.054	54.308
Autocorrealtions, R_t:								
1	0.209 *	0.044 *	0.333 *	0.074 *	0.277 *	0.064 *	0.162 *	0.028 *
2	-0.024 *	0.000 *	0.246 *	0.065 *	0.047 *	0.020 *	-0.082 *	-0.017 *
3	-0.070 *	-0.011 *	0.168 *	0.053 *	-0.053 *	-0.031 *	-0.095 *	-0.003 *
4	-0.046 *	-0.006 *	0.075 *	0.000 *	-0.083 *	-0.008 *	-0.031 *	-0.006 *
5	-0.024 *	0.002 *	0.005 *	-0.026 *	-0.061 *	-0.008 *	-0.004 *	0.011 *
6	-0.004 *	-0.001 *	-0.038 *	-0.018 *	-0.029 *	-0.008 *	0.013 *	0.003 *
7	0.017 *	0.007 *	-0.064 *	-0.035 *	0.003 *	0.021 *	0.030 *	0.000 *
8	0.013 *	0.001 *	-0.074 *	-0.027 *	0.004 *	-0.013 *	0.024 *	0.014 *
9	0.004 *	-0.005 *	-0.068 *	-0.006 *	0.003 *	-0.017 *	0.011 *	0.003 *
10	0.010 *	-0.010 *	-0.058 *	0.009 *	0.014 *	-0.013 *	0.012 *	-0.007 *
11	0.007 *	-0.003 *	-0.033 *	0.012 *	0.008 *	-0.004 *	0.009 *	-0.003 *
12	0.005 *	-0.000 *	-0.020 *	0.014 *	0.015 *	-0.002 *	-0.001 *	0.000
Autocorrelations, R_t^2:								
1	0.045 *	0.012 *	0.007	0.023 *	0.014	0.013	0.077 *	0.003
2	0.011 *	0.005 *	0.009	0.011	0.012	0.006	0.003 *	-0.002
3	0.017 *	0.014 *	0.019	0.014	0.020 *	0.016	0.005 *	0.005
4	0.013 *	0.004 *	0.007	0.027 *	0.010 *	0.002	0.01 *	0.002
5	0.009 *	0.008 *	0.005	0.032 *	0.009 *	0.004	0.002 *	0.009
6	0.007 *	0.006 *	0.002	0.012 *	0.009 *	0.008	-0.002 *	-0.001
7	0.007 *	0.006 *	0.010	0.009 *	0.007	0.006	0.001 *	0.001
8	0.005 *	0.006 *	0.009	0.011 *	0.005	0.006	-0.003 *	0.001

9	0.004 *	0.003 *	0.001	0.014 *	0.005	0.003	-0.005 *	0.000
10	0.008 *	0.003 *	-0.001	0.015 *	0.011	0.003	-0.003 *	-0.001
11	0.007 *	0.004 *	0.003	0.028 *	0.008	0.003	-0.002 *	0.002
12	0.004 *	0.005 *	-0.002	0.011 *	0.004	0.006	-0.003 *	-0.002

* indicates significance at the 5% level.

Table 8.5.2 Sample Cross-Correlation Coefficients Between Intraday Five-Minute Interval KOSPI 200 Spot and KOSPI 200 Futures Returns

	Entire		1996		1997		1998	
Lead/Lag	Cross Correlation	Ljung-Box Q-Stat.	Cross Correlation	Ljung-Box Q-Stat.	Cross Correlation	Ljung-Box Q-Stat.	Cross Correlation	Ljung-Box Q-Stat.
12	0.0033	0.40 (0.53)	0.0283 *	7.02 (0.01)	-0.0043	0.24 (0.62)	0.0062	0.51 (0.48)
11	0.0052	0.96 (0.33)	0.0266 *	6.19 (0.01)	0.0063	0.52 (0.47)	0.0028	0.11 (0.74)
10	0.0010	0.03 (0.85)	0.0215 *	4.04 (0.04)	0.0116	0.76 (0.19)	-0.0070	0.65 (0.42)
9	0.0003	0.00 (0.95)	0.0045	0.18 (0.68)	0.0023	0.07 (0.79)	-0.0084	0.01 (0.92)
8	0.0026	0.23 (0.63)	-0.0069	0.42 (0.52)	-0.0107	1.50 (0.22)	0.0120	1.92 (0.17)
7	-0.0038	0.52 (0.47)	-0.0288 *	7.24 (0.01)	-0.0054	0.38 (0.54)	-0.0012	0.02 (0.89)
6	0.0026	0.23 (0.63)	-0.0410 *	14.73 (0.00)	0.0002	0.00 (0.98)	0.0064	0.54 (0.46)
5	0.0100	3.49 (0.06)	-0.0521 *	23.74 (0.00)	0.0007	0.01 (0.94)	0.0191 *	4.84 (0.03)
4	0.0044	0.67 (0.41)	-0.0538 *	25.39 (0.00)	-0.0038	0.19 (0.67)	0.0133	2.37 (0.12)
3	-0.0080	2.27 (0.13)	-0.0185	2.99 (0.08)	-0.0134	2.33 (0.13)	-0.0040	0.21 (0.64)
2	-0.0262 *	24.09 (0.00)	-0.0174	2.65 (0.10)	-0.0240 *	7.54 (0.01)	-0.0285 *	10.80 (0.00)
1	-0.0115 *	4.36 (0.04)	0.0142	1.77 (0.18)	0.0342 *	15.23 .(0.00)	-0.0422 *	23.62 (0.00)
0	0.5629 *	11118.78 (0.00)	0.5792 *	2936.70 (0.00)	0.5716 *	4265.00 .(0.00)	0.5572 *	4123.92 (0.00)
-1	0.2980 *	3116.82 (0.00)	0.2769 *	671.08 (0.00)	0.2420 *	764.44 .(0.00)	0.3363 *	1502.68 (0.00)
-2	0.1190 *	497.24 (0.00)	0.2452 *	526.59 (0.00)	0.1552 *	314.36 .(0.00)	0.0874 *	101.39 (0.00)
-3	0.0140 *	6.88 (0.01)	0.2064 *	373.14 (0.00)	0.0384 *	19.29 .(0.00)	-0.0146	2.82 (0.09)
-4	-0.0154 *	8.28 (0.00)	0.1458 *	186.09 (0.00)	-0.0059	0.45 (0.50)	-0.0323 *	13.90 (0.00)
-5	-0.0061	1.31 (0.25)	0.0945 *	78.20 (0.00)	-0.0174 *	3.94 (0.04)	-0.0057	0.43 (0.51)
-6	-0.0093	3.04 (0.08)	0.0533 *	24.92 (0.00)	-0.0245 *	7.81 (0.01)	-0.0038	0.19 (0.66)
-7	0.0125 *	5.45 (0.02)	0.0166	2.40 (0.12)	0.0048	0.30 (0.59)	0.0170	3.84 (0.04)
-8	0.0096	3.26 (0.07)	-0.0131	1.50 (0.22)	-0.0046	0.28 (0.60)	0.0202 *	5.45 (0.02)
-9	0.0067	1.60 (0.21)	-0.0250 *	5.48 (0.02)	-0.0032	0.14 (0.71)	0.0152	3.09 (0.08)
-10	0.0048	0.80 (0.37)	-0.0241 *	5.08 (0.02)	-0.0010	0.01 (0.91)	0.0101	1.36 (0.24)
-11	-0.0019	0.13 (0.72)	-0.0066	0.38 (0.54)	-0.0021	0.06 (0.81)	-0.0015	0.03 (0.87)
-12	0.0048	0.80 (0.37)	-0.0183	2.94 (0.09)	0.0059	0.46 (0.50)	0.0054	0.38 (0.54)

* indicates significance at the 5% level.
Significance levels are reported in parentheses.

Table 8.6 Summary of Phillips-Perron Unit Root Tests for Log of Five-Minute Interval KOSPI 200 Spot and Futures Prices

	Test statistics											
	$Z(\tilde{\alpha})$	$Z(t_{\tilde{\alpha}})$	$Z(t_{\tilde{\beta}})$	$Z(t_{\tilde{\mu}})$	$Z(\Phi_3)$	$Z(\Phi_2)$	$Z(\alpha^*)$	$Z(t_{\alpha^*})$	$Z(t_{\mu^*})$	$Z(\Phi_1)$	$Z(\hat{\alpha})$	$Z(t_{\hat{\alpha}})$
Entire period												
Spot	-2.93	-0.68	-0.07	0.97	1.61	1.25	-4.03	-1.82	1.76	1.93	-0.14	-0.87
Futures	-5.18	-1.13	-0.26	1.22	1.77	1.29	-4.76	-1.87	1.82	1.90	-0.14	-0.17
1996												
Spot	-4.48	-0.95	-2.15	2.20	1.68	3.46	-0.91	-0.58	0.52	3.68	-0.10	-2.66
Futures	-4.97	-1.20	-1.65	1.57	1.30	3.48	-0.35	-0.22	0.15	3.94	-0.11	-2.80
1997												
Spot	-2.40	-0.78	-2.14	1.10	2.24	1.88	0.39	0.16	-0.20	0.59	-0.11	-1.07
Futures	-3.64	-1.15	-2.09	1.22	2.19	1.74	-0.42	-0.16	0.11	0.43	-0.11	-0.92
1998												
Spot	-0.83	-0.35	0.76	0.44	0.48	0.57	-1.45	-0.63	0.68	0.57	0.11	0.83
Futures	-1.50	-0.57	0.55	0.67	0.46	0.57	-1.99	-0.79	0.84	0.70	0.13	0.83
Critical Values at 5%	(-21.8)	(-3.41)	(±3.11)	(±3.38)	(6.25)	(4.68)	(-14.1)	(-2.86)	(±2.83)	(4.59)	(-8.1)	(-1.95)

For the general model $Y_t = \tilde{\mu} + \tilde{\beta}(t - T/2) + \tilde{\alpha} Y_{t-1} + \tilde{u}_t$.

$Z(\tilde{\alpha})$ and $Z(t_{\tilde{\alpha}})$ test H_0: $\tilde{\alpha}=1$.

$Z(t_{\tilde{\beta}})$ tests H_0: $\tilde{\beta}=0$,

$Z(t_{\tilde{\mu}})$ tests H_0: $\tilde{\mu}=0$,

$Z(\Phi_3)$ tests H_0: $\tilde{\alpha}=1$. $\tilde{\beta}=0$,

$Z(\Phi_2)$ tests H_0: $\tilde{\alpha}=1$. $\tilde{\beta}=0$. $\tilde{\mu}=0$.

For the model $Y_t = \mu^* + \alpha^* Y_{t-1} + u_t^*$.

$Z(\alpha^*)$ and $Z(t_{\alpha^*})$ test H_0: $\alpha^*=1$,

$Z(t_{\mu^*})$ tests H_0: $\mu^*=0$,

$Z(\Phi_1)$ tests H_0: $\alpha^*=1$. $\mu^*=0$.

For the model $Y_t = \hat{\alpha} Y_{t-1} + \hat{u}_t$,

$Z(\hat{\alpha})$ and $Z(t_{\hat{\alpha}})$ test H_0: $\hat{\alpha} = 1$.

The reported results are for a lag window of 12; they are invariant for the range used for *l* from 4 to 49.
Our notation follows that in Perron, P. (1988) 'Trends and Random Walks in Macroeconomic Time Series' *Journal of Economic Dynamics and Control*, Vol. 12, pp. 297-332

Table 8.7 Engle-Granger Cointegration: KOSPI 200 Spot and Futures

Period	Cointegrating regression	R^2	CRADF	Lag order
Entire	$s_t = 0.179 + 0.958f_t$	0.994	-7.97*	10
	$f_t = -0.160 + 1.038s_t$	0.994	-7.99*	10
1996	$s_t = 0.050 + .0988f_t$	0.983	-4.78*	2
	$f_t = 0.027 + 0.994s_t$	0.983	-4.72*	2
1997	$s_t = 0.482 + 0.887f_t$	0.980	-5.62*	6
	$f_t = -0.448 + 1.105s_t$	0.980	-5.67*	6
1998	$s_t = 0.373 + 0.904f_t$	0.994	-7.50*	6
	$f_t = -0.386 + 1.099s_t$	0.994	-7.52*	6

* indicates significance at the 5% level.

Table 8.8.1 Error Correction Models: KOSPI 200 Spot and Futures

	Panel A: Dependent Variable is Spot Returns					Panel B: Dependent Variable is Futures Returns			
	Entire	1996	1997	1998		Entire	1996	1997	1998
Constant	0.000	0.000	0.000	0.000	Constant	0.000	0.000	0.000	0.000
	(-0.73)	(-1.70)	(-1.02)	(0.75)		(-0.59)	(-2.92) *	(-0.92)	(0.90)
$R_{s,t-1}$	0.007	0.111	0.174	-0.126	$R_{f,t-1}$	0.075	0.093	0.063	0.077
	(1.07)	(8.22) *	(16.01) *	(-11.66) *		(11.33) *	(6.86) *	(5.78) *	(7.08) *
$R_{s,t-2}$	-0.144	0.058	-0.102	-0.210	$R_{f,t-2}$	0.033	0.112	0.048	0.025
	(-21.88) *	(4.25) *	(-9.29) *	(-19.43) *		(4.83) *	(8.17) *	(4.44) *	(2.15) *
$R_{s,t-3}$	-0.099	0.042	-0.065	-0.155	$R_{f,t-3}$	0.007	0.089	-0.034	0.027
	(-15.06) *	(3.15) *	(-5.94) *	(-14.31) *		(1.01)	(6.55) *	(-3.07) *	(2.31) *
$R_{s,t-4}$	-0.059	-0.009	-0.078	-0.072	$R_{f,t-4}$	0.001	0.042	0.002	0.000
	(-9.07) *	(-0.73)	(-7.13) *	(-6.76) *		(0.12)	(3.17) *	(0.18)	(-0.02)
$R_{s,t-5}$	-0.052	-	-0.052	-0.061	$R_{f,t-5}$	0.000	-	-0.005	0.002
	(-8.36) *		(-5.03) *	(-6.18) *		(0.04)		(-0.50)	(0.24)
$R_{f,t-1}$	0.222	0.134	0.101	0.315	$R_{s,t-1}$	-0.072	-0.087	0.007	-0.112
	(45.22) *	(15.08) *	(13.07) *	(38.35) *		(-8.07) *	(-4.22) *	(0.44)	(-7.79) *
$R_{f,t-2}$	0.140	0.109	0.120	0.182	$R_{s,t-2}$	-0.042	-0.111	-0.072	-0.035
	(27.74) *	(12.06) *	(15.42) *	(20.82) *		(-4.73) *	(-5.40) *	(-4.67) *	(-2.46) *
$R_{f,t-3}$	0.078	0.078	0.043	0.121	$R_{s,t-3}$	-0.006	-0.039	0.027	-0.023
	(15.26) *	(8.68) *	(5.51) *	(13.64) *		(-0.64)	(-1.91)	(1.74)	(-1.57)
$R_{f,t-4}$	0.047	0.052	0.045	0.059	$R_{s,t-4}$	0.001	-0.051	-0.007	0.007
	(9.26) *	(6.05) *	(5.73) *	(6.68) *		(0.07)	(-2.62) *	(-0.44)	(0.46)
$R_{f,t-5}$	0.043	-	0.036	0.049	$R_{s,t-5}$	0.006	-	0.000	0.012
	(8.64) *		(4.61) *	(5.77) *		(0.75)		(0.03)	(0.95)
$\hat{z}_{s,t-1}$	-0.003	-0.003	-0.001	-0.012	$\hat{z}_{f,t-1}$	-0.003	0.000	-0.006	-0.002
	(-4.91) *	(-3.30) *	(-0.77)	(-5.96) *		(-3.16) *	(0.24)	(-4.53) *	(-0.98)
Granger Causality Test									
	H_0: all lag coefficients on $R_{f,t-i}$ are zero.					H_0: all lag coefficients on $R_{s,t-i}$ are zero.			
F- statistic	536.89	118.01	87.44	341.60		19.14	24.14	4.58	14.17
	(0.00) *	(0.00) *	(0.00) *	(0.00) *		(0.00) *	(0.00) *	(0.00) *	(0.00) *

* indicates significance at the 5% level.
Figures in parentheses are t-statistics.

Table 8.8.2 Error Correction Models: KOSPI 200 Spot and Futures

	Panel A: Dependent Variable is Spot Returns					Panel B: Dependent Variable is Futures Returns			
	Entire	1996	1997	1998		Entire	1996	1997	1998
Constant	0.000	0.000	0.000	0.000	Constant	0.000	0.000	0.000	0.000
	(-0.35)	(-0.97)	(-0.48)	(0.20)		(0.10)	(-1.35)	(-0.02)	(0.04)
$R_{f,t+5}$	0.007	-	0.005	0.010	$R_{s,t+5}$	0.023	-	0.022	0.018
	(2.08) *		(0.88)	(1.83)		(4.28) *		(2.32) *	(2.18) *
$R_{f,t+4}$	0.006	-0.021	0.002	0.011	$R_{s,t+4}$	0.013	0.058	0.030	0.005
	(1.78)	(-3.71) *	(0.41)	(2.07) *		(2.31) *	(4.73) *	(2.96) *	(0.57)
$R_{f,t+3}$	0.001	-0.020	0.007	0.000	$R_{s,t+3}$	0.042	0.076	0.030	0.052
	(0.29)	(-3.56) *	(1.38)	(-0.09)		(7.48) *	(6.00) *	(2.91) *	(6.09) *
$R_{f,t+2}$	-0.016	-0.037	-0.020	-0.012	$R_{s,t+2}$	0.110	0.103	0.131	0.103
	(-4.93) *	(-6.63) *	(-3.88) *	(-2.22) *		(19.54) *	(8.04) *	(13.08) *	(12.15) *
$R_{f,t+1}$	-0.026	-0.029	0.001	-0.041	$R_{s,t+1}$	0.211	0.132	0.083	0.292
	(-7.84) *	(-5.08) *	(0.13)	(-7.56) *		(37.59) *	(10.26) *	(8.29) *	(34.27) *
$R_{f,t}$	0.437	0.397	0.421	0.453	$R_{s,t}$	0.716	0.856	0.790	0.690
	(134.26) *	(70.16) *	(81.43) *	(84.16) *		(127.26) *	(66.68) *	(78.46) *	(80.56) *
$R_{f,t-1}$	0.210	0.151	0.147	0.252	$R_{s,t-1}$	-0.150	-0.250	-0.158	-0.129
	(64.24) *	(26.65) *	(28.33) *	(46.40) *		(-26.74) *	(-19.44) *	(-15.68) *	(-15.16) *
$R_{f,t-2}$	0.082	0.126	0.096	0.069	$R_{s,t-2}$	0.030	-0.154	-0.022	0.068
	(25.24) *	(22.20) *	(18.51) *	(12.84) *		(5.26) *	(-12.03) *	(-2.17) *	(8.02) *
$R_{f,t-3}$	0.012	0.099	0.033	-0.010	$R_{s,t-3}$	0.038	-0.050	0.037	0.046
	(3.55) *	(17.57) *	(6.31) *	(-1.84)		(6.75) *	(-3.92) *	(3.64) *	(5.40) *
$R_{f,t-4}$	-0.008	0.078	0.000	-0.024	$R_{s,t-4}$	0.021	-0.031	0.043	0.020
	(-2.56) *	(13.77) *	(-0.09)	(-4.42)		(3.72) *	(-2.52) *	(4.25) *	(2.33) *
$R_{f,t-5}$	-0.004	-	-0.006	-0.010	$R_{s,t-5}$	0.02	-	0.020	0.024
	(-1.18)		(-1.08)	(-1.89)		(3.67) *		(2.11)	(2.91) *
$\hat{z}_{s,t-1}$	-0.006	-0.002	-0.005	-0.019	$\hat{z}_{f,t-1}$	-0.009	-0.004	-0.008	-0.023
	(-10.28) *	(-2.91) *	(-5.09) *	(-11.65) *		(-12.32) *	(-3.62) *	(-7.48) *	(-12.56) *
Sims Causality Test									
	H_0: all lead coefficients of R_f are zero.					H_0: all lead coefficients of R_s are zero.			
F-statistic	19.61	28.64	3.53	14.27		472.78	107.47	79.73	310.62
	(0.00) *	(0.00) *	(0.00) *	(0.00) *		(0.00) *	(0.00) *	(0.00) *	(0.00) *

* indicates significance at the 5% level.
Figures in parentheses are t-statistics.

Table 8.8.3 Error Correction Models: KOSPI 200 Spot and Futures

	Panel A: Dependent Variable is Spot Returns					Panel B: Dependent Variable is Futures Returns			
	Entire	1996	1997	1998		Entire	1996	1997	1998
Constant	0.000	0.000	0.000	0.000	Constant	0.000	0.000	0.000	0.000
	(-0.48)	(-0.39)	(-0.60)	(0.33)		(0.13)	(-1.45)	(-0.02)	(0.09)
$R_{s,t-1}$	0.037	0.139	0.171	-0.077	$R_{f,t-1}$	-0.139	-0.069	-0.044	-0.222
	(6.93) *	(13.03) *	(19.57) *	(-8.92) *		(-25.91) *	(-6.47) *	(-5.02) *	(-25.44) *
$R_{s,t-2}$	-0.125	0.099	-0.072	-0.194	$R_{f,t-2}$	-0.099	-0.017	-0.062	-0.151
	(-23.56) *	(9.24) *	(-8.10) *	(-22.37) *		(-18.43) *	(-1.55)	(-7.14) *	(-16.97) *
$R_{s,t-3}$	-0.097	0.056	-0.076	-0.144	$R_{f,t-3}$	-0.069	-0.004	-0.079	-0.086
	(-18.10) *	(5.26) *	(-8.63) *	(-16.55) *		(-12.80) *	(-0.38)	(-9.01) *	(-9.59) *
$R_{s,t-4}$	-0.059	0.011	-0.075	-0.074	$R_{f,t-4}$	-0.048	-0.023	-0.041	-0.061
	(-11.23) *	(1.10)	(-8.49) *	(-8.67) *		(-9.00) *	(-2.26) *	(-4.70) *	(-6.86) *
$R_{s,t-5}$	-0.054	-	-0.053	-0.066	$R_{f,t-5}$	-0.040	-	-0.039	-0.040
	(-10.92) *		(-6.37) *	(-8.34) *		(-7.52) *		(-4.57) *	(-4.69) *
$R_{f,t+5}$	0.007	-	0.005	0.009	$R_{s,t-5}$	0.025	-	0.023	0.017
	(2.12) *		(0.97)	(1.78)		(4.61) *		(2.40) *	(2.11) *
$R_{f,t+4}$	0.005	-0.019	0.001	0.012	$R_{s,t-4}$	0.017	0.062	0.032	0.008
	(1.65)	(-3.35) *	(0.26)	(2.12) *		(3.06) *	(5.05) *	(3.21) *	(0.93)
$R_{f,t+3}$	0.001	-0.015	0.006	0.002	$R_{s,t-3}$	0.046	0.081	0.032	0.054
	(0.38)	(-2.73) *	(1.24)	(0.39)		(8.40) *	(6.36) *	(3.23) *	(6.56) *
$R_{f,t+2}$	-0.015	-0.031	-0.022	-0.009	$R_{s,t-2}$	0.119	0.110	0.137	0.115
	(-4.76) *	(-5.60) *	(-4.28) *	(-1.72)		(21.39) *	(8.55) *	(13.71) *	(13.90) *
$R_{f,t+1}$	-0.024	-0.020	0.005	-0.040	$R_{s,t-1}$	0.232	0.141	0.094	0.321
	(-7.48) *	(-3.52) *	(1.06)	(-7.60) *		(41.56) *	(10.93) *	(9.33) *	(38.45) *
$R_{f,t}$	0.437	0.407	0.420	0.449	$R_{s,t}$	0.759	0.868	0.806	0.769
	(136.14) *	(73.33) *	(83.49) *	(85.45) *		(132.77) *	(66.92) *	(79.67) *	(87.49) *
$R_{f,t-1}$	0.190	0.101	0.074	0.281	$R_{s,t-1}$	-0.021	-0.186	-0.105	0.075
	(47.69) *	(14.36) *	(11.81) *	(42.44) *		(-3.00) *	(-11.68) *	(-8.52) *	(6.83) *
$R_{f,t-2}$	0.126	0.066	0.099	0.171	$R_{s,t-2}$	0.101	-0.155	0.034	0.174
	(30.74) *	(9.22) *	(15.86) *	(24.38) *		(14.42) *	(-9.72) *	(2.74) *	(15.83) *
$R_{f,t-3}$	0.075	0.042	0.057	0.108	$R_{s,t-3}$	0.090	-0.060	0.096	0.119
	(18.08) *	(5.99) *	(9.06) *	(15.20) *		(12.99) *	(-3.81) *	(7.86) *	(10.93) *
$R_{f,t-4}$	0.047	0.035	0.044	0.059	$R_{s,t-4}$	0.061	-0.022	0.066	0.079
	(11.34) *	(5.15) *	(6.93) *	(8.29) *		(8.82) *	(-1.45) *	(5.42) *	(7.36) *
$R_{f,t-5}$	0.043	-	0.039	0.048	$R_{s,t-5}$	0.050	-	0.048	0.06
	(10.69) *		(6.24) *	(6.94) *		(7.69) *		(4.14) *	(6.07) *
$\hat{z}_{s,t-1}$	-0.005	-0.003	-0.004	-0.013	$\hat{z}_{f,t-1}$	-0.006	-0.003	-0.007	-0.014
	(-8.14) *	(-3.89) *	(-4.22) *	(-8.05) *		(-8.63) *	(-3.08) *	(-6.00) *	(-7.82) *
Geweke-Meese-Dent Causality Test									
	H_0: all lead coefficients of $R_{f,t}$ are zero.					H_0: all lead coefficients of $R_{s,t}$ are zero.			
F-statistic	18.02	18.37	4.26	14.09		569.66	116.58	90.82	389.52
	(0.00) *	(0.00) *	(0.00) *	(0.00) *		(0.00) *	(0.00) *	(0.00) *	(0.00)

* indicates significance at the 5% level.
Figures in parentheses are t-statistics.

Table 8.9.1 Lead-Lag Relationships: KOSPI 200 Spot Returns and Futures Returns

	Entire period		1996		1997		1998	
	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
a	-4.64^{-6}	-0.33	-4.28^{-6}	-0.44	-1.25^{-5}	-0.55	2.80^{-6}	0.18
b_8	0.0039	1.18	0.0015	0.26	0.0012	0.24	0.0038	0.70
b_7	-0.0059	-1.82	-0.0035	-0.63	-0.0093	-1.80	-0.0048	-0.89
b_6	0.0010	0.29	-0.0128	-2.28 *	0.0029	0.57	0.0026	0.47
b_5	0.0061	1.88	-0.0123	-2.20 *	0.0035	0.67	0.0092	1.69
b_4	0.0051	1.56	-0.0198	-3.52 *	0.0008	0.15	0.0102	1.88
b_3	0.0003	0.09	-0.0184	-3.28 *	0.0059	1.14	-0.0018	-0.33
b_2	-0.0166	-5.10 *	-0.0348	-6.21 *	-0.0214	-4.15 *	-0.0120	-2.21 *
b_1	-0.0261	-8.00 *	-0.0269	-4.79 *	0.0001	0.01	-0.0413	-7.64 *
b_0	0.4367	133.94 *	0.3990	70.99 *	0.4203	81.14 *	0.4524	83.64 *
b_{-1}	0.2124	65.15 *	0.1540	27.38 *	0.1475	28.47 *	0.2607	48.21 *
b_{-2}	0.0836	25.64 *	0.1240	22.15 *	0.0961	18.55 *	0.0727	13.44 *
b_{-3}	0.0124	3.79 *	0.0951	16.95 *	0.0321	6.21 *	-0.0076	-1.41
b_{-4}	-0.0074	-2.27 *	0.0720	12.83 *	-0.0003	-0.06	-0.0214	-3.96 *
b_{-5}	-0.0026	-0.81	0.0541	9.64 *	-0.0048	-0.92	-0.0068	-1.26
b_{-6}	-0.0063	-1.92	0.0325	5.80 *	-0.0118	-2.29 *	-0.0073	-1.35
b_{-7}	0.0070	2.13 *	0.0216	3.86 *	-0.0025	-0.48	0.0123	2.28 *
b_{-8}	0.0049	1.49	0.0063	1.12	-0.0001	-0.02	0.0094	1.74

H_0: all lead coefficients are zero				
F- statistic	13.14*	14.76*	2.76*	9.10*
(*p*-value)	(0.000)	(0.000)	(0.005)	(0.000)
H_0: all lag coefficients are zero				
F- statistic	638.05*	282.26*	162.91*	322.43*
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

* indicates significance at the 5% level.

Results are reported for the lead-lag regressions with the use of intraday five-minute KOSPI 200 spot returns as the dependent variable, and lead, contemporaneous, and lag five-minute KOSPI 200 futures returns as the independent variables.

Table 8.9.2 Lead-Lag Relationships: KOSPI 200 Spot Returns Innovations and Futures Returns Innovations

	Entire period		1996		1997		1998	
	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
a	4.10^{-7}	0.03	1.65^{-7}	0.02	-9.40^{-8}	-0.01	1.04^{-6}	0.04
b_8	0.0012	0.37	0.0025	0.45	-0.0041	-0.82	0.0031	0.56
b_7	-0.0085	-2.59 *	-0.0053	-0.95	-0.0135	-2.65 *	-0.0061	-1.16
b_6	-0.0003	-0.10	-0.0105	-1.87	0.0012	0.24	0.0019	0.35
b_5	0.0020	0.62	-0.0077	-1.37	-0.0017	-0.33	0.0047	0.87
b_4	-0.0009	-0.29	-0.0163	-2.90 *	-0.0075	-1.47	0.0048	0.88
b_3	-0.0016	-0.48	-0.0172	-3.07 *	0.0041	0.80	-0.0046	-0.84
b_2	-0.0156	-4.78 *	-0.0260	-4.62 *	-0.0197	-3.88 *	-0.0117	-2.13 *
b_1	-0.0185	-5.66 *	-0.0109	-1.93	0.0060	1.17	-0.0336	-6.16 *
b_0	0.4330	132.85 *	0.4020	71.41 *	0.4156	81.63 *	0.4475	82.03 *
b_{-1}	0.1435	44.02 *	0.0546	9.71 *	0.0697	13.69 *	0.2008	36.79 *
b_{-2}	0.0305	9.35 *	0.0664	11.81 *	0.0494	9.69 *	0.0148	2.71 *
b_{-3}	-0.0196	-6.00 *	0.0482	8.58 *	-0.0043	-0.85	-0.0333	-6.10 *
b_{-4}	-0.0172	-5.28 *	0.0337	6.00 *	-0.0134	-2.63 *	-0.0257	-4.71 *
b_{-5}	-0.0058	-1.77	0.0235	4.19 *	-0.0098	-1.92	-0.0052	-0.96
b_{-6}	-0.0089	-2.73 *	0.0094	1.67	-0.0128	-2.52 *	-0.0093	-1.70
b_{-7}	0.0061	1.86	0.0067	1.20	-0.0006	-0.12	0.0111	2.03 *
b_{-8}	0.0015	0.45	-0.0014	-0.25	0.0011	0.21	0.0034	0.63

	Entire period	1996	1997	1998
H_0: all lead coefficients are zero				
F-statistic	7.75*	6.13*	3.26*	5.89*
(*p*-value)	(0.000)	(0.000)	(0.001)	(0.000)
H_0: all lag coefficients are zero				
F-statistic	269.85*	45.53*	38.97*	184.23*
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

* indicates significance at the 5% level.

Results are reported for the lead-lag regressions with the use of intraday five-minute KOSPI 200 spot returns innovations as the dependent variable, and lead, contemporaneous, and lag five-minute KOSPI 200 futures returns innovations as the independent variables. The spot return innovations and futures return innovations series are based on the residual from an AR(1) model fit to the spot returns and futures returns series each day, respectively.

9 Conclusion

In this thesis, I have investigated the Korean stock market, which is representative of typical, fast-growing emerging markets. Although other emerging markets in the Pacific Basin have analysed in some of the chapters, the main focus was on the empirical analysis of the dynamics of stock market prices and stock returns in Korea in the short- and long-runs. The last four decades are covered but the principal analysis focuses on the 1980s and 1990s because both the quantitative and qualitative growth of the stock market has been dramatic and accelerated in these periods. The impact of the Asian financial market crisis in 1997 was also examined. For this purpose, the discussion began with the definition of the term 'emerging stock market' and outline the nature and recent performance of emerging stock markets in the Pacific Basin: Indonesia, Malaysia, Thailand, the Philippines, Taiwan and Korea. The development of the Korean stock market, and how the stock market has changed since its internationalisation and opening-up to foreign investors in the last two decades were discussed in Chapter 3. Then the behaviour of stock market returns and their conditional volatility was analysed using daily data in Chapter 4. The relationship between macroeconomic variables and the variance of stock returns was analysed in Chapter 5, and the informational efficiency under a changing price limits system was investigated in Chapter 6. The long-run behaviour of total returns of six emerging and five developed stock markets in the Pacific Basin was examined in

Chapter 7. Finally the relationship between stock index futures and spot markets are analysed in Chapter 8. First the main findings of each chapter are summarised and then more general results of the research are identified.

Chapter 2 briefly reviewed emerging stock markets in the Pacific Basin. As the emerging markets have grown rapidly, on average, a great deal of attention has been turned to them by investors and academia alike. Nevertheless, little is known about what an emerging market means. In this context, the various definitions of what constitutes an emerging stock market and a brief review of the nature and recent performance of emerging markets focusing on those in the Pacific Basin have presented. The definition of emerging markets varied considerably across the literature surveyed. However, six emerging stock markets, Korea, Taiwan, Malaysia, Indonesia, the Philippines and Thailand seemed to meet the various classifications without much of argument. The speed of quantitative growth of the emerging markets in the Pacific Basin has been slow due to the Asian financial market crisis, but their qualitative developments through liberalisation, deregulation and changes in investment environment are expected to be accelerated.

In Chapter 3, the development of the Korean stock market and its particular characteristics were examined in order to provide some background understanding of (i) changes in the trading system; (ii) relevant regulation system; and (iii) the liberalisation programme in a historical context; and (iv) particular features, for instance, Stock Market Stabilisation Fund, price limits system and introduction of derivative securities trading. Up until the late 1970s, the stock market played a minor role in the economy and closed to foreign investors throughout most of its development. Although internationalisation of the market began in the early 1980s, portfolio investment by foreign investors was allowed only through special funds which bought Korean securities and whose shares traded abroad. The qualitative development of the stock market started in the 1990s when stock market liberalisation (which allowed foreign investors' direct investment on the stock market) accelerated and derivative securities trading and a cyber stock trading system were introduced. The sudden outset of the Korean financial market crisis in the last quarter of 1997, led meltdown of the Korean stock market—but it recovered rapidly due to positive developments in the economy and liberalised investment status.

In Chapter 4, the behaviour of Korean stock market volatility for the period from 1975 to 1997 was investigated using a set of models belonging to the class of autoregressive conditional heteroscedasticity (ARCH). The descriptive statistics confirm that the daily stock market returns are skewed to the left and leptokurtic. Consequently, the ARCH class models were used to capture successfully these aspects of the abnormal distribution of the data. One of the interesting findings was that there was no structure change in volatility even after the stock market opening, i.e. liberalisation in 1992. Overall, the class of GARCH models is found to be a better fit than the class of ARCH, EGARCH and TARCH models. Among the GARCH class models GARCH(1,1)-AR(1) and the GARCH(1,1)-MA(1) seemed to be the best fit models. When the tests in order to distinguish forecasting ability among the estimated models it appears that GARCH(1,1)-MA(1) is the most accurate forecasting model among the six different GARCH class models for the historical forecast for 1975-1997. However, since there exist negligibly small differences between these two models we also estimate forecasts for three subsample periods: pre-opening, the post-opening, and the post-sample. The results confirm that the GARCH(1,1)-AR(1) and GARCH(1,1)-MA(1) are the best forecasting model for the post-opening and the post-sampling period, respectively.

In Chapter 5, the nexus between Korean stock market returns and macroeconomic variables was investigated for the period from January 1987 to June 1997. The findings using innovation accounting analysis are interesting. The results show that a substantial proportion of the variance of stock returns was attributable to its own innovations in the pre- and post-opening periods. The evidence suggests that changes in the exports/imports ratio was an important determinant of the variance of stock returns in both the pre-and post-opening periods. In the pre-opening period, changes in money growth together with the exports/imports ratio jointly accounted for over one third of the variance of stock returns, and a considerable proportion of the variance of stock returns are also attributed to changes in the Korean won-US dollar exchange rate and interest rate. In the post-opening period, however. the results show that changes in the interest rate and the exports/imports ratio have relatively more significant influence on stock return variability than those due to money growth and exchange rate fluctuations. Therefore, the findings suggested that changes in the balance of trade was one of the important determinants in forecasting the variance of stock returns in the Korean export-oriented economy.

Chapter 6 investigated the long-term equilibrium among eleven emerging and developed stock markets in the Pacific Basin over the period starting in March 1988 and ending in April 2000, a period spanning the Asian financial market crises. Unlike existing studies on the long-term relationship among stock markets total returns indices, which included dividends paid and reinvested, are used. The unit root tests allow for a possible crash and find that four of our series, those for Australia, Hong Kong, Indonesia and Malaysia were trend stationary and so random shocks only had a temporary effect on these returns. Based on a common currency, the US$, there is no cointegration between world returns and each of the remaining I(1) series. Further test results of pairwise cointegration between all I(1) country returns indices find no cointegration except some evidence of cointegration involving Japan and Korea. The results are not affected by the Asian financial market crisis. Overall, the findings on pair-wise cointegration tests suggest that stock markets in the Pacific Basin are not pair-wise cointegrated even after the Southeast Asian financial market crisis. Therefore, international diversification of investment portfolios by investors from one of the countries to another single country could be justified and beneficial because gaining abnormal profits in these markets by diversifying investment portfolios was possible and country-specific risk could be reduced. However, the results of mutivariate cointegration tests exhibit that there in one cointegrating vector in the pre-crash period whereas two cointegrating vectors are exhibited when the Asian crisis is included. Therefore, stock markets in this region are collectively linked in the long-run.

In Chapter 7, the multiple variance ratio tests were implemented to examine the random walk hypothesis for the Korean stock market under five regimes of daily price limits from March 1988 to December 1998. Using a sample of 55 actively traded stocks selected to cover a wide range of sectors, the hypothesis is tested under each price limit regime. The results showed several striking findings. First, the results generally supported the idea that price limits do impact on volatility. The results showed that stock price volatility increased when the price limits were widened its bands from ±6% to ±8% and further to ±12%. This suggested that tighter price limits can reduce volatility, although a less volatile market is not necessarily desirable. Second, in general, approximately 10% of returns for the entire sample period in our data had been affected by the price limits. This implies that neglecting the presence of price limits could result in misleading empirical evidence because price limits can be price limits can be a crucial factor affecting stock price movement. It can be quite problematic because the time paths of stock prices under price limits might not coincide with the time paths which would prevail in the absence of price limits. Thus equity prices are prevented from efficiently reaching equilibrium levels. Finally, excluding the unusual period of the Korean financial market crisis, as price limits were relaxed, the proportion of stock prices in the sample which follow a random walk increased. That is, the stock market as a whole approaches a random walk. Overall, the evidence indicates that price limits can prevent stock price evolving from a random walk process and hence the stock market is inefficient. Although price limits in Korean Stock Exchange have been modified several times as the bands have widened, they have played a role in hindering the Korean stock market from becoming informationally efficient. Consequently, whatever the pros and cons of price limits, one should not ignore the fact that the behaviour of stock prices is not likely to be efficient as long as price limits remain the norm.

In Chapter 8, the impact on the spot market of trading in stock index futures in Korea in May 1996 was investigated and several important results were found. First, the results show there has been an increase in volatility and a slight increase in the persistence of volatility following the introduction of stock index futures. Although the volatility increase might be due to destabilising effects of futures trading associated with speculation, stock index futures add a new dimension to the market by providing a new instrument to facilitate hedging. Secondly, the evidence indicated that futures trading did not result in increased jump volatility, abnormally large increases or decreases in stock prices. Thirdly, there was a long-run equilibrium relationship between the KOSPI 200 spot and futures prices with bidirectional causality between spot and futures markets. This differs from most of the literature on developed markets which finds unidirectional causality from futures to spot markets. Fourthly, returns in these two markets were largely contemporaneous but there is evidence that the futures market leads the stock market. This suggested that news disseminates first in the futures market and then in the spot market. In summary, the impact of futures trading has been beneficial for the stock market; it accelerates the speed at which information is impounded into spot market prices.

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