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AN ECONOMETRIC ANALYSIS OF THAI STOCK MARKET IN THE CONTEXT OF GLOBAL STOCK MARKET INTEGRATION

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by

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CERTIFICATION

I, Surachai Chancharat, declare that this thesis, submitted in fulfillment of the requirements for the award of Doctor of Philosophy, in the School of Economics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Surachai Chancharat

25 March 2008

To my dear parents, my wife and my son

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroscedasticity
APT	Arbitrage Pricing Theory
ASEAN	Association of Southeast Asian Nations
CAPM	Capital Asset Pricing Model
CPI	Consumer Price Index
DF-GLS	Dickey-Fuller Generalize Least Squares
ECM	Error Correction Model
EMH	Efficient Market Hypothesis
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GARCH-M	GARCH-in-mean
GH	Gregory and Hansen
IFS	International Financial Statistics
KMO	Kaiser-Meyer-Olkin
LM	Lagrange Multiplier
LP	Lumsdaine and Papell
ML	Maximum Likelihood
MSCI	Morgan Stanley Capital International
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares

PC	Principle Component
PP	Phillips-Perron
SEC	Securities and Exchange Commission
SIC	Schwartz Information Criterion
SET	Stock Exchange of Thailand
VAR	Vector Autoregressive
ZA	Zivot and Andrews

ABSTRACT

This thesis provides an econometric analysis of the Thai stock market in the context of global stock market integration. Chapter 3 examines whether stock prices for 16 countries are trend stationary or follow a random walk process using the Zivot and Andrews (1992) and Lumsdaine and Papell (1997) tests and monthly data spanning December 1987 to April 2007. With one and two structural breaks, the Zivot and Andrews and Lumsdaine and Papell test results provide evidence in favor of the random walk hypothesis in 12 and 11 countries, respectively, out of 16 countries. Thus, based on the empirical results in this chapter, the stock market price indices in the majority of countries analyzed exhibit a random walk. In addition, the key structural break in most of the cases points to the Asian crisis over the period 1996-1998.

Chapter 4 investigates the existence of cointegration and causality between the stock market price indices of Thailand and its major trading partners (Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States), using monthly data spanning December 1987 to December 2005. Both the Engle-Granger two-step procedure (assuming no structural breaks) and the Gregory and Hansen (1996) test (allowing for one structural break) provide no evidence of a long-run relationship between the stock prices of Thailand and these countries. Based on the empirical results obtained from these two residual-based cointegration tests, potential long-run benefits exist from

diversifying the investment portfolios internationally to reduce the associated systematic risks across countries. However, in the short run, three unidirectional Granger causalities run from the stock returns of Hong Kong, the Philippines and the United Kingdom to those of Thailand, pair-wise. Furthermore, there are two unidirectional causalities running from the stock returns of Thailand to those of Indonesia and the United States. The results also found empirical evidence of bidirectional Granger causality, suggesting that the stock returns of Thailand and three of its neighboring countries (Malaysia, Singapore and Taiwan) are interrelated.

Chapter 5 explores the relationships between stock market returns of 13 countries based upon monthly data (December 1987 to April 2007). Specifically, the principal component and maximum likelihood methods are used to examine any discernable patterns of stock market co-movements. Factor analysis provides evidence that stock returns in a number of Asian countries are highly correlated and, based on the resulting robust factor loadings, they form the first well-defined common factor. The results also find consistent results (based on both the principal component and maximum likelihood methods) suggesting that the stock returns of all global developed economy stock markets are also highly correlated, and constitute the second factor. That means, *inter alia*, geographical proximity and the level of economic development do matter when it comes to co-movements of stock returns and this has important implications for financial portfolio diversification if the aim is to reduce systematic risks across countries.

Chapter 6 analyzes how 15 international stock markets and five key Thai macroeconomic variables influenced monthly stock market returns in Thailand in the pre- and post-1997 Asian crisis eras. The results indicate that the Singapore stock market influenced the Thai stock market significantly in both the pre- and post-1997 periods. Before 1997 the Indonesian and Malaysian stock markets were significantly related to the Thai stock market, whereas after the crisis Korea and the Philippines played a dominant role in explaining sources of variation in the monthly returns in the Thai stock market. Therefore, to a large extent, one may conclude that the Thai stock market is very much influenced by the performance of its neighboring countries' stock markets, but non regional markets exerted an insignificant effect. This goes some way to explaining why the financial crisis of 1997 remained a primarily regional crisis.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF THE ISSUE

International capital flows have gradually increased over the past three decades. The extraordinary increase in capital flows starting in 1990 was truly phenomenal in Asia. For example, international portfolio investments have steadily flown into all emerging countries rose from 30 billion U.S. dollars in the 1970s to about 180 billion U.S. dollars in the 1990s. While most developed countries opened their financial markets in the early 1970s, many emerging countries liberalized their markets in the late 1980s and early 1990s (Kaminsky and Schmukler, 2002). This liberalization process allowed investors to extend their investment opportunity set to include multiple financial markets.

The increased capital flows between economies is likely to intensify the interdependence of economies and, therefore, the heightened possibility of contagion. This was clearly illustrated by the Asian financial crisis which first began with the floating of the Thai baht in July 1997. It thereafter spread rapidly to the Philippines, Malaysia, Indonesia and Korea. Following this crisis, relatively small depreciations also engulfed Singapore and Japan. A noteworthy aspect of the crisis is how rapidly it spread from one country to another in the region, the so-called contagion effect, and further to Russia and some South American countries.

There is a growing interest in the international transmission of stock market shocks among economies since the 1997 Asian financial crisis. A number of studies have shown that global stock markets have become increasingly integrated and co-movements among stock markets have been on the rise through time. The main reasons are financial deregulation in emerging stock markets and new technology developments that facilitate the information transfer across global stock markets.

Stock market integration studies were originally motivated by the intention to examine the diversification benefits gained by investing across global stock markets. Some recent studies, such as Richards (1995), Kanas (1998a), Chang (2001), Ng (2002) and Phylaktis and Ravazzolo (2005a), found no evidence of stock market integration, on the other hand others (Kasa, 1992; Choudhry, 1996a; Chaudhuri, 1997; Syriopoulos, 2004) have indicated an increased degree of stock market integration over time. Therefore, the empirical findings are mixed. In addition, earlier market integration studies were based on various versions of asset pricing models while more recent studies have tended to rely on econometric techniques. Thus, this thesis focuses on stock market integration in the region as well as globally by using econometric techniques. More details on the stock market integration literature are discussed in the next chapter.

This thesis intends to empirically investigate stock market integration of Thailand and international countries, namely Argentina, Australia, Brazil, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Russia, Singapore, Taiwan, the United Kingdom and the United States. The results of the present study indicate whether investors can enjoy international portfolio diversification benefits when allocating their funds across these stock markets. If stock markets are linked together, meaning that they have a tendency to move in the same direction, then these stock markets are integrated. Thus, this research examines stock market integration from a primarily statistical perspective.

This thesis has made three significant contributions to the analysis of integration between stock markets of Thailand and international countries. First, this is the first study to address the issue of structural breaks when testing for the unit root hypothesis in the Thai stock market. After conducting an exhaustive review of the literature, no study has addressed this issue. Second, this study employed a larger sample of stock markets than that of previous studies and the period of the study has been conducted over a longer period than previous studies. Finally, no previous study has examined the possibility that the long-run relationship between the stock markets have been subject to a structural break.

1.2 DATA AND METHODOLOGY

The data included in this study incorporates the stock prices of 16 countries: Argentina, Australia, Brazil, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Russia, Singapore, Taiwan, Thailand, the United Kingdom and the United States. Throughout this thesis, the terms ‘countries’ and ‘international stock markets’ have been variously used while recognizing the political relationships that exist among China, Hong Kong and Taiwan. Monthly data covering the period December 1987 to April 2007 with a base value of 100 in December 1987 is used, except for the stock price index of Russia which includes the period December 1994 to April 2007 with a base value of 100 in December 1994. This different base year has been modified accordingly.

All stock price indices were obtained from Morgan Stanley Capital International (MSCI), available at http://www.msci.com/equity/index2.html, which is one of the most widely used sources of financial data in the literature (Kasa, 1992; Richards, 1995; Meric and Meric, 1997; Hamori and Imamura, 2000; Ahlgren and Antell, 2002; Ng, 2002; Climent and Meneu, 2003; Worthington, Katsuura and Higgs, 2003) in terms of the degree of comparability and avoidance of dual listings. The MSCI indices have the following features: first, they cover 60 percent of market capitalization of these markets; second, they have the same component ratio of industrial sectors as each market; third, they exclude nonresident companies and investment funds; fourth, in consideration of liquidity, the component ratio of large-, medium- and small-size stocks is also equivalent to the actual situation in each market. Since this study is concerned with the comparative performance of international stock markets, all price indices (P) are denominated in U.S. dollars. The MSCI indices for different markets are computed using the same consistent formula which is value weighted. The monthly rate of returns

$\ln(P_t / P_{t-1})$ calculated from the MSCI price indices consists of both capital and income gains.

Cointegration tests, factor analysis and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models are utilized to test stock market integration. However, the preliminary requirement for cointegration is that all variables under study must be integrated in the same order. In order to obtain robust results, the study employs the Augmented Dickey-Fuller (ADF) test, Dickey-Fuller Generalize Least Squares (DF-GLS) test, Zivot and Andrews (1992) test and Lumsdaine and Papell (1997) test to determine the order of integration in the level and return of the stock prices.

1.3 STRUCTURE OF THE THESIS

This study is separated into seven chapters. An introduction is given in Chapter 1 followed by Chapter 2, which summarizes the relevant but selective review of the literature on stock market integration and Asian financial crisis.

Chapter 3 investigates the random walk hypothesis in stock prices of 16 countries for which consistent and comparable time series data could be obtained. First, conventional unit root tests, which do not consider any structural breaks in the data, including the ADF test and the DF-GLS test, are used. Then more relevant unit root tests, which allow one structural break, Zivot and Andrews test, and two structural breaks, Lumsdaine and Papell test, are employed to examine the significance of structural breaks. These two tests also empirically determine the most significant structural breaks in the data.

Chapter 4 examines the long-run and short-run relationships between the Thai stock market and those of its major trading partners: Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States. Both the Engle-Granger two-step procedure and Gregory and Hansen (1996) test are conducted in order to obtain long-run relationships between stock markets. The Granger causality test is employed to examine short-run relationships between stock markets.

Chapter 5 investigates the relationship between stock market returns of 13 countries, namely Australia, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, the United Kingdom and the United States, using factor analysis to investigate the systematic covariation of stock market returns. The results shed light on the scope for risk diversification and increased returns through international diversification of stocks across both developed and developing countries.

Chapter 6 explores specifically the impact of international linkages and macroeconomic variables on the Thai stock market using GARCH models. The main reason to use GARCH pertains to the fact that the variance of forecast errors depends on the size of the preceding disturbances. A generalized form of the conditional heteroscedasticity allows for lagged variances and further lagged values of the error term. Consequently, it is naturally expected that the GARCH model is an efficient way to deal with volatility clustering observed in residuals which usually occur in stock price data.

Chapter 7 provides a summary of major findings of this thesis and discusses key policy implications. Finally, suggestions for future work are provided at the end of the chapter.

CHAPTER 2

STOCK MARKET INTEGRATION--AN OVERVIEW

2.1 INTRODUCTION

The main purpose of this chapter is to review the general literature on stock market integration. As mentioned in the first chapter, a growing interest in the integration of international stock markets is evident in the number of empirical studies that examine various aspects of stock market integration. This research area has drawn great attention because the degree of stock market integration has important implications for investor diversification strategy and market efficiency. If stock markets are integrated, then diversification benefits might be limited according to modern portfolio theory. In addition, stock market integration may contradict the weak form of market efficiency if movements in one stock market can be used to predict changes of another stock market.

The chapter is divided into six sections. Section 2.2 presents early work on stock market integration. Section 2.3 provides a more extensive review of empirical work relating to stock market integration using various econometric techniques. Section 2.4 sheds some light on the Asian financial crisis and stock market integration. Section 2.5 identifies a statement of the problem which this thesis will focus upon. Finally, Section 2.6 provides conclusions.

2.2 STOCK MARKET INTEGRATION BASED ON THE ASSET PRICING MODELS

Early work on stock market integration was based on the asset pricing models with different treatment of international investment barriers such as taxes, transaction costs and ownership restrictions. Most theoretical models generalized the domestic version of the asset pricing model with reference to the international framework, taking into account international investment barriers.

Extending Markowitz's (1952) portfolio selection theory, the Capital Asset Pricing Model (CAPM), developed by Sharpe (1964) and Lintner (1965), is the classic basis for early theoretical work on stock market integration. The CAPM suggests a linear and positive relationship between a security's expected return and its systematic risk. In addition, it is assumed in the CAPM that capital markets are highly efficient, investors are well informed, transaction costs are zero, there are insignificant restrictions on investment, there are no taxes and no investor is large enough to affect the market price of stocks.

Ross (1976) developed the Arbitrage Pricing Theory (APT) which is an equilibrium model like the CAPM, and is used to examine how stock prices are determined. The APT is based on the idea that in competitive financial markets, arbitrage will ensure that risk-less assets provide the same expected return. Unlike the CAPM, which requires market equilibrium and restrictions on the stock return distribution and investor's utility functions, the APT reveals that individuals eliminating arbitrage profits across factors drive the stock market equilibrium process. The model does not identify factors that could be economically or behaviorally relevant in determining stock returns.

Stehle (1977) was the first to test market integration using the asset pricing models. The test was based on both the domestic asset pricing model and the international asset pricing model. Stehle finds that risk, which could only be diversified away through international diversification, should be priced if international markets are integrated. Moreover, the results obtained indicated that international risk factors are not significant and thus showed that international markets are segmented.

Jorion and Schwartz (1986) investigated the relationship between Canadian stock market and the global North American market, by using the consumption-based asset pricing model. The results obtained suggested that the international CAPM is not a good description of the pricing of Canadian stocks. In addition, the empirical evidence rejected the joint hypothesis of the specification of the asset pricing model employed and the hypothesis of market integration between the Canadian stock market and the global North American market.

Wheatley (1988) provides tests of international stock market integration using a simple version of the consumption-based asset pricing model. The main objective of this study was to predict if there is an asset pricing line for each country, that related a representative individual's expected real return on each asset to the covariance of this return with growth in the individual's real consumption. Monthly data were collected during the period between January

1960 and December 1985. The results provided evidence in favor of supporting market integration between the United States and 17 international stock markets, Australia, Austria, Belgium, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Singapore, Spain, Sweden, Switzerland and the United Kingdom.

In a more recent study, Bekaert and Harvey (1995) extend the conditional regime-switching model, which is essentially a combination of the asset pricing model for completely segmented international stock markets. The results indicate that a number of emerging stock markets displayed time-varying integration. Some stock markets, such as Chile, Greece, India, Mexico, Nigeria, Taiwan, Thailand and Zimbabwe, appeared more integrated than one might expect based on previous knowledge of investment restrictions. Other stock markets, namely Colombia, Jordan, Korea and Malaysia, appeared segmented even though foreigners have relatively free access to their markets.

In summary, early theoretical work on stock market integration approached this issue by incorporating international investment barriers, such as taxes, transaction costs and ownership restrictions, into the asset pricing models. More recently, development of the conditional regime-switching model allows probabilistic transactions between domestic and international asset pricing models such that changes in the degree of stock market integration can be observed over time. The empirical results are mixed, however, differing by the stock markets examined, the time period covered and the models employed in the study.

2.3 EMPIRICAL WORK ON STOCK MARKET INTEGRATION BASED ON ECONOMETRIC TECHNIQUES

While most of the previous studies of stock market integration are based on certain asset pricing models, since the 1990s a number of studies have utilized different econometric techniques to examine stock market integration issues. Econometric techniques such as Granger causality analysis, cointegration test, factor analysis and the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models have been widely employed in empirical studies of stock market integration.

2.3.1 Granger Causality and Cointegration Test

Kasa (1992) examined the co-movement of five stock markets, the United States, Japan, the United Kingdom, Germany and Canada using monthly and quarterly data from January 1974 to August 1990. Morgan Stanley Capital International (MSCI) indices are employed to compute the multivariate cointegration test. The results reveal that there are four cointegrating vectors and one common stochastic trend among the stock markets. Kasa found that further estimation of the factor loadings from this trend is most important in the Japanese stock market and least important in the Canadian stock market. The major conclusion from this study is that the gains from international diversification might have been overstated because of the existence of a common stochastic trend within these stock markets.

On the other hand, Richards (1995) used a sample of 16 developed stock market indices to investigate their long-run relationships. Quarterly data for Australia, Austria, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States covering the period December 1969 to December 1994 from MSCI was employed. The Johansen and Engle-Granger methodologies are utilized to test for the existence of cointegration between the stock markets. The cointegration tests indicate that stock markets are not cointegrated around the common component.

In a similar approach to Kasa (1992), Choudhry (1996a) employed the Johansen methodology of multivariate cointegration to examine the long-run relationships between the stock markets of six European countries which are Spain, France, Italy, Sweden, Czechoslovakia and Poland. The cointegration tests show a long-run relationship between these stock markets during the longest period (1925-1936) and also during the pre-October 1929 stock market crash period (1925-1929). However, the results fail to indicate a long-run relationship during the post-crash period (1929-1936). The extensive international financial integration and cooperation that took place between European countries after the First World War up until 1929 might be the reason behind the long-run relationship between these stock markets.

Chan, Gup and Pan (1997) test and examine the long-run relationships among 18 stock market indices, including developed and emerging stock markets. They use monthly stock market indices in these markets and the sample period covered was from January 1961 to December 1992. Johansen's cointegration tests indicate that only a small number of stock markets show evidence of long-run co-movement with others. However, the number of significant cointegrating vectors increased before the October 1987 stock market crash. The results also imply that international diversification among stock markets might be effective, because the stock markets do not have long-run relationships.

Chaudhuri (1997) investigated the long-run relationships among stock market indices in six Latin American emerging markets, Argentina, Brazil, Chile, Colombia, Mexico and Venezuela. Monthly stock market indices were collected from January 1985 to December 1993. The bivariate cointegration tests found evidence of a long-run relationship among all of these countries. Granger causality indicated the presence of bidirectional rather than unidirectional causality, and suggested the absence of weak exogeneity among stock prices.

Kanas (1998a) employed the multivariate approach to test for pairwise cointegration between the United States and each of the six largest European stock markets namely the United Kingdom, Germany, France, Switzerland, Italy, and the Netherlands. The results are robust and consistent in suggesting that the United States stock market is not pairwise cointegrated with any of the major European stock markets. This finding implies that there exist potential long-run benefits in risk reduction from diversifying in the United States and any of the major European stock markets. That is in sharp similarity to Ahlgren and Antell’s (2002) study who found no evidence of long-run relationship among the United States and the European stock markets.

Masih and Masih (1999) examined the long- and short-run relationships among international and Asian emerging stock markets. Using multivariate cointegration analysis and causality test, the results confirmed the leading role of the United States, and the existence of a significant long- and short-run relationship between the established OECD and emerging Asian stock markets. At the regional level, the results indicated the leadership of Hong Kong. Consistent with the contagion effect hypothesis, their results supported the view that stock market fluctuations in all these Asian stock markets were generally linked to other regional stock markets.

Syriopoulos (2004) investigated the long-run relationship among stock market indices of major emerging Central European countries, namely Poland, Czech Republic, Hungary and Slovakia and developed stock markets, specifically Germany and the United States. The multivariate cointegration test results found a stationary long-run relationship among these countries, and the individual Central European stock markets were likely to display stronger linkages with their mature international counterparts rather than their neighbors.

A recent study by Phylaktis and Ravazzolo (2005a) examined the linkages between Pacific-Basin markets. Their results were robust and consistent in that no evidence was found to indicate a long-run relationship among the stock markets under study. The results were also consistent with those obtained in previous studies such as Chang (2001) and Ng (2002). These findings indicate that international investors have opportunities for portfolio diversification by investing in most Asian stock markets.

2.3.2 Factor Analysis

Hui and Kwan (1994) examined the systematic covariation in stock market indices among the United States and Asia Pacific countries during the 1980s. Using factor analysis, the results indicated that the first factor had relatively high positive weights for Australia, Hong Kong and Singapore, while the second factor was dominated by Taiwan alone. The third factor belonged to Korea and Japan, and the fourth factor had a relatively large weight on the United States alone. They also suggested that if investors were to select stock markets for risk diversification, then Japan, Taiwan and the United States would certainly be more appropriate.

Naughton (1996) analyzed the relationship between Asian and developed stock markets. The results indicated low correlation between Asian emerging markets and between these markets and developed markets. Factor analysis confirmed a developed market grouping which included Australia, Hong Kong and the United States, but excluded Japan. Korea and Japan formed a separate group. The Philippines and Taiwan were both separated to different factors. This means, according to this study, a good range of diversification potential appeared to exist in Asian emerging markets.

Meric and Meric (1997) studied the co-movements among the 12 largest European stock markets. Monthly data covering the period February 1975 to February 1994 from MSCI was employed. The principle component analysis test results indicated that the co-movement of those stock markets changed significantly after the 1987 stock market crash. Their findings showed that the correlations among the 12 largest European stock markets were low but increased significantly after the crash. Thus, the benefit of international portfolio diversification with stock markets decreased considerably.

More recently, Illueca and Lafuente (2002) employed a sample of 15 international stock market indices to investigate any possible linkages. Factor analysis was utilized to test the factor structure of stock markets. The empirical results revealed four factors that could be identified with four geographic areas: Europe, Asia, North and South America. They also suggested that such a portfolio diversification strategy needed to consider a number of assets that were negotiated in most stocks around the world.

2.3.3 GARCH Model

Hamao, Masulis and Ng (1990) investigated the extent of financial integration and international efficiency across stock markets of the United States, the United Kingdom and Japan using a GARCH-M model. Daily opening and closing data covering the period between 1 April 1985 and 31 March 1988 were used. They examined the effect that global news generated overnight had on opening price, and additional transmission of risk between the markets. The results indicated statistically significant spillovers in close-to-open returns and variances in all three markets. This suggested non-instantaneous adjustments to news, however they attributed these findings to overlapping trading between the stock markets.

Using a similar approach to Hamao, Masulis and Ng (1990), Lin, Engle and Ito (1994) examined volatility spillovers between the stock markets of the United States and Japan. Their daily data covered the period from 1 October 1985 to 29 December 1989. The empirical results found bidirectional spillovers between daytime returns in one market and overnight returns in the other. The findings suggested that these two stock markets were integrated with the global news relevant for both market being generated both in the United States and Japan. The results were consistent with the findings of other studies such as Bae and Karolyi (1994), who found that the degree and persistence of shocks originating in the stock markets of the United States or Japan that spread to other markets were extensively understated.

In contrast to previous studies, Susmel and Engle (1994) studied the stock markets of the United States and the United Kingdom. Daily data was collected for the period 2 January 1987 to 29 February 1989. Using several GARCH models to examine volatility spillovers between both stock markets under study, the results found that there was no significant evidence of volatility spillovers between these stock markets. In addition, the inclusion of the October 1987 crash period did not support the existence of spillovers between the stock markets.

Choudhry (1996b) investigated the volatility, time-varying risk premium and persistence of volatility in six emerging stock markets, namely Argentina, Greece, India, Mexico, Thailand and Zimbabwe. A GARCH-M model was utilized using monthly data spanning from January 1976 to August 1994. The empirical results revealed evidence of changes in the ARCH parameters, the risk premium and volatility persistent in these stock markets. However, these changes were not consistent and they fluctuated between individual markets.

Kanas (1998b) provided an empirical investigation of volatility spillovers across the three largest European stock markets. The investigation was conducted using the multivariate exponential GARCH model applied to daily stock returns from the United Kingdom, France and Germany from 1 January 1984 to 7 December 1993. Kanas found evidence of volatility spillovers between these stock markets. The results showed that spillovers were asymmetric in the sense that bad news in one market had a larger effect on the volatility of another market in comparison to that of good news.

Christofi and Pericli (1999) turned their attention to examine short-run dynamics in returns and volatility between five major Latin American stock markets using an exponential GARCH model. Daily indices in these markets were collected during the period between 25 May 1992 and 16 May 1997. They provided evidence of first and second moment interactions among the stock markets examined. In addition, the results indicated that volatility spillovers were more common in these stock markets than other regional stock markets.

Fratzscher (2002) investigated the integration process among European stock markets using a trivariate GARCH model and daily data covering the period from 2 January 1986 to 2 March 2000. The empirical results revealed that the European stock markets had increased in importance in the world financial markets since the mid-1990s, while the degree of integration has been highly volatile over the years.

Following this line of research, Kim and In (2002) analyzed the impact of major stock market developments and macroeconomic news announcements for Australian investors. Daily data collected during the period 1 July 1991 and 18 December 2000 and they employed a bivariate GARCH model to examine dynamic integration between Australian stock markets and other major global stock markets. Their results indicated that the movements of these three major stock markets, and some macroeconomic news, had significant effects on the Australian stock markets.

2.4 THE ASIAN FINANCIAL CRISIS AND STOCK MARKET INTEGRATION

The 1997 Asian financial crisis is considered to be the first emerging stock market crisis with a global impact. It first began with the floating of the Thai baht in July 1997. The crisis spread rapidly to the Philippines and Malaysia. In August, Indonesia's currency, the rupiah, depreciated by more than other Asian currencies. Relatively small depreciations occurred in Singapore in August and

Taiwan in October. Korea devalued the won significantly on November. Japan also had a moderate devaluation between July 1997 and January 1998 (Barro, 2001). The global impact of the 1997 Asian financial crisis has been investigated by a number of studies discussed below.

Tuluca and Zwick (2001), using a sample of 13 stock market indices, including Asian and non-Asian markets, investigated the effects of the Asian financial crisis on global stock markets. Tests were conducted in two sub-periods, one before and one after the 1997 Asian financial crisis. For individual pairs of markets, Granger causality analysis revealed a seven-fold increase in bidirectional causality. The uncertainty surrounding the crisis considerably increased the transmission of disturbances from one market to another, and this transition was clearly global. Factor analysis test results showed that the non-Asian stock markets were characterized in one factor, however Asian stock markets were grouped by two, rather than four, additional factors. In short, it is concluded that the importance of such changes for long-term international portfolio diversification is less than previously believed.

In *et al*. (2001) studied three Asian stock markets, Hong Kong, Korea and Thailand. They searched for dynamic interdependence, volatility transmission and market integration across these markets. They used daily data covering the period from 3 February 1997 to 30 June 1998. A multivariate exponential GARCH model was used to capture lead-lag relationships and volatility interactions among the three Asian stock markets under study. During the crisis period empirical evidence of bidirectional volatility transmissions was found between Hong Kong and Korea, and unidirectional volatility transmission from Korea to Thailand. Thus, Hong Kong played an important role in the transmission of volatility to other Asian stock markets.

Sharma and Wongbangpo (2002) analyzed the degree of long- and short-run relationships among five ASEAN stock markets. Monthly indices in these markets were collected during the period between January 1986 and December 1996. The empirical results found a long-run relationship between the stock markets of Indonesia, Malaysia, Singapore and Thailand with the exception of the Philippines. The cointegrated remaining four stock markets indicate evidence of market inefficiency. However, in the short-run, these four countries can be characterized into two groups, *i.e.*, the first group consisted of Malaysia and Singapore and the rest were classified into another group.

Climent and Meneu (2003) investigated the effect of the 1997 Asian financial crisis on the short- and long-run relationships among the stock markets of Southeast Asia and a group of international stock markets. Daily stock price indices covering the period 4 January 1995 to 15 May 2000 from MSCI were employed. Within this sample, two sub-periods were identified. The pre-crisis interval runs from 4 January 1995 to 1 July 1997. The post-crisis interval covered from 1 November 1997 to 15 May 2000. The bivariate causality test results showed that the United States best predicted the Asian stock markets and this became stronger after the crisis. However, using the multivariate cointegration test the results revealed no long-run relationship across these stock markets.

Worthington, Katsuura and Higgs (2003) examined the dynamic linkages between Asian stock markets in the period during the Asian financial crisis. Weekly data from MSCI was employed to compute the multivariate cointegration test. Three sub-periods were examined: the first ran before the crisis, covering the period from 1 January 1988 through 25 July 1997, the second covered from 1 August 1997 to 18 February 2000 and the entire sample extended from 1 January1988 to 18 February 2000. Their empirical results provided evidence of long-run relationships among the Asian stock markets, both before and after the Asian crisis. However, this dynamic interdependency appears to decrease in the period during and after the crisis.

Following this line of research, Yang, Kolari and Min (2003) investigated long- and short-run relationships between the stock markets of the United States, Japan and 10 Asian emerging markets. Daily stock price indices covering the period 2 January 1995 to 15 May 2001 were used. Tests are conducted in three sub-periods, pre-crisis, crisis and post-crisis periods. The results indicated that both long- and short-run relationships among these stock markets were strengthened in the crisis period. In addition, these stock markets have been more integrated after the crisis rather than before the crisis.

Fernandez-Izquierdo and Lafuente (2004) employed a sample of 12 stock market indices to investigate the dynamic linkages between international stock markets. Daily data were collected during the period between 7 January 1997 and 28 December 2001. Using factor analysis, the results indicated that the first factor has a relatively high loading for the European markets, the second one for the Asian markets and the third one for the American market. By examining the transmission of volatility between these stock markets, they find evidence of the existence of volatility transmission in all regions during the crisis.

In a recent study, Hui (2005) made an attempt to analyze the gain of international diversification for Singaporean investors during the period 1990 to 2001. His data included 10 Asia Pacific stock markets. From the factor analysis tests the results indicated that the first factor had relatively high positive weights on Hong Kong, the Philippines, Korea, Singapore and Thailand, while the second factor was dominated by Australia and New Zealand. Japan, the United States and Taiwan were categorized alone into different factors. Hui also suggested that if Singaporean investors or portfolio managers were to select relatively developed markets for risk diversification, then the United States, Australia and Japan would be considered as better options.

The literature discussed in this chapter regarding the empirical studies of stock market integration has been summarized in Table 2.1.

TABLE 2.1
SUMMARY OF SELECTED EMPIRICAL STUDIES ON STOCK MARKET INTEGRATION

No.	Study	Data		Methodology	Results
		Period	Countries		
1.	Hamao, Masulis and Ng (1990)	Daily opening and closing data Period: 1 April 1985 to 31 March 1988	The United States, the United Kingdom and Japan	GARCH-M	• There exist significant spillovers in close-to-open returns and variances in all three markets • This suggested non-instantaneous adjustment to news, however they attribute these findings to overlapping trading between the stock markets.
2.	Kasa (1992)	Monthly and quarterly data Period: January 1974 to August 1990	The United States, Japan, the United Kingdom, Germany and Canada	Multivariate cointegration test	• There are four cointegrating vectors and one common stochastic trend among the stock markets • Estimation of the factor loadings from this trend is most important in the Japanese stock market and least important in the Canadian stock market • The gains from international diversification might have been overstated because of the existence of a common stochastic trend within these stock markets
3.	Bae and Karolyi (1994)	Intraday open and closing prices Period: 31 May 1988 to 29 May 1992	The United States and Japan	GARCH	• The degree and persistence of shocks originating in the stock markets of the United States or Japan that spread to other markets are extensively understated

TABLE 2.1 Continued

No.	Study	Data: Period	Data: Countries	Methodology	Results
4.	Hui and Kwan (1994)	Weekly price indices Period: January 1980 to December 1987	The United States and Asia Pacific countries: Australia, Hong Kong, Korea, Singapore, Taiwan and Japan	Factor Analysis	• The first factor has relatively high positive weights for Australia, Hong Kong and Singapore • The second factor is dominated by Taiwan alone • The third factor goes to Korea and Japan • The fourth factor has a relatively large weight on the United States alone • If investors are to select stock markets for risk diversification, then Japan, Taiwan and the United States would certainly be appropriate
5.	Lin, Engle and Ito (1994)	Daily data Period: 1 October 1985 to 29 December 1989	The United States and Japan.	GARCH-M	• Bidirectional spillovers between daytime returns in one market and overnight returns in the other are found • These two stock markets are integrated with global news relevant for both markets being generated both in the United States and Japan
6.	Susmel and Engle (1994)	Daily data Period: 2 January 1987 to 29 February 1989	The United States and the United Kingdom	Several GARCH models	• There is no significant evidence of volatility spillovers between these stock markets • The inclusion of the October 1987 crash period did not support the existence of spillovers between the stock markets
7.	Richards (1995)	Quarterly data Period: December 1969 to December 1994	16 developed stock markets: Australia, Austria, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States	• The Johansen methodology • Engle-Granger test	• Stock market indices are not cointegrated around the common component • National stock market indices include a common world component and two country-specific components, one permanent and one transitory

TABLE 2.1 Continued

No.	Study	Data: Period	Data: Countries	Methodology	Results
8.	Choudhry (1996a)	Monthly data: Period: the 1920s to 1930s.	Six European countries: Spain, France, Italy, Sweden, Czechoslovakia and Poland	The Johansen methodology	• The cointegration tests show a long-run relationship between these stock markets during the longest period (1925-1936) and also during the pre-October 1929 stock market crash period (1925-1929)
9.	Choudhry (1996b)	Monthly data Period: January 1976 to August 1994	Six emerging stock markets: Argentina, Greece, India, Mexico, Thailand and Zimbabwe	GARCH-M	• There is evidence of changes in the ARCH parameters, the risk premium and volatility is persistent in these stock markets • These changes are not consistent and they fluctuate between individual markets
10.	Naughton (1996)	Weekly return series Period: 1 January 1986 to 31 December 1992	Asian and developed stock markets: The United States, Australia, Japan, Hong Kong, Korea, Taiwan and Thailand	Factor Analysis	• There exists a low correlation between Asian emerging markets and between these markets and the developed market group • Factor analysis confirmed a developed market grouping which included Australia, Hong Kong and the United States, but excluded Japan • Korea and Japan are allocated to another group • The Philippines and Taiwan are both separated to a different factor alone • A good range of diversification potential appeared to exist in Asian emerging markets
11.	Chan, Gup and Pan (1997)	Monthly stock market indices Period: January 1961 to December 1992	18 stock markets: Australia, Belgium, Canada, Denmark, Finland, France, Germany, India, Italy, Japan, the Netherlands, Norway, Pakistan, Spain, Sweden, Switzerland, the United Kingdom and the United States	Johansen's cointegration tests	• Only a small number of stock markets show evidence of long-run co-movement with others • A number of significant cointegrating vectors increase before the October 1987 stock market crash • International diversification among stock markets might be effective, because the stock markets do not have long-run relationships

TABLE 2.1 Continued

No.	Study	Data: Period	Data: Countries	Methodology	Results
12.	Chaudhuri (1997)	Monthly stock market indices Period: January 1985 to December 1993	Six Latin American emerging markets: Argentina, Brazil, Chile, Colombia, Mexico and Venezuela	• Bivariate cointegration tests • Granger causality	• There exists a long-run relationship among all of these countries • The presence of bidirectional rather than unidirectional causality, and suggested the absence of weak exogeneity among the stock prices
13.	Meric and Meric (1997)	Monthly data Period: February 1975 to February 1994	12 largest European stock markets: Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom	Factor analysis	• The co-movement of these stock markets changed significantly after the 1987 stock market crash • The correlations among the 12 largest European stock markets are low but significantly increased • The benefit of international portfolio diversification with stock markets decreased considerably after the crash
14.	Kanas (1998a)	Daily closing values for the stock indices Period: 3 January 1983 to 29 November 1996	The United States and the six largest European stock markets: the United Kingdom, Germany, France, Switzerland, Italy, and the Netherlands	• The Johansen methodology	• The United States stock market is not pairwise cointegrated with any of the major European stock markets
15.	Kanas (1998b)	Daily closing values Period: 1 January 1984 to 7 December 1993	The three largest European stock markets: the United Kingdom, France and Germany	The multivariate exponential GARCH model	• The evidence of volatility spillovers between these stock markets is found • Spillovers are asymmetric in the sense that bad news in one market has a larger effect on the volatility of another market than good news
16.	Christofi and Pericli (1999)	Daily indices Period: 25 May 1992 to 16 May 1997	Five major Latin American stock markets: Argentina, Brazil, Chile, Colombia and Mexico	An exponential GARCH model.	• There exists evidence of first and second moment interactions among the stock markets examined • Volatility spillovers are more common in these stock markets than other regional stock markets

TABLE 2.1 Continued

No.	Study	Data		Methodology	Results
		Period	Countries		
17.	Masih and Masih (1999)	Daily stock price indices Period: 14 February 1992 to 19 June 1997	Four major established markets: the United States, Japan, the United Kingdom and Germany and four Asian emerging markets: Hong Kong, Singapore, Thailand and Malaysia	• Multivariate cointegration analysis • Causality test	• The leading role of the United States is confirmed • There exists a significant long- and short-run relationship between the established OECD and emerging Asian stock markets • Stock market fluctuations in all these Asian stock markets are generally linked to other regional stock markets
18.	Chang (2001)	Daily closing stock price indexes Period: 6 January 1997 to 30 December 1998.	Taiwan and Hong Kong, Japan, Korea, Thailand and the United States	• Multivariate Trace statistic • Harris-Inder approach • Johansen methodology	• Taiwan stock market is not pairwise cointegrated with the Hong Kong, Japan, Korea, Thailand and the United States stock markets
19.	In *et al*. (2001)	Daily data Period: 3 February 1997 to 30 June 1998	Three Asian stock markets: Hong Kong, Korea and Thailand	Multivariate exponential GARCH model	• During the crisis period empirical evidence of bidirectional volatility transmissions is found between Hong Kong and Korea • There is unidirectional volatility transmission from Korea to Thailand • Hong Kong played an important role in the transmission of volatility to other Asian stock markets
20.	Tuluca and Zwick (2001)	Daily equity returns Period: April 1996 to June 1997 (pre-crisis) and November 1997 to January 1999 (post-crisis)	13 stock market indices, including Asian and non-Asian markets: the United States, Canada, Mexico, Brazil, the United Kingdom, Japan, Hong Kong, Singapore, Taiwan, Korea, Malaysia, Indonesia, and Thailand	• Granger causality analysis • Factor analysis	• A seven-fold increase in bidirectional causality. • Uncertainty surrounding the crisis considerably increased the transmission of disturbances from one market to another, and this transition was clearly global • The non-Asian stock markets are characterized in one factor • Asian stock markets are grouped by two additional factors

TABLE 2.1 Continued

No.	Study	Data: Period	Data: Countries	Methodology	Results
21.	Ahlgren and Antell (2002)	Monthly and quarterly data Period: January 1980 to February 1997	The United States and the European stock markets: Finland, France, Germany, Sweden, and the United Kingdom	• Johansen's maximum likelihood (ML) cointegration method • likelihood ratio (LR) tests	• No evidence of long-run relationship among the United States and European stock markets
22.	Fratzscher (2002)	Daily data Period: 2 January 1986 to 2 March 2000	European stock markets: Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Spain, Denmark, Sweden and the United Kingdom Countries from outside the EU: Australia, Canada, Japan, Norway and Switzerland	Trivariate GARCH model	• The European stock markets had increased in importance in world financial markets since the mid-1990s • The degree of integration has been highly volatile over the years
23.	Illueca and Lafuente (2002)	Daily stock price index Period: 9 January 1995 to 28 December 2001	15 international stock markets: Argentina, Chile, France, Germany, Hong Kong, Italy, Japan, Mexico, Singapore, Korea, Spain, Taiwan, the United Kingdom, the United States (NASDAQ) and the United States (S&P 500)	Factor analysis	• There are four factors that could be identified with four geographic areas: Europe, Asia, North and South America • A portfolio diversification strategy needed to consider a number of assets that are negotiated in most stocks around the world
24.	Kim and In (2002)	Daily data Period: 1 July 1991 to 18 December 2000	Australia and the major stock markets: the United States, the United Kingdom and Japan	Bivariate GARCH model	• The movements of these three major stock markets, and some macroeconomic news, had significant effects on the Australian stock markets

TABLE 2.1 Continued

No.	Study	Data: Period	Data: Countries	Methodology	Results
25.	Ng (2002)	Monthly Stock Indices Period: December 1987 to December 1997	South-East Asia: Indonesia, Malaysia, the Philippines, Singapore and Thailand	Johansen methodology	• The South-East Asian stock markets are becoming more integrated • The stock market returns of Indonesia, the Philippines and Thailand had all become more closely linked with that of Singapore
26.	Sharma and Wongbangpo (2002)	Monthly indices Period: January 1986 to December 1996	Five ASEAN stock markets: Indonesia, Malaysia, Singapore, Thailand and the Philippines	Cointegration	• There exists a long-run relationship between the stock markets of Indonesia, Malaysia, Singapore and Thailand with the exception of the Philippines • The cointegrated remaining four stock markets indicate evidence of market inefficiency • In the short-run, these four countries can be characterized into two groups, *i.e.*, the first group consists of Malaysia and Singapore and the rest are classified into another group
27.	Climent and Meneu (2003)	Daily stock price indices Period: 4 January 1995 to 15 May 2000	South-East Asia: Thailand, Malaysia, Indonesia, the Philippines, Korea, Hong Kong, and Japan Europe: the United Kingdom and Eurozone (Germany, Austria, Belgium, Spain, Finland, France, Holland, Ireland, Italy, and Portugal) North America: the United States and Latin America: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela	• Bivariate causality test • Multivariate cointegration test	• The bivariate causality test results show that the United States best predicts the Asian stock markets and this becomes stronger after the crisis • Using the multivariate cointegration test the results find no long-run relationship across these stock markets

TABLE 2.1 Continued

No.	Study	Data		Methodology	Results
		Period	Countries		
28.	Worthington, Katsuura and Higgs (2003)	Weekly data Period: 1 January1988 to 18 February 2000	Three developed markets: Hong Kong, Japan and Singapore and six emerging markets: Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand	• Multivariate cointegration • Level VAR procedures	• Evidence of long-run relationships among the Asian stock markets, both during and after the Asian crisis are found • This dynamic interdependency appears to decrease in the period before and after the crisis
29.	Yang, Kolari and Min (2003)	Daily stock price indices Period: 2 January 1995 to 15 May 2001	The United States, Japan and 10 Asian emerging markets: Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, the Philippines, Singapore, Thailand and Taiwan	Cointegration	• Both long- and short-run relationships among these stock markets are strengthened in the crisis period • These stock markets have become more integrated after the crisis than before the crisis
30.	Fernandez-Izquierdo and Lafuente (2004)	Daily data Period: 7 January 1997 to 28 December 2001	12 stock market indices: Argentina, Chile, Germany, Hong Kong, Italy, Japan, Mexico, Singapore, Korea, Spain, the United Kingdom and the United States	Factor analysis	• The first factor has a relatively high loading for the European markets • The second one for the Asian markets and the third one for the American markets • There exists the evidence of the existence of volatility transmission in all regions during the crisis
31.	Syriopoulos (2004)	Daily stock index closing prices. Period: 1 January 1997 to 20 September 2003	Major emerging Central European countries: Poland, Czech Republic, Hungary and Slovakia and developed stock markets: Germany and the United States	Multivariate cointegration test	• There is a stationary long-run relationship among those countries • The individual Central European stock markets are likely to display stronger linkages with their mature international counterparts rather than their neighbors
32.	Phylaktis and Ravazzolo (2005a)	Annual, quarterly, monthly, weekly and daily data Period: 1980 to 1998.	Japan , the United States and group of Pacific-Basin stock markets: Hong Kong, Korea, Malaysia, Singapore, Taiwan and Thailand	Multivariate cointegration model	• No evidence was found to indicate a long-run relationship among the stock markets under study

TABLE 2.1 Continued

No.	Study	Data		Methodology	Results
		Period	Countries		
33.	Hui (2005)	Weekly data for stock market indices Period: 1 January 1990 to 30 June 2001	The United States and 10 Asia Pacific stock markets: Australia, Hong Kong, New Zealand, Japan, the Philippines, Singapore, Korea, Taiwan and Thailand	Factor Analysis	• The first factor has relatively high positive weights on Hong Kong, the Philippines, Korea, Singapore and Thailand • The second factor is dominated by Australia and New Zealand. Japan, the United States and Taiwan are categorized alone into different factors • If Singaporean investors or portfolio managers are to select relatively developed markets for risk diversification, then the United States, Australia and Japan would be considered as better choices

2.5 STATEMENT OF THE PROBLEM

Although a number of studies have investigated the issue of stock market integration, the focus mainly was on developed markets, such as the United States, the United Kingdom, Germany, Japan and Canada. Nevertheless, in recent years, the fast-growing economic activities and the increasing investment opportunities in emerging stock markets have started to attract the attention of investors and researchers. For example, Hui and Kwan (1994), Masih and Masih (1999) and Phylaktis and Ravazzolo (2005a) looked at the relationship between the United States and Asia Pacific stock markets. Bekaert and Harvey's (1995) study examined 12 selected emerging stock markets from Africa, Asia and Latin America. While Chaudhuri (1997) and Christofi and Pericli (1999) focused on Latin American stock markets. Syriopoulos' (2004) study aimed at analyzing the Central European stock markets.

Despite this increasing interest in emerging stock markets, the volume of literature in this area is still far less than that focusing on developed stock markets. This study fills this important gap in the literature, and provides further evidence that has important implications for the portfolio diversification decision of international investors.

Previous studies employed a cointegration test to investigate the long-run relationships among stock markets. However, no previous study has examined the possibility that the long-run relationship between stock markets may have been subject to a structural break. Gregory and Hansen (1996) argue that structural breaks have important implications for cointegration analysis because these breaks can decrease the power of the cointegration tests, and lead to the under-rejection of the null hypothesis of no cointegration.

Therefore, in addition to the Engle-Granger two-step procedure, this study will employ the Gregory and Hansen (1996) cointegration test, which allows for a structural break in the cointegrating vector, to make an accurate empirical investigation of stock market integration. The results of this study can provide useful information for investors regarding whether or not diversification benefits can be achieved by allocating their portfolios across the countries examined.

2.6 SUMMARY AND CONCLUDING REMARKS

This chapter has reviewed an extensive literature examining stock market integration. Recent empirical studies of market integration have shown increasing interest in emerging stock markets. The results from the studies of market integration have important implications for international portfolio diversification and market efficiency. If stock markets are integrated the scope of international diversification benefits might be limited, and also the weak form of market efficiency will be violated. Econometric techniques such as cointegration test, factor analysis and GARCH models provide a useful tool to investigate the relationship among economic variables. In the context of stock market integration, these techniques, *inter alia*, can be used to examine whether international stock markets have a tendency to move together.

CHAPTER 3

STRUCTURAL BREAKS AND TESTING FOR THE RANDOM WALK HYPOTHESIS IN INTERNATIONAL STOCK PRICES

3.1 INTRODUCTION

As discussed in the first chapter a financial crisis afflicted most Asian countries in the late 1990s, plunging some of the most rapidly growing and successful economies into financial turbulence and deep economic depression. This means there has been some dramatic shocks to these world economies resulting in the occurrence of a large number of structural changes in international stock markets. The major objective of this study is to investigate the random walk hypothesis in the stock prices of 16 countries for which consistent and comparable time series data could be obtained. The conventional unit root tests, which do not consider any structural breaks in the data, including the Augmented Dickey-Fuller (ADF) test and the Dickey-Fuller Generalize Least Squares (DF-GLS) test, have been used. Then unit root tests, which allow one structural break, the Zivot and Andrews (ZA, 1992) test, and two structural breaks, Lumsdaine and Papell (LP, 1997) test, have been employed to examine the significance of structural breaks. These two tests will empirically determine the most significant structural breaks in the data.

Vibrant stock markets are important to promote economic growth. The essential function of stock markets is to allocate funds from savers to investors, leading to more efficient allocation of resources and economic prosperity. However, stock markets can trouble the economy as a whole too. Previous studies in the financial literature have found that an inefficient market cannot serve the economy as much as an efficient market (Ma, 2004). Therefore, the efficient market hypothesis has been widely investigated in numerous financial studies. There are several approaches to testing the efficiency of stock markets. However, the random walk hypothesis has been broadly used by a large number of financial analysts.

The issue of whether stock prices can be characterized as a random walk[1] or trend stationary process has been widely investigated. If stock prices follow a random walk process, then any shocks to stock prices will be permanent and future returns cannot be forecasted by using information on historical prices. Nevertheless, if stock prices follow a trend stationary process, the price level returns will revert to trend path over time, and future returns can be predicted by using historical prices (Chaudhuri and Wu, 2003). The term random walk implies that the movement of stock prices that cannot be predicted, because they can change without frontier in the long run. Although the subject of random walk in stock prices has been studied before, there is no consensus among analysts due to the inconclusive results in the literature.

Fama (1970) and Fama and French (1988) found that United States stock prices are trend stationary. In addition, using variance ratio tests, Lo and MacKinlay (1988) and Poterba and Summers (1988) also offered some evidence of trend stationarity in United States stock prices. On the other hand, Kim, Nelson and Startz (1991) and McQueen (1992) demonstrated that trend

[1] Gujarati (2003) argues that the terms random walk, unit root and nonstationarity can be used interchangeably. However, while every random walk is an $I(1)$ process, the reverse is not always the case.

stationarity in United States stock prices is not robust to outliers or alternative distributional assumptions. A number of studies have also investigated the trend stationary property of international stock prices. However, evidence of random walk or the trend stationary process in stock prices is quite mixed (Urrutia, 1995; Zhen, 1998; Malliaropulos and Priestley, 1999; Balvers, Wu and Gilliland, 2000).

The issue of structural breaks in macroeconomic time series has been subject to extensive investigation. Structural breaks manifest themselves in time series data for a number of reasons. For instance, due to economic crises, policy changes and regime shifts. Perron (1989) argued that if structural breaks are not dealt with appropriately, one may obtain spurious results. However, few studies have incorporated structural breaks in testing for unit roots in stock prices. Chaudhuri and Wu (2003) employed one structural break proposed by Zivot and Andrews (1992), to test the random walk hypothesis in stock prices of 17 emerging markets. They found evidence of trend stationarity for 10 out of 18 stock markets. Narayan and Smyth (2005) investigated the existence of a random walk for OECD countries using the ZA test. Similar to the present study, their findings also provided strong support for the random walk hypothesis.

The rest of this chapter is organized as follows: Section 3.2 briefly discusses the empirical methodology utilized in the analysis. Then Section 3.3 describes the summary statistics of the data employed. Section 3.4 presents the empirical econometric results as well as policy implications of the study, followed by some concluding remarks.

3.2 EMPIRICAL METHODOLOGY

This section briefly reviews the econometric methodology and common procedures which are adopted in this chapter and the next. The issues considered here are as follows: the Augmented Dickey-Fuller test; the Zivot and Andrews (1992) test; and the Lumsdaine and Papell (1997) test.

3.2.1 The Augmented Dickey-Fuller Test

The ADF unit root test has been performed to examine the time series properties of the data without allowing for any structural breaks. The ADF test (Dickey and Fuller, 1979) is conducted using the following equation:

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \tag{3.1}$$

where y_t denotes the time series being tested, Δ is the first different operator, t is a time trend term, k denotes the number of lagged terms and ε is a white noise disturbance term. In this study, the lowest value of the Schwartz Information Criterion (SIC) has been used as a guide to determine the optimal lag in the ADF regression. These lags augment the ADF regression to ensure that the error is white noise and free of serial correlation. To select the lag length the sequential procedure suggested by Campbell and Perron (1991), with the maximum lag length (k_{max}) set to 12, has been used. In addition the

DF-GLS test proposed by Elliott, Rothenberg and Stock (1996) has been used as an alternative nonparametric model of controlling for serial correlation when testing for a unit root.

3.2.2 The Zivot and Andrews (1992) Test

An important shortcoming associated with the ADF test and the DF-GLS test is that they do not allow for the effect of structural breaks. Perron (1989) argued that if a structural break in a series is ignored, unit root tests can be erroneous in rejecting the null hypothesis. Perron (1989) proposed models which allow for a one-time structural break in Equation (3.1). Moreover, ZA (1992) have developed methods to endogenously search for a structural break in the data. Model C, which allows for a structural break in both the intercept and slope, has been employed in the following equation:

$$\Delta y_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \qquad (3.2)$$

where $DU_t = 1$ if $t > TB$, otherwise zero; TB denotes the time of break, $DT_t = t - TB$ if $t > TB$, otherwise zero. The lag length is selected using the same approach as in the ADF test. The "trimming region", searching for *TB*, covers the 0.15*T*-0.85*T* period. The break point has been chosen based on the minimum value of *t* statistic for α.

3.2.3 The Lumsdaine and Papell (1997) Test

As Ben-David, Lumsdaine and Papell (2003) argued, if there are two structural breaks in the deterministic trend then unit root tests with one structural break will also lead to a misleading conclusion. LP (1997) argue that unit root tests accounting for two structural breaks are more powerful than those, accommodating one structural break. They introduced a new procedure to capture two structural breaks as an extension of model C by including two endogenous breaks in Equation (3.1). Consequently, model CC can be represented as follows:

$$\Delta y_t = \mu + \beta t + \theta DU1_t + \gamma DT1_t + \omega DU2_t + \psi DT2_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \quad (3.3)$$

where $DU1_t = 1$ if $t > TB1$, otherwise zero; $DU2_t = 1$ if $t > TB2$, otherwise zero; $DT1_t = t - TB1$ if $t > TB1$, otherwise zero; $DT2_t = t - TB2$ if $t > TB2$, otherwise zero. Two dummy variables (*i.e.* $DU1_t$ and $DU2_t$) are indicators for structural breaks in the intercept at $TB1$ and $TB2$, respectively. However, the other dummy variables (*i.e.* $DT1_t$ and $DT2_t$) are indicators for structural breaks in trend at $TB1$ and $TB2$, respectively. The lag length and break points are selected using the same approach as in the ZA test.

TABLE 3.1

Please see print copy for image

Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

Note: Data employed covering the period December 1987 to April 2007 except for the stock price index of Russia which covers the period from December 1994 to April 2007.

3.3 DATA AND SUMMARY STATISTICS

Sample data included in this study are stock prices from the following 16 countries: Argentina (AR), Australia (AU), Brazil (BA), Germany (GE), Hong Kong (HK), Indonesia (IN), Japan (JA), Korea (KO), Malaysia (MA), the Philippines (PH), Russia (RU), Singapore (SG), Taiwan (TA), Thailand (TH), the United Kingdom (UK) and the United States (US). Seven of these markets are categorized as developed or mature markets (*e.g.* Australia, Germany, Hong Kong, Japan, Singapore, the United Kingdom and the United States) and the remainders are regarded as emerging markets. Monthly data cover the period December 1987 to April 2007 with a base value of 100 in December 1987, except for the stock price index of Russia which includes the period December 1994 to April 2007 with a base value of 100 in December 1994. This different base year has been modified accordingly.

Table 3.1 presents the descriptive statistics of the data. Sample means, medians, maximums, minimums, standard deviations, skewness, kurtosis as well as the Jarque-Bera statistics and *p*-values are presented. The highest mean return is 0.017 percent in Russia and the lowest is 0.000 percent in Japan. The standard deviations range from 0.040 percent (the least volatile) to 0.178 percent (the most volatile). The standard deviations of stock returns are lowest in developed economies (*i.e.* the United States, the United Kingdom, Australia, Germany, Japan and Singapore), and the most volatile in Russia, Brazil, Argentina, Indonesia, Thailand and Taiwan. All monthly stock returns, $\ln(P_t / P_{t-1})$, have excess kurtosis which means that they have a thicker tail and a higher peak than a normal distribution. The calculated Jarque-Bera statistics and corresponding *p*-values are used to test for the normality assumption. Based on the Jarque-Bera statistics and *p*-values this assumption is rejected at any conventional level of significance for all stock returns, with the only two exceptions being the monthly stock returns in Japan and the United Kingdom.

3.4 EMPIRICAL RESULTS

As mentioned earlier the ADF test and the DF-GLS test have been used to determine the order of integration of the 16 stock prices studied in this study. Based on the results of both the ADF test and the DF-GLS test presented in Table 3.2 the null hypothesis (unit root) cannot be rejected for all 16 countries, with the only exception being the case of Taiwan. While the ADF test indicates that the stock market in Taiwan is $I(0)$ the DF-GLS test still supports the random walk hypothesis. The results showed that all stock prices employed in this study are $I(1)$. In other words they follow a random walk.

In the second stage, each variable has been subjected to one and two structural breaks. For each series, model C is estimated and the results are reported in Table 3.3. As mentioned earlier the ADF and DF-GLS test results reveal that all stock prices examined in this study followed a random walk, whereas the results of the ZA test show that the stock prices for four countries (*i.e.* Indonesia, Korea, Malaysia and Russia) are stationary. These same four countries show an $I(0)$ process also according to the LP test results discussed below. The remaining 12 countries still contain a unit root in the data. The estimated coefficients μ and θ are statistically significant for all variables except for μ in the case of Russian stock prices. Thus, at least there has been one structural break in the intercept during the sample period for all stock prices. The estimated coefficients for β and γ are statistically significant in 12 and 11 out of 16 countries, respectively, implying the stock price series exhibit an upward or downward trend and there exist at least one structural break in trend in these 10 countries.

The reported *TB*s are endogenously determined in the ZA test and presented in the second column of Table 3.3. It is not surprising to note that the most important structural break in these stock prices occurred in the Asian crisis period 1996-1998. See *TB*s for Indonesia, Korea, Malaysia, the Philippines, Russia, Singapore, Thailand, and the United States.

Table 3.4 presents the results of the LP test allowing for the two most significant structural breaks. The results show that stock prices for five countries (*i.e.* Argentina, Indonesia, Korea, Malaysia and Russia) now become stationary. Comparing the results of the ZA and LP tests, as can be seen from Tables 3.3 and 3.4, shows that the addition of another endogenous break in the data can marginally change the order of integration of the variables: only one more country (Argentina) now exhibits a stationary process. So the conclusion regarding the order of integration of the stock market price indices remain robust.

TABLE 3.2
UNIT ROOT TEST RESULTS

Variable	ADF test Constant and trend		DF-GLS test Constant and trend	
$\ln P_t^{AR} = \ln P_t^1$	-2.483	(0)	-1.308	(0)
$\Delta \ln P_t^{AR} = \Delta \ln P_t^1$	-14.846***	(0)	-14.664***	(0)
$\ln P_t^{AU} = \ln P_t^2$	-1.397	(0)	-1.711	(0)
$\Delta \ln P_t^{AU} = \Delta \ln P_t^2$	-16.481***	(0)	-12.814***	(0)
$\ln P_t^{BA} = \ln P_t^3$	-2.998	(0)	-2.477	(0)
$\Delta \ln P_t^{BA} = \Delta \ln P_t^3$	-17.584***	(0)	-8.289***	(1)
$\ln P_t^{GE} = \ln P_t^4$	-1.990	(0)	-1.845	(0)
$\Delta \ln P_t^{GE} = \Delta \ln P_t^4$	-16.055***	(0)	-2.334	(5)
$\ln P_t^{HK} = \ln P_t^5$	-2.129	(0)	-1.517	(0)
$\Delta \ln P_t^{HK} = \Delta \ln P_t^5$	-14.387***	(0)	-14.386***	(0)
$\ln P_t^{IN} = \ln P_t^6$	-2.164	(1)	-1.350	(1)
$\Delta \ln P_t^{IN} = \Delta \ln P_t^6$	-12.788***	(0)	-12.803***	(0)
$\ln P_t^{JA} = \ln P_t^7$	-1.975	(0)	-2.066	(0)
$\Delta \ln P_t^{JA} = \Delta \ln P_t^7$	-14.660***	(0)	-13.132***	(0)
$\ln P_t^{KO} = \ln P_t^8$	-1.540	(0)	-1.683	(0)
$\Delta \ln P_t^{KO} = \Delta \ln P_t^8$	-14.650***	(0)	-2.596	(5)
$\ln P_t^{MA} = \ln P_t^9$	-2.628	(2)	-2.046	(2)
$\Delta \ln P_t^{MA} = \Delta \ln P_t^9$	-7.749***	(1)	-7.439***	(1)
$\ln P_t^{PH} = \ln P_t^{10}$	-1.960	(1)	-1.217	(1)
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	-12.181***	(0)	-12.215***	(0)
$\ln P_t^{RU} = \ln P_t^{11}$	-2.309	(0)	-2.263	(0)
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	-10.619***	(0)	-3.472**	(3)
$\ln P_t^{SG} = \ln P_t^{12}$	-2.082	(0)	-1.405	(0)
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	-14.761***	(0)	-8.162***	(1)
$\ln P_t^{TA} = \ln P_t^{13}$	-3.807**	(0)	-1.761	(0)
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	-13.645***	(0)	-5.258**	(2)
$\ln P_t^{TH} = \ln P_t^{14}$	-1.874	(0)	-1.170	(0)
$\Delta \ln P_t^{TH} = \Delta \ln P_t^{14}$	-9.0132***	(1)	-2.927**	(6)
$\ln P_t^{UK} = \ln P_t^{15}$	-1.891	(0)	-1.877	(0)
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{15}$	-12.745***	(1)	-15.228***	(0)
$\ln P_t^{US} = \ln P_t^{16}$	-1.331	(0)	-1.147	(0)
$\Delta \ln P_t^{US} = \Delta \ln P_t^{16}$	-15.844***	(0)	-14.590***	(0)

Notes: (a) Data employed covering the period December 1987 to April 2007 except for the stock price index of Russia December 1994 to April 2007. (b) Figures in parentheses are lag lengths for the ADF test and the DF-GLS test. (c) *, ** and *** indicates that the corresponding null hypothesis is rejected at the 10, 5 and 1 percent significance levels, respectively.

It should be noted that the estimated coefficients for θ, γ, ω and ψ are significant for the stock prices of Argentina, Brazil, Germany, Hong Kong, the Philippines, the United Kingdom and the United States, indicating that the reported structural changes at *TB*1 and *TB*2 (Table 3.4) have impacted on both the intercept and trend. In the case of Indonesia, Japan and Singapore, while γ, ω and ψ are significant, θ is not, suggesting that the second structural break occurring at *TB*2 affected both the intercept and slope but the first on structural break exerted a significant change in trend only. Finally, based on the magnitudes of *t*-ratios for θ, γ, ω and ψ, while the first structural break in Korea shifted both the intercept and slope, the second one had no significant effect.

Figures 3.1 to 3.16 show the log and the monthly return of each of the 16 stock prices employed as well as their corresponding structural breaks--the thick dashed line denotes *TB* for the ZA test and the solid and thin dashed lines are used to show *TB*1 and *TB*2 in the LP test, respectively. The *TB*1s and *TB*2s are presented in the second and third column of Table 3.4. The results are quite consistent in identifying structural breaks in most stock prices. *TB* in the ZA test is the same as that of either *TB*1 or *TB*2 in the LP test for the following seven countries: Germany, Indonesia, Japan, Korea, Malaysia, Russia and Singapore.

TABLE 3.3

THE ZIVOT AND ANDREWS TEST RESULTS: BREAK IN BOTH INTERCEPT AND TREND

Variable	*TB*	μ	β	θ	γ	α	k	Inference
$\Delta \ln P_t^{AR} = \Delta \ln P_t^1$	2001:02	0.449 (3.856)***	0.001 (1.740)*	-0.163 (-3.019)***	0.002 (2.911)***	-0.072 (-3.521)	0	Random walk
$\Delta \ln P_t^{AU} = \Delta \ln P_t^2$	2001:02	0.746 (3.990)***	0.001 (3.143)***	-0.120 (-1.861)*	-0.061 (-3.06)***	-0.155 (-3.947)	4	Random walk
$\Delta \ln P_t^{BA} = \Delta \ln P_t^3$	2001:02	0.628 (3.380)***	0.002 (2.587)**	-0.164 (-2.805)***	0.002 (2.129)**	-0.123 (-3.293)	12	Random walk
$\Delta \ln P_t^{GE} = \Delta \ln P_t^4$	2002:04	0.533 (3.417)***	0.001 (2.684)***	-0.102 (-3.357)***	0.002 (3.394)***	-0.111 (-3.292)	9	Random walk
$\Delta \ln P_t^{HK} = \Delta \ln P_t^5$	1993:01	0.537 (3.661)***	0.002 (2.132)**	0.053 (1.785)*	-0.001 (-1.999)**	-0.119 (-3.696)	11	Random walk
$\Delta \ln P_t^{IN} = \Delta \ln P_t^6$	1997:08	0.721 (5.608)***	0.000 (0.461)	-0.249 (-4.792)***	0.001 (2.416)	-0.118 (-5.535)**	8	Stationary
$\Delta \ln P_t^{JA} = \Delta \ln P_t^7$	2002:06	0.633 (4.283)***	-0.000 (-2.334)**	-0.060 (-2.480)**	0.002 (3.305)***	-0.134 (-4.304)	9	Random walk
$\Delta \ln P_t^{KO} = \Delta \ln P_t^8$	1997:09	0.952 (5.559)***	-0.000 (-0.554)	-0.159 (-4.007)***	0.003 (4.594)***	-0.189 (-5.581)***	9	Stationary
$\Delta \ln P_t^{MA} = \Delta \ln P_t^9$	1997:07	0.858 (6.428)***	0.002 (4.842)***	-0.235 (-6.121)***	-0.001 (-2.099)**	-0.179 (-6.361)***	11	Stationary
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	1999:05	0.264 (2.735)***	0.000 (0.974)	-0.095 (-2.775)***	0.000 (0.495)	-0.049 (-2.518)	12	Random walk
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	1998:05	-0.477 (-1.517)	0.021 (4.805)***	-0.598 (-5.692)***	-0.013 (-3.576)***	-0.344 (-6.458)***	7	Stationary
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	1997:03	0.385 (3.005)***	0.001 (2.166)**	-0.066 (-2.814)***	-0.000 (-0.827)	-0.079 (-2.923)	7	Random walk
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	1993:10	0.821 (3.941)***	-0.002 (-1.961)*	0.095 (2.658)***	0.001 (1.643)	-0.140 (-4.028)	9	Random walk
$\Delta \ln P_t^{TH} = \Delta \ln P_t^{14}$	1996:10	0.411 (4.123)***	0.001 (1.349)	-0.172 (-3.789)***	0.000 (0.128)	-0.076 (-3.923)	12	Random walk
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{15}$	2001:01	0.373 (3.218)***	0.001 (2.884)***	-0.063 (-3.822)***	0.001 (2.215)**	-0.081 (-3.140)	2	Random walk
$\Delta \ln P_t^{US} = \Delta \ln P_t^{16}$	1996:09	0.293 (3.292)***	0.001 (2.466)**	0.033 (2.335)**	-0.000 (-2.342)**	-0.062 (-3.223)	7	Random walk

Notes: (a) Data employed covering the period December 1987 to April 2007 except for the stock price index of Russia which covers the period from December 1994 to April 2007. (b) *, ** and *** indicates that the corresponding null hypothesis is rejected at the 10, 5 and 1 percent significance levels, respectively. (c) Critical values for t_α at the 10, 5, and 1 percent are -4.82, -5.08 and -5.57, respectively (Zivot and Andrews, 1992).

TABLE 3.4
THE LUMSDAINE AND PAPELL TEST RESULTS: BREAK IN BOTH INTERCEPT AND TREND

Variable	*TB*1	*TB*2	μ	β	θ	γ	ω	ψ	α	k	Inference
$\Delta \ln P_t^{AR} = \Delta \ln P_t^1$	1991:08	2002:01	1.722 (7.883)***	0.010 (4.231)***	0.758 (6.364)***	-0.010 (-4.193)***	-2.580 (-7.427)***	0.012 (7.407)***	-0.348 (-7.755)***	4	Stationary
$\Delta \ln P_t^{AU} = \Delta \ln P_t^2$	1993:07	2002:06	1.187 (6.390)***	0.000 (0.012)	0.052 (2.185)**	0.000 (0.865)	-0.843 (-5.931)***	0.005 (6.117)***	-0.244 (-6.317)	0	Random walk
$\Delta \ln P_t^{BA} = \Delta \ln P_t^3$	1998:08	2002:06	1.482 (5.348)***	0.005 (4.943)***	0.512 (1.757)*	-0.005 (-2.523)**	-2.008 (-3.967)***	0.010 (3.695)***	-0.315 (-5.319)	12	Random walk
$\Delta \ln P_t^{GE} = \Delta \ln P_t^4$	1998:02	2002:05	0.980 (5.155)***	0.002 (4.435)***	0.446 (4.346)***	-0.003 (-4.182)***	-1.039 (-5.806)***	0.005 (5.580)***	-0.207 (-5.088)	9	Random walk
$\Delta \ln P_t^{HK} = \Delta \ln P_t^5$	1997:10	2002:05	1.160 (6.051)***	0.004 (5.680)***	0.248 (2.287)**	-0.003 (-3.536)***	-0.536 (-3.273)***	0.002 (2.685)***	-0.258 (-5.983)	10	Random walk
$\Delta \ln P_t^{IN} = \Delta \ln P_t^6$	1997:08	2003:02	1.189 (6.913)***	0.001 (1.509)	0.041 (0.280)	-0.003 (-2.227)**	-1.189 (-3.224)***	0.007 (3.510)***	-0.199 (-6.831)**	8	Stationary
$\Delta \ln P_t^{JA} = \Delta \ln P_t^7$	1993:05	2002:06	1.006 (5.497)***	-0.002 (-3.492)***	-0.019 (-0.564)	0.002 (2.564)**	-0.694 (-4.661)***	0.004 (4.728)***	-0.200 (-5.553)	9	Random walk
$\Delta \ln P_t^{KO} = \Delta \ln P_t^8$	1993:11	1997:10	1.598 (6.759)***	-0.003 (-3.145)***	0.107 (0.957)	0.001 (0.545)	-0.963 (-5.815)***	0.006 (4.663)***	-0.302 (-6.899)**	11	Stationary
$\Delta \ln P_t^{MA} = \Delta \ln P_t^9$	1993:08	1997:08	1.120 (7.125)***	0.002 (2.583)**	0.149 (1.875)*	-0.001 (-0.939)	-0.329 (-3.658)***	0.001 (0.708)	-0.229 (-7.158)**	12	Stationary
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	1995:11	2002:10	1.031 (5.331)***	0.004 (4.533)***	0.921 (4.890)***	-0.009 (-5.013)***	-1.720 (-5.021)***	0.009 (5.148)***	-0.224 (-5.245)	12	Random walk
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	1997:11	1998:05	1.275 (6.387)***	0.031 (5.660)***	0.005 (0.004)	-0.006 (-0.173)	0.058 (0.042)	-0.015 (-0.420)	-0.383 (-7.103)**	7	Stationary
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	1997:06	2002:06	1.131 (5.466)***	0.002 (4.543)***	0.137 (1.621)	-0.002 (-2.949)***	-0.733 (-4.225)***	0.003 (3.923)***	-0.236 (-5.378)	12	Random walk
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	1990:03	2000:09	1.064 (5.279)***	0.014 (2.791)***	0.071 (0.702)	-0.013 (-2.564)**	-0.162 (-1.697)*	-0.000 (-0.005)	-0.226 (-6.203)	9	Random walk
$\Delta \ln P_t^{TH} = \Delta \ln P_t^{14}$	1993:10	2000:05	0.807 (5.309)***	0.001 (1.346)	0.542 (4.302)***	-0.006 (-3.867)***	-1.121 (-4.938)***	0.007 (4.969)***	-0.154 (-5.295)	12	Random walk
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{15}$	1997:05	2002:06	0.828 (4.838)***	0.001 (4.531)***	0.319 (5.043)***	-0.002 (-4.991)***	-0.694 (-5.504)***	0.004 (5.617)***	-0.180 (-4.816)	2	Random walk
$\Delta \ln P_t^{US} = \Delta \ln P_t^{16}$	1998:09	2002:04	0.518 (4.596)***	0.001 (4.417)***	0.418 (4.873)***	-0.003 (-4.893)***	-0.514 (-5.076)***	0.002 (4.887)***	-0.112 (-4.529)	0	Random walk

Notes: (a) Data employed covering the period December 1987 to April 2007 except for the stock price index of Russia which covers the period from December 1994 to April 2007. (b) *, ** and *** indicates that the corresponding null hypothesis is rejected at the 10, 5 and 1 percent significance levels, respectively. (c) Critical values for t_α at the 10, 5, and 1 percent are -6.49, -6.82 and -7.34, respectively (Lumsdaine and Papell, 1997).

FIGURE 3.1
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF ARGENTINA

Please see print copy for image

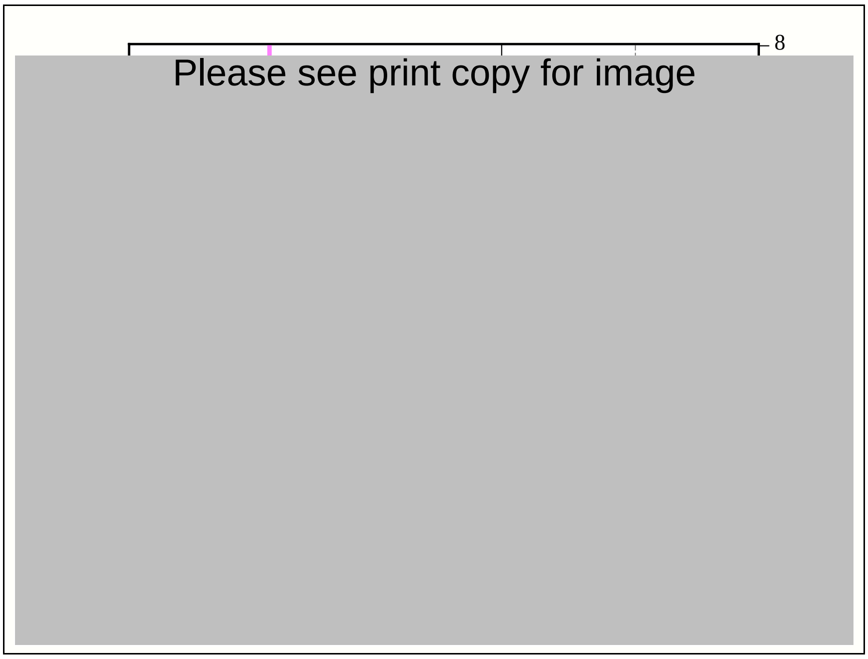
Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.2
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF AUSTRALIA

Please see print copy for image

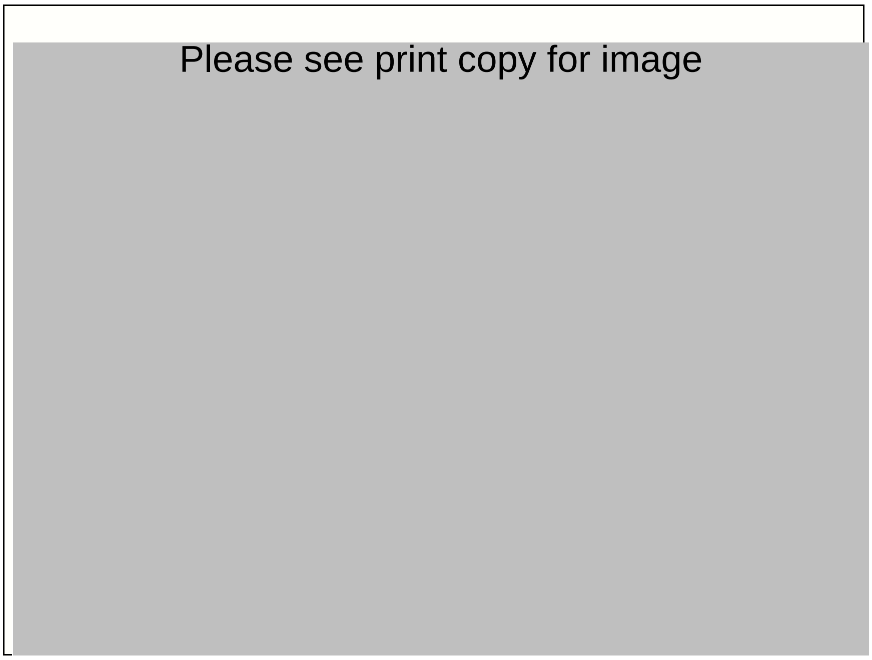
Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.3
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF BRAZIL



Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.4
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF GERMANY



Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.5
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF HONG KONG

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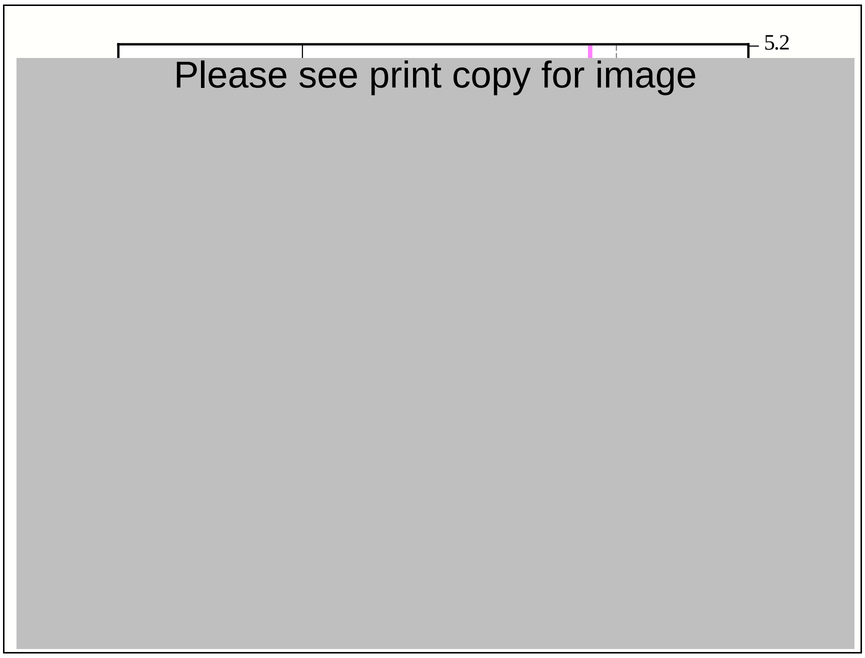
Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.6
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF INDONESIA

Please see print copy for image

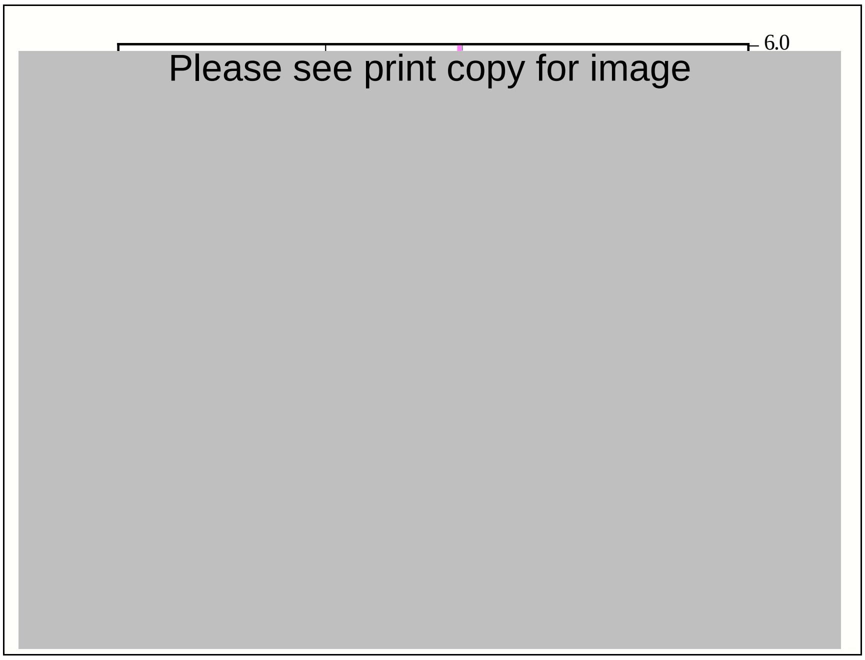
Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.7
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF JAPAN



Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.8
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF KOREA



Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.9
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF MALAYSIA

Please see print copy for image

Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.10
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF THE PHILIPPINES

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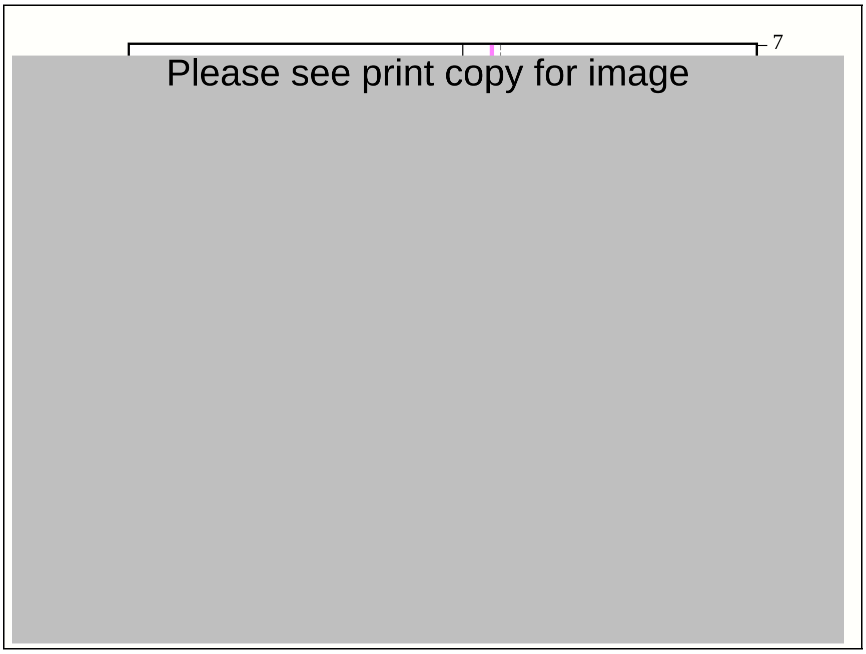
Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.11
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF RUSSIA



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Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.12
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF SINGAPORE

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Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.13
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF TAIWAN

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Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.14
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF THAILAND

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Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html

FIGURE 3.15
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF THE UNITED KINGDOM

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Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

FIGURE 3.16
PLOT OF THE LOG OF STOCK PRICES AND RETURNS OF THE UNITED STATES

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Source: Morgan Stanley Capital International, http://www.msci.com/equity/index2.html.

In order to facilitate cross model comparison the times of the structural breaks obtained by the ZA test and the LP test are presented in Table 3.5. As mentioned earlier, the results from both tests are quite consistent. The most significant break occurred during various months in the period 1996-1998 for seven and 10 countries in the ZA test and the LP test, respectively. Two other important breaks across various markets occurred in 1991-1993 and 2000-2002, which coincided with two world-wide recessions. Based on the ZA test, in two countries the structural break occurred in 1991-1993 and in six countries the structural break occurred in 2000-2002. On the other hand the LP test results in Table 3.5 show that in five countries the first break occurred in 1991-1993, and for 12 countries the second break was identified in 2000-2002. Apart from the 1997-1998 Asian crisis and the above two global recessions, there have been several other country-specific events which caused jitters in financial markets (See Table 3.5).

TABLE 3.5
COMPARING THE TIME OF STRUCTURAL BREAKS FOR THE ZIVOT AND ANDREWS TEST AND LUMSDAINE AND PAPELL TEST RESULTS

Variable	Zivot and Andrews test		Lumsdaine and Papell test			
	TB	Possible causes for *TB*s	*TB*1	Possible causes for *TB*1s	*TB*2	Possible causes for *TB*2s
$\Delta \ln P_t^{AR} = \Delta \ln P_t^1$	2001:02	- Global recession 2000-2002	1991:08	- Global recession 1991-1993	2002:01	- Global recession 2000-2002
$\Delta \ln P_t^{AU} = \Delta \ln P_t^2$	2001:02	- Global recession 2000-2002	1993:07	- Global recession 1991-1993	2002:06	- Global recession 2000-2002
$\Delta \ln P_t^{BA} = \Delta \ln P_t^3$	2001:02	- Global recession 2000-2002	1998:08	- Asian crisis	2002:06	- Global recession 2000-2002
$\Delta \ln P_t^{GE} = \Delta \ln P_t^4$	2002:04	- Global recession 2000-2002	1998:02	- Asian crisis	2002:05	- Global recession 2000-2002
$\Delta \ln P_t^{HK} = \Delta \ln P_t^5$	1993:01	- Global recession 1991-1993	1997:10	- Asian crisis	2002:05	- Global recession 2000-2002
$\Delta \ln P_t^{IN} = \Delta \ln P_t^6$	1997:08	- Asian crisis	1997:08	- Asian crisis	2003:02	- Domestic event
$\Delta \ln P_t^{JA} = \Delta \ln P_t^7$	2002:06	- Global recession 2000-2002	1993:05	- Global recession 1991-1993	2002:06	- Global recession 2000-2002
$\Delta \ln P_t^{KO} = \Delta \ln P_t^8$	1997:09	- Asian crisis	1993:11	- Global recession 1991-1993	1997:10	- Asian crisis
$\Delta \ln P_t^{MA} = \Delta \ln P_t^9$	1997:07	- Asian crisis	1993:08	- Global recession 1991-1993	1997:08	- Asian crisis
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	1999:05	- Asian crisis	1995:11	- Domestic event	2002:10	- Global recession 2000-2002
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	1998:05	- Asian crisis	1997:11	- Asian crisis	1998:05	- Asian crisis
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	1997:03	- Asian crisis	1997:06	- Asian crisis	2002:06	- Global recession 2000-2002
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	1993:10	- Global recession 1991-1993	1990:03	- Domestic event	2000:09	- Global recession 2000-2002
$\Delta \ln P_t^{TH} = \Delta \ln P_t^{14}$	1996:10	- Asian crisis	1993:10	- Global recession 1991-1993	2000:05	- Global recession 2000-2002
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{15}$	2001:01	- Global recession 2000-2002	1997:05	- Asian crisis	2002:06	- Global recession 2000-2002
$\Delta \ln P_t^{US} = \Delta \ln P_t^{16}$	1996:09	- Asian crisis	1998:09	- Asian crisis	2002:04	- Global recession 2000-2002

Source: Tables 3.3 and 3.4.

3.5 SUMMARY AND CONCLUDING REMARKS

The main purpose of the empirical analysis presented in this chapter is to examine the random walk hypothesis in stock prices of 16 countries for which there are consistent monthly data available. The results of the ADF test and the DF-GLS test suggest that there is a unit root in almost all stock prices; supporting a random walk hypothesis. However, after incorporating one structural break in the data, the ZA test found evidence in favor of the random walk hypothesis for 12 countries. By applying the LP test, which allows for two endogenously determined structural breaks in each series, similar results have been obtained, supporting the view that the random walk hypothesis is again applicable for the majority of countries (11 out of 16). Thus, allowing for more structural breaks in the data did not lead to a reversal of the inference regarding the order of the integration of the variables employed.

That is to say, while monthly stock prices in Argentina, Indonesia, Korea, Malaysia and Russia were $I(0)$, the stock prices in the rest of countries continued to follow a random walk process. According to the weak form of the efficient market hypothesis, stock prices completely reflect the information contained in the data and consequently no one can devise an investment strategy to obtain abnormal profits on the basis of an analysis of past price patterns. The majority of market prices evolve according to a random walk and as such they cannot be predicted using historical data, despite considering up to two significant structural breaks in the data.

CHAPTER 4

DYNAMIC LINKAGES BETWEEN THAI AND INTERNATIONAL STOCK MARKETS

4.1 INTRODUCTION

As mentioned in the previous chapter, structural breaks have important implications for time properties of the data because these breaks can decrease the power of the tests, and lead to spurious results for the null hypothesis. Compared to the previous studies in Chapter 2, this study differs in two aspects. First, no previous study has examined the possibility that the pair-wise long-run relationship between the stock prices of two countries may have been subject to a structural break. In addition to the Engle–Granger two-step procedure, this study employs the Gregory and Hansen (1996), hereafter GH, cointegration test, which allows for a structural break in the cointegrating vector. Gregory and Hansen argue that structural breaks can lead to the under-rejection of the null hypothesis of no cointegration.

Second, most previous studies focus on developed markets, and few examine both emerging and developed markets. In contrast, this study examines whether the Thai stock market is linked with the stock markets of its major trading partners. No existing study focuses specifically on the Thai stock market, although some include Thailand in their sample of countries (Masih and Masih, 1999; Chang, 2001; Ng, 2002; Sharma and Wongbangpo, 2002; Climent and Meneu, 2003; Worthington, Katsuura and Higgs, 2003; Phylaktis and Ravazzolo, 2005a).

This chapter investigates the long-run and short-run relationships between the Thai stock market and those of its major trading partners: Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States. These 11 countries have been chosen because of their relatively high share of Thai exports and imports. It should be noted that Japan and the United States are Thailand's two biggest trading partners. Malaysia, Singapore, Indonesia and the Philippines are all members of the Association of Southeast Asian Nations (ASEAN), which aims to remove trade barriers among its member countries. Hong Kong, Taiwan and Australia are also among Thailand's top-ten trading partners, followed by Korea and the United Kingdom, which are just outside the top ten.

There are many reasons why the stock markets of different countries may have significant co-movements. For example, global capital movements and the presence of economic ties and regional policy coordination among countries, can directly or indirectly interconnect their stock prices through time. According to Phylaktis and Ravazzolo (2005a), unlike other crises, the Asian crisis engulfed a group of countries that were both financially and economically integrated prior to the crisis. However, Chan, Gup and Pan (1997) argue that although common economic and geographic factors were considered as crucial factors, they were not necessarily major causes of national stock markets to follow the same stochastic trend. It is also argued that there is less evidence of stock market integration after major stock market crises, and hence international diversification among stock markets can be undertaken more effectively due to the lack of long-run co-movements of international stock prices (Patev, Kanaryan and Lyroudi, 2006). In the context of the Malaysian stock market, for example, Ibrahim and Aziz (2003) provide some evidence that the Asian crisis appears to have given rise to irregularity in the interactions between stock prices and macroeconomic variables.

A growing interest in the integration of international stock markets is evident in the number of empirical studies that examine the various aspects of stock market linkages. These studies were mainly motivated by the stock market crash in October 1987 and subsequent Asian financial crisis in 1997. For instance, Susmel and Engle (1994), Fraser and Power (1997), Kanas (1998b) and Fratzscher (2002) examine volatility spillovers across stock markets; while Phylaktis and Ravazzolo (2002) report their test results using international capital asset pricing models.

In addition to these studies, cointegration techniques in the literature are widely used to investigate the long-run relationships between stock markets. These studies can be classified into three groups. First, some focus mainly on developed markets in the United States, Canada, Europe and Japan (Kasa, 1992; Richards, 1995; Choudhry, 1996a; Kanas, 1998a; Hamori and Imamura, 2000; Ahlgren and Antell, 2002) and find some evidence that there are interdependent linkages among the stock markets of developed countries. Second, other studies in the literature examine the stock price linkages among only emerging stock markets, without capturing the important influence of stock markets in developed countries. They find only weak evidence of a relationship among the Asian stock markets (Chaudhuri, 1997; Sharma and Wongbangpo, 2002; Worthington, Katsuura and Higgs, 2003; Yang, Kolari and Min, 2003).

The last group of studies examines the interdependencies between developed and emerging markets but they do not incorporate the effect of possible structural changes in the long-run relationships, such as the 1987 great crash and the Asian financial crisis in 1997. Due to earlier inconclusive results, there is no consensus among previous studies as to whether international stock markets are interdependent. For instance, while Masih and Masih (1999) and Syriopoulos (2004) found some pair-wise long-run relationships between stock markets in developed countries and the stock markets of emerging countries, other studies (Chang, 2001; Ng, 2002; Climent and Meneu, 2003) do not find any empirical evidence suggesting that stock market dependence exists among such countries. These studies have deepened the understanding of the interplay among international stock market linkages; however, by allowing for a possible break in cointegration vectors, this study specifically examines the interplay between the stock markets in Thailand and 11 other countries, including both developed and emerging markets.

The 1997 Asian financial crisis first began with the floating of the Thai baht in July 1997, and, soon after, the crisis spread rapidly to the Philippines, Malaysia, Indonesia and Korea. Following this crisis, relatively small depreciations also engulfed Singapore and Japan (Barro, 2001). Therefore, Thailand can be considered as an important case among the other emerging markets. In 2004, on the Stock Exchange of Thailand (SET), market turnover was 93.8 percent, there were 465 listed domestic companies, and the value traded was 109,949 million U.S. dollars. The SET was classified as the ninth largest among emerging markets in terms of these three measures, and the nineteenth, twentieth and twenty-fourth on a global scale. In terms of market capitalization the SET reached a record high 115,400 million U.S. dollars, which ranked twelfth-highest among all emerging markets and thirty-first in the world (Standard and Poor's, 2005).

This chapter is structured as follows. Section 4.2 discusses briefly the empirical methodology adopted in this chapter. Section 4.3 presents the empirical results of cointegration and causality tests. Finally, Section 4.4 provides some concluding remarks.

4.2 EMPIRICAL METHODOLOGY

The augmented Dickey-Fuller (ADF) unit root test is initially performed to examine the time series properties of the data without allowing for any structural breaks. In addition, the Phillips-Perron (PP) test is used as an alternative nonparametric model to control for serial correlation. Using the PP test ensures that the higher-order serial correlations in the ADF equation are handled properly. That is, the ADF test corrects for higher-order autocorrelation by including lagged differenced terms on the right-hand side of the ADF equation; whereas the PP test corrects the ADF *t*-statistic by removing the serial correlation in it. This nonparametric t-test uses the Newey-West heteroscedasticity autocorrelation consistent estimate, and is robust to heteroscedasticity and autocorrelation of unknown form.

An important shortcoming associated with the ADF and PP tests is that they do not allow for the effect of structural breaks. Perron (1989) argues that if a structural break in a series is ignored, unit root tests can be erroneous in rejecting the null hypothesis. Zivot and Andrews, hereafter ZA, (1992) developed methods to search endogenously for a structural break in the data. Model C which allows for one structural break in both the intercept and slope coefficients has been employed. The ‘trimming region’ searching for TB covers the $0.15T$-$0.85T$ period, where T is the sample size. Following Chaudhuri and Wu (2003) and Narayan and Smyth (2005), the selected break point (TB) based on the minimum value of the t statistic for α. In this study, k_{max} is set equal to 12.

4.2.1 The Engle-Granger two-step Procedure

After determining the order of integration of each variable, testing for the existence of any long-run relationship between the stock prices of Thailand and its major trading partners is required. The Engle-Granger two-step procedure is employed first by obtaining the resulting residuals of the following equation, and then conducting a unit root test on them:

$$y_t = \mu_0 + \beta t + \varphi x_t + \varepsilon_t \tag{4.1}$$

where y_t and x_t are the natural log of the stock price indices of Thailand and one of its major trading partners, respectively.

According to Engle and Granger (1987), if both y_t and x_t are $I(1)$, and $\hat{\varepsilon}_t$ is $I(0)$, then a long-run relationship between these two variables exists. The resulting error correction model (ECM) from such a model can then be written as:

$$\Delta y_t = \phi + \sum_{i=0}^{k1} \lambda_i \Delta x_{t-i} + \sum_{i=1}^{k2} \delta_i \Delta y_{t-i} + \eta ECM_{t-1} + v_t \qquad (4.2)$$

where $\lambda_i s$ are the estimated short-term coefficients; $\delta_i s$ denotes the estimated coefficients of the lagged dependent variables added to ensure v_t or the disturbance term is white noise; η is the feedback effect capturing the speed of adjustment, whereby short-term dynamics converge to the long-term equilibrium path indicated in Equation (4.1); and ECM_t or $\hat{\varepsilon}_t$ is obtained from Equation (4.1) by the OLS method.

The general-to-specific methodology can then be used to omit insignificant variables in Equation (4.2) based on a battery of maximum likelihood tests. In this method joint zero restrictions are imposed on explanatory variables in the unrestricted (general) model to obtain a parsimonious model. The null hypothesis of no cointegration is rejected if $\eta < 0$ and is statistically significant.

4.2.2 The Gregory and Hansen (1996) Test

The lack of evidence of cointegration in previous studies in the literature could be attributed to the ignorance of the structural break in the cointegrating vector. To address this issue the GH (1996) test has also been utilized. GH (1996) postulate three alternative models, similar to those proposed by ZA (1992), to capture the changes in parameters of the cointegrating vector. First, the level shift model (*C*), which assumes a change only in the intercept, is as follows:

$$y_t = \mu_0 + \theta DU_t + \mu_1 x_t + \varepsilon_t \tag{4.3}$$

The second model, a level shift and change in trend (*C/T*), takes the form:

$$y_t = \mu_0 + \theta DU_t + \beta t + \mu_1 x_t + \varepsilon_t \tag{4.4}$$

The third model, which allows for changes in both the intercept and slope of the cointegration vector (*C/S*), is presented as:

$$y_t = \mu_0 + \theta DU_t + \beta t + \mu_1 x_t + \mu_2 x_t DU_t + \varepsilon_t \tag{4.5}$$

where DU_t is defined as previously in Equation (3.2).

Intuitively, within the range of 0.15*T*-0.85*T*, this technique searches for a particular *TB,* which minimizes the value of the ADF* statistic for $\hat{\varepsilon}_t$. The GH (1996) method tests the null hypothesis of no cointegration against the alternative hypothesis of cointegration with a single structural break at time *TB*, which is determined endogenously.

4.2.3 The Granger Causality Test

Finally, the Granger causality test, based on the error correction model specified in Equation (4.2), is conducted. A variable such as Δx_t (the stock returns) Granger causes Δy_t if its past values can explain Δy_t, but past values of Δy_t do not explain Δx_t (Granger, 1969). If the two variables are not cointegrated, and η in Equation (4.2) is not negative and significant, the following bivariate vector autoregressive (VAR) equations will then be used for the causality test:

$$\Delta y_t = \phi + \lambda_0 \Delta x_t + \sum_{i=1}^{k1} \lambda_i \Delta x_{t-i} + \sum_{i=1}^{k2} \delta_i \Delta y_{t-i} + v_t \tag{4.6}$$

$$\Delta x_t = \phi' + \lambda'_0 \Delta y_t + \sum_{i=1}^{k'1} \lambda'_i \Delta y_{t-i} + \sum_{i=1}^{k'2} \delta'_i \Delta x_{t-i} + v'_t \tag{4.7}$$

on the other hand, if y_t and x_t are cointegrated, these error correction models are adopted:

$$\Delta y_t = \phi + \lambda_0 \Delta x_t + \sum_{i=1}^{k1} \lambda_i \Delta x_{t-i} + \sum_{i=1}^{k2} \delta_i \Delta y_{t-i} + \eta ECM_{t-1} + v_t \tag{4.8}$$

$$\Delta x_t = \phi' + \lambda'_0 \Delta y_t + \sum_{i=1}^{k'1} \lambda'_i \Delta y_{t-i} + \sum_{i=1}^{k'2} \delta'_i \Delta x_{t-i} + \eta' ECM_{t-1} + v'_t \tag{4.9}$$

The Granger causality test can be conducted under two assumptions. First, if y_t and x_t are not cointegrated, then Equations (4.6) and (4.7) are used in order to test the following two null hypotheses: If in Equation (4.6) $H_o : \lambda_1 = \lambda_2 = ... = \lambda_{k1} = 0$ is rejected, then $\Delta x_t = \ln P_t^j - \ln P_{t-1}^j$, or the stock price return in country *j*, Granger causes $\Delta y_t = \ln P_t^i - \ln P_{t-1}^i$ or the stock price return in country *i*. This can be written as $\Delta x_t \to \Delta y_t$. Similarly, if, in Equation (4.7), $H_o' : \lambda_1' = \lambda_2' = ... = \lambda_{k1}' = 0$ is rejected, then the conclusion is that Δy_t causes Δx_t or $\Delta y_t \to \Delta x_t$. If both null hypotheses are rejected simultaneously there would be a bidirectional causality between the two variables, that is, $\Delta y_t \leftrightarrow \Delta x_t$. Second, if y_t and x_t are in fact cointegrated, then Equations (4.8) and (4.9) are employed to test the same two hypotheses. The inclusion of ECM in these two equations ensures that the long-term properties of the data are not lost when dealing with the first difference form. If in Equation (4.8) $H_o : \lambda_1 = \lambda_2 = ... = \lambda_{k1} = 0$ is rejected, then $\Delta x_t \to \Delta y_t$ (Δx_t Granger causes Δy_t). In the same way, if in Equation (4.9) $H_o' : \lambda_1' = \lambda_2' = ... = \lambda_{k1}' = 0$ is rejected then one can conclude that $\Delta y_t \to \Delta x_t$. If both H_o and H_o' are rejected the causality between the two variables is bidirectional, or $\Delta y_t \leftrightarrow \Delta x_t$.

TABLE 4.1
UNIT ROOT TEST RESULTS

Variable	ADF test		PP test	
	Constant and trend	Optimal lag	Constant and trend	Bandwidth
$\ln P_t^{TH}$	-2.372	12	-2.046	5
$\Delta \ln P_t^{TH}$	-4.656***	6	-14.169***	7
$\ln P_t^{AU}$	-2.573	0	-2.478	7
$\Delta \ln P_t^{AU}$	-9.002***	4	-16.265***	12
$\ln P_t^{HK}$	-2.086	0	-2.050	8
$\Delta \ln P_t^{HK}$	-14.003***	0	-14.001***	11
$\ln P_t^{IN}$	-3.350	8	-2.595	5
$\Delta \ln P_t^{IN}$	-10.271***	1	-12.274***	3
$\ln P_t^{JA}$	-2.188	0	-2.387	3
$\Delta \ln P_t^{JA}$	-14.151***	0	-14.151***	1
$\ln P_t^{KO}$	-1.668	0	-1.744	1
$\Delta \ln P_t^{KO}$	-14.103***	0	-14.103***	4
$\ln P_t^{MA}$	-3.053	9	-2.332	4
$\Delta \ln P_t^{MA}$	-3.862**	10	-12.440***	0
$\ln P_t^{PH}$	-2.099	1	-2.006	2
$\Delta \ln P_t^{PH}$	-11.696***	0	-11.700***	3
$\ln P_t^{SG}$	-2.537	0	-2.552	1
$\Delta \ln P_t^{SG}$	-14.393***	0	-14.393***	1
$\ln P_t^{TA}$	-3.759**	1	-4.068***	5
$\Delta \ln P_t^{TA}$	-13.130***	0	-13.145***	2
$\ln P_t^{UK}$	-1.551	2	-1.805	6
$\Delta \ln P_t^{UK}$	-13.546***	1	-15.718***	9
$\ln P_t^{US}$	-1.178	0	-1.146	3
$\Delta \ln P_t^{US}$	-15.805***	0	-15.794***	3

Notes: (a) ** and *** indicate that the corresponding null hypothesis is rejected at the 5 and 1 percent significance levels, respectively. (b) Critical values at the 5 and 1 percent are -3.43 and -4.00, respectively (MacKinnon, 1991).

4.3 DATA AND EMPIRICAL RESULTS

The data included in this study include the stock prices of these 12 countries: Thailand (TH), Australia (AU), Hong Kong (HK), Indonesia (IN), Japan (JA), Korea (KO), Malaysia (MA), the Philippines (PH), Singapore (SG), Taiwan (TA), the United Kingdom (UK) and the United States (US). Monthly data span December 1987 to December 2005, with a base value of 100 in December 1987. All stock price indices were obtained from Morgan Stanley Capital International (MSCI).

As mentioned earlier, the ADF and PP tests are used to determine the order of integration of the 12 stock prices studied. The lowest value of the AIC was used to determine the optimal lag length in the estimation procedure. Based on the results of the unit root tests presented in Table 4.1 the ADF and PP tests reject the random walk hypothesis for only the stock price index in Taiwan at the five and one percent significance levels, respectively. However, for all other countries, both unit root tests cannot reject the random walk hypothesis. Therefore, the conclusion is that the stock price indices in 11 out of the 12 countries are $I(1)$.

In the second stage, each variable has been subjected to one structural break. For each series the ZA test (model C) is conducted. As mentioned earlier, the ADF and PP test results reveal that most stock prices examined in this study follow a random walk; whereas the results of the ZA test show that stock prices for three countries (that is, Indonesia, Korea and Malaysia) are now stationary. Despite allowing for one endogenous structural break in the data the data in the remaining nine countries still contain a unit root. The estimated coefficients μ and θ are statistically significant for all variables, except for θ in the case of Philippine stock prices. There was at least one structural break in the intercept during the sample period for all stock prices. The estimated coefficients for β and γ are also statistically significant in eight and nine out of 12 countries, respectively, implying that the stock price series exhibits an upward or downward trend, and at least one structural break in trend in these countries exists.

The reported *TB*s in the second column of Table 3.3 were endogenously determined by the ZA test. It is not surprising that the endogenously-determined structural breaks in these stock prices occurred mostly in the Asian crisis period 1996–1997 (see *TB*s for Indonesia, Korea, Malaysia, Singapore, Thailand and the United States in Table 3.3).

Because the majority of the stock price indices are non-stationary the Engle-Granger cointegration test has been conducted. Table 4.2 shows the results of this test for all 12 countries. The results show that the null hypothesis of no cointegration cannot be rejected for all pair-wise cases. In order to make robust conclusions the GH test has also been employed, and the results are presented in Table 4.3. Similar to the Engle-Granger test results the results find that the Thai stock price index is not cointegrated with the stock prices of any other of the 11 countries in the sample. This means that there is no pair-wise long-run relationship between the stock prices in Thailand and its trading partners. More importantly, according to Table 4.3, the structural break in the cointegrating vector for most countries occurred in 1998 (the year after the 1997 Asian financial crisis). However, the cointegration test results remain robust even after capturing the structural breaks in cointegrating vectors.

In sum, similar results emerged from applying both the Engle-Granger test and the GH (1996) test to the data, suggesting that the Thai stock market is not cointegrated pair-wise with the stock markets of any of these countries: Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States. The results are also consistent with the previous findings of no cointegration between the Thai stock market and some regional stock markets, including those of South-East Asia (Ng, 2002) and the Pacific Basin (Chang, 2001; Climent and Meneu, 2003).

TABLE 4.2
THE ENGLE-GRANGER TWO-STEP TEST RESULTS

	t-statistics	
	ADF test on $\hat{\varepsilon}_t$ (Equation 4.3)[a]	$\hat{\eta}$ coefficient (Equation 4.4)
Thailand-Australia	-2.165(0)	-1.390
Thailand-Hong Kong	-2.412(12)	-0.771
Thailand-Indonesia	-2.965(0)	-1.270
Thailand-Japan	-2.098(0)	-1.520
Thailand-Korea	-2.117(0)	-2.190*
Thailand-Malaysia	-2.884(12)	0.109
Thailand-Philippines	-2.130(12)	-1.610
Thailand-Singapore	-1.297(2)	-0.885
Thailand-Taiwan	-2.406(12)	-1.470
Thailand-UK	-2.309(12)	-2.300*
Thailand-US	-2.468(12)	-3.050*

Notes: (a) The null (*i.e.* a unit root in $\hat{\varepsilon}_t$) cannot be rejected at the 5 percent level or better as the critical values at the 5 and 1 percent significance levels are -3.43 and -4.00, respectively (MacKinnon, 1991). (b) Figures in parentheses are the optimal lag length determined by the AIC.

TABLE 4.3
THE GREGORY AND HANSEN TEST RESULTS

Model	*TB*	ADF*	*k*
Thailand-Australia			
C	1998:06	-3.842	12
C/T	1998:07	-3.609	10
C/S	1998:06	-3.862	12
Thailand-Hong Kong			
C	1998:06	-3.527	12
C/T	2002:10	-3.797	12
C/S	1998:06	-3.444	12
Thailand-Indonesia			
C	1991:12	-3.526	8
C/T	1997:08	-3.301	8
C/S	1991:11	-3.476	8
Thailand-Japan			
C	1998:06	-3.130	12
C/T	1998:06	-3.896	12
C/S	1998:06	-3.129	12
Thailand-Korea			
C	1998:07	-2.719	10
C/T	1998:07	-3.413	10
C/S	1998:07	-2.660	10
Thailand-Malaysia			
C	1998:02	-3.755	12
C/T	2003:06	-3.752	12
C/S	1994:10	-3.461	12
Thailand-Philippines			
C	1995:04	-2.795	12
C/T	2001:09	-3.443	12
C/S	1998:06	-2.834	12
Thailand-Singapore			
C	1996:04	-2.909	12
C/T	2002:10	-3.675	12
C/S	1996:04	-2.908	12
Thailand-Taiwan			
C	1998:06	-3.166	12
C/T	1998:06	-3.706	12
C/S	1998:06	-3.037	12
Thailand-UK			
C	1998:06	-3.247	12
C/T	1998:06	-3.947	12
C/S	1998:06	-3.177	12
Thailand-US			
C	1992:04	-3.298	12
C/T	1998:06	-4.120	12
C/S	1996:07	-3.349	12
Critical values		5 percent	1 percent
C		-4.61	-5.13
C/T		-4.99	-5.45
C/S		-4.95	-5.47

Note: Given the reported critical values (Gregory and Hansen, 1996), the null is not rejected at the 5 and 1 percent levels of significance for any pair of countries.

TABLE 4.4
THE GRANGER CAUSALITY TEST RESULTS

Inference		Null hypothesis $H_o : \lambda_1 = \lambda_2 = ... = \lambda_{k1} = 0$ or $H'_o : \lambda'_1 = \lambda'_2 = ... = \lambda'_{k1} = 0$	
		F-statistic	Probability
No causality	$\Delta \ln P_t^{AU} \nrightarrow \Delta \ln P_t^{TH}$	1.034	0.399
No causality	$\Delta \ln P_t^{TH} \nrightarrow \Delta \ln P_t^{AU}$	1.817	0.111
Unidirectional causality	$\Delta \ln P_t^{HK} \rightarrow \Delta \ln P_t^{TH}$	7.013***	0.009
No causality	$\Delta \ln P_t^{TH} \nrightarrow \Delta \ln P_t^{HK}$	0.253	0.616
No causality	$\Delta \ln P_t^{IN} \nrightarrow \Delta \ln P_t^{TH}$	1.322	0.256
Unidirectional causality	$\Delta \ln P_t^{TH} \rightarrow \Delta \ln P_t^{IN}$	4.290***	0.001
No causality	$\Delta \ln P_t^{JA} \nrightarrow \Delta \ln P_t^{TH}$	0.144	0.704
No causality	$\Delta \ln P_t^{TH} \nrightarrow \Delta \ln P_t^{JA}$	1.720	0.191
No causality	$\Delta \ln P_t^{KO} \nrightarrow \Delta \ln P_t^{TH}$	0.358	0.550
No causality	$\Delta \ln P_t^{TH} \nrightarrow \Delta \ln P_t^{KO}$	0.404	0.526
Bidirectional causality $\Delta \ln P_t^{TH} \leftrightarrow \Delta \ln P_t^{MA}$	$\Delta \ln P_t^{MA} \rightarrow \Delta \ln P_t^{TH}$	1.870**	0.046
	$\Delta \ln P_t^{TH} \rightarrow \Delta \ln P_t^{MA}$	3.771***	0.000
Unidirectional causality	$\Delta \ln P_t^{PH} \rightarrow \Delta \ln P_t^{TH}$	1.936**	0.049
No causality	$\Delta \ln P_t^{TH} \nrightarrow \Delta \ln P_t^{PH}$	1.628	0.110
Bidirectional causality $\Delta \ln P_t^{TH} \leftrightarrow \Delta \ln P_t^{SG}$	$\Delta \ln P_t^{SG} \rightarrow \Delta \ln P_t^{TH}$	2.322*	0.076
	$\Delta \ln P_t^{TH} \rightarrow \Delta \ln P_t^{SG}$	2.633*	0.051
Bidirectional causality $\Delta \ln P_t^{TH} \leftrightarrow \Delta \ln P_t^{TA}$	$\Delta \ln P_t^{TA} \rightarrow \Delta \ln P_t^{TH}$	2.690**	0.011
	$\Delta \ln P_t^{TH} \rightarrow \Delta \ln P_t^{TA}$	1.798*	0.090
Unidirectional causality	$\Delta \ln P_t^{UK} \rightarrow \Delta \ln P_t^{TH}$	3.358***	0.006
No causality	$\Delta \ln P_t^{TH} \nrightarrow \Delta \ln P_t^{UK}$	1.577	0.168
No causality	$\Delta \ln P_t^{US} \nrightarrow \Delta \ln P_t^{TH}$	1.422	0.190
Unidirectional causality	$\Delta \ln P_t^{TH} \rightarrow \Delta \ln P_t^{US}$	2.335**	0.020

Note: *, ** and *** indicate that the corresponding null hypothesis is rejected at the 10, 5 and 1 percent significance levels, respectively.

Finally, in the absence of long-run relationships between the stock prices of Thailand and its major trading partners, the Granger causality test was then utilized to examine the pair-wise short-run interactions between different stock markets. Table 4.4 presents the results of the Granger causality tests. The Wald *F*-statistics are calculated to test the null hypotheses outlined in the previous section. According to the results presented in Table 4.4, in the short term there is a unidirectional Granger causality running from the stock returns of Hong Kong, the Philippines and the United Kingdom to that of Thailand. On the other hand, there is a unidirectional Granger causality from Thailand's stock return to the stock returns of Indonesia and the United States. Summers (2000) argues that a financial crisis in one country, however big or small, can adversely and psychologically affect investors' perceptions and expectations in other countries. Investors' reactions to acute market shocks when coincided with unwise government policy responses can influence the other markets. For example, the Asian crisis influenced the other stock markets in the world (including the United States market) as investors started panicking that the financial downturn could also engulf their market due to knock-on effects across international markets. This could partially explain why the stock market return in such a small country such as Thailand Granger influences the return in the United States market.

A bidirectional Granger causality has been found between stock market returns in Thailand and its three neighboring countries (that is, Malaysia, Singapore and Taiwan). Therefore, the short-run movements of stock returns in these three countries can influence the performance of Thailand’s stock market. It can also be concluded that any short-run variation of the stock returns in Thailand can affect the market returns of its three neighboring countries, and vice versa. Hence, in order to avoid financial contagion and future crises similar to the one which occurred in 1997, central bankers and individual investors must keep abreast of new developments in international stock markets — particularly those for which have been found the evidence of bidirectional and unidirectional causality.

4.4 SUMMARY AND CONCLUDING REMARKS

This study examines the long-run and short-run relationships between the stock prices of Thailand and its major trading partners (Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States), using monthly data for the period December 1987 to December 2005. In addition to the Engle-Granger two-step procedure, the Gregory and Hansen (1996) test, which allows for a structural break in the cointegration vector, has been used.

Based on the cointegration results there is no evidence of long-run relationships between the stock price indices of Thailand and its major trading partners. The policy implication of this finding for international investors is quite straightforward: in the long run, there are potential gains (for example, reduced systematic risks) which can be leveraged by astute investors through portfolio diversification across different international markets.

Second, in terms of short-run movements of international stock market returns the results pointed to three pairwise unidirectional Granger causalities, whereby the returns in Hong Kong, the Philippines and the United Kingdom can Granger cause the return in Thailand. Based on these results the performance of stock markets in Honk Kong, the Philippines and the United Kingdom may have a direct bearing on the Thai stock market. However, there were also two unidirectional Granger causalities running from Thailand to Indonesia and the United States. Thus any abnormal movement in Thailand's stock returns could lead to similar changes in Indonesia and the United States. Third, the result found evidence of bidirectional Granger causality between the stock returns in Thailand and those of three of its neighboring countries (that is, Malaysia, Singapore and Taiwan). The reported causality test results are useful for any assessment of the Asian stock markets. For example, the interplay between these three pairs of countries (Thailand–Malaysia, Thailand–Singapore and Thailand–Taiwan) can be useful for central bankers and international investors alike in evaluating stock market performance.

The empirical results presented in this study support the view that international investors have long-run opportunities for portfolio diversification by acquiring stocks from these 11 countries. However, in the short-run the scope of these opportunities is rather limited due to systematic and transitory fluctuations which are inherent to stock markets as evidenced by the causality test results.

CHAPTER 5

A FACTOR ANALYSIS OF INTERNATIONAL PORTFOLIO DIVERSIFICATION MARKETS

5.1 INTRODUCTION

The main objective of this chapter is to investigate the relationship between the stock market returns of 13 countries, namely Australia, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, the United Kingdom and the United States, using factor analysis to investigate the systematic covariation of stock market returns. The results shed light on the scope for risk diversification and increased returns through international diversification of stock across developed and developing countries.

Since the time that Grubel (1968) extended the concepts of modern portfolio analysis to international capital markets, a large number of empirical studies have examined the advantages of international diversification. Early studies, such as Levy and Sarnat (1970), Lessard (1973), Ripley (1973) and Eun and Resnick (1988), investigated the performance of ex-post efficient portfolios and demonstrated that the benefits of internationally diversified portfolios stem from the fact that co-movements between different national stock markets are low.

More recently there has been a growing interest in international portfolio diversification, exemplified by a number of empirical studies examining various aspects of stock market co-movements. Previous studies have adopted different methodologies in the context of international equity market integration. The traditional approach has been to look at the estimates of correlation coefficients between national stock prices, with the argument being that if the correlation structure demonstrates stability over time then, assuming that the correlation is on an upward trajectory, this indicates greater integration. Based upon this approach Bailey and Stulz (1990) and Meric and Meric (1997) find that international diversification is possible, however the preponderance of the literature indicates that there is instability in the relationship (Wahab and Lashgari, 1993; Longin and Solnik, 1995).

A second approach emphasizes the cointegration technique to evaluate the degree of international integration in stock markets. Arshanapalli and Doukas (1993), Chaudhuri (1997), Narayan and Smyth (2004) and Syriopoulos (2004) find some evidence of a long-run relationship among all countries in their studies, implying that attempts by investors to diversify risk and attain superior portfolio returns by investing in different markets may have limited potential. Nevertheless, DeFusco, Geppert and Tsetsekos (1996), Kanas (1998a), Worthington, Katsuura and Higgs (2003) and Phylaktis and Ravazzolo (2005a) argue that the long term relationships between stock markets are much weaker indicating that investors have opportunities for reducing risk and enhancing returns through portfolio diversification investment in different countries.

A third approach employs the generalized autoregressive conditional heteroscedasticity (GARCH) model to capture potential asymmetric effects of innovations on volatility. Bekaert and Harvey (1995), Fratzscher (2002) and Fernandez-Izquierdo and Lafuente (2004) find that a number of stock markets exhibit a high degree of integration. Similar results were found by Longin and Solnik (1995) and Christofi and Pericli (1999) who use correlation and covariance matrix estimates that provide evidence of increased integration, implying fewer opportunities to diversify risk and increase returns across various stock markets.

A final approach involves the use of factor analysis to search for systematic variation patterns among stock markets. An early study by Ripley (1973) found evidence that major stock markets moved together. Subsequently, Hui and Kwan (1994), Naughton (1996) and Hui (2005) employed factor analysis to examine the systematic variation patterns among the United States and Asia-Pacific stock markets. Illueca and Lafuente (2002), Fernandez-Izquierdo and Lafuente (2004) used the same technique to investigate the systematic covariation of stock prices for four international areas, *i.e.* Europe, Asia, North and South America. Consistent with these findings, their results mostly reveal that the computed factor loadings are in accord with international geographic clustering.

This chapter is organized as follows. Section 5.2 presents briefly the empirical methodology utilized in this chapter. Section 5.3 discusses the data and empirical results followed by some concluding remarks.

5.2 EMPIRICAL METHODOLOGY

Traditional factor analysis assumes that time series data do not have a unit root in time series data. As discussed in previous chapters the empirical results indicate that, with or without capturing the endogenously-determined one or two structural breaks, the stock price indices (P_t) are mainly $I(1)$ and the stock market returns $\ln(P_t / P_{t-1})$ are $I(0)$. Correlation analysis has been used in earlier studies of stock market integration, where the higher the correlation coefficient the greater the evidence of stock market linkages across countries.

Factor analysis is one of the most well known methods of classical multivariate analysis (Hair et al., 1998; Tabachnick and Fidell, 2001; Tsay, 2002). The objective is to obtain a reduced set of uncorrelated latent variables using a set of linear combinations of the original variables, so as to maximize the variance of these components. Specifically, for a given multivariate set of k variables the model can be described as follows:

$$\begin{cases} r_1 - \mu_1 = l_{11} f_1 + l_{12} f_2 + \ldots + l_{1m} f_m + \varepsilon_1 \\ r_2 - \mu_2 = l_{21} f_1 + l_{22} f_2 + \ldots + l_{2m} f_m + \varepsilon_2 \\ \qquad \vdots = \vdots \\ r_k - \mu_k = l_{k1} f_1 + l_{k2} f_2 + \ldots + l_{km} f_m + \varepsilon_k \end{cases} \tag{5.1}$$

or in matrix notation can be written:

$$\boldsymbol{r} - \boldsymbol{\mu} = \boldsymbol{LF} + \boldsymbol{\varepsilon} \tag{5.2}$$

with $m < k$ and where $\boldsymbol{r} = (r_1, r_2, \ldots, r_k)'$ denotes the multivariate vector of stock returns, $\boldsymbol{\mu} = (\mu_1, \mu_2, \ldots, \mu_k)'$ is the corresponding mean vector, $\boldsymbol{F} = (f_1, f_2, \ldots, f_m)'$

is the resulting common factor vector, $\boldsymbol{L} = [l_{ij}]_{k\times m}$ is the matrix of factor loadings, l_{ij} denotes the loading of the i^{th} variable on the j^{th} factor and $\boldsymbol{\varepsilon} = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_k)'$ is the specific error of r_i.

5.2.1 Factor Estimation Methods

The orthogonal factor model in Equation (5.2) can be estimated by principle component (PC) analysis which does not require the normality assumption of the data and the prior specification of the number of common factors. Depending on the measurement scale of the variables included, this method can be used based on both the covariance and correlation matrixes. The maximum likelihood (ML) method is the second most widely used estimation method, and is based, on the other hand, on the normal density function and requires a pre-specification of the number of common factors.

First the PC method is briefly discussed. Let assume that $(\hat{\lambda}_1, \hat{\boldsymbol{e}}_1), (\hat{\lambda}_2, \hat{\boldsymbol{e}}_2), \ldots, (\hat{\lambda}_k, \hat{\boldsymbol{e}}_k)$ are pairs of eigenvalues and eigenvectors of the sample covariance matrix $\hat{\Sigma}_r$, where $\hat{\lambda}_1 \geq \hat{\lambda}_2 \geq \ldots \geq \hat{\lambda}_k$ and $m < k$ means that the number of latent common factors should be less than the number of original variables. The matrix of factor loading can be defined as follows:

$$\hat{\boldsymbol{L}} \equiv [\hat{l}_{ij}] = \left[\sqrt{\hat{\lambda}_1}\hat{\boldsymbol{e}}_1 \mid \sqrt{\hat{\lambda}_2}\hat{\boldsymbol{e}}_2 \mid \ldots \mid \sqrt{\hat{\lambda}_m}\hat{\boldsymbol{e}}_m \right] \tag{5.3}$$

The diagonal elements of the matrix $\hat{\Sigma}_r - \hat{\boldsymbol{L}}\hat{\boldsymbol{L}}'$ consist of the estimated specific variances. This means that $\hat{\boldsymbol{\Psi}} = \operatorname{diag}\{\hat{\Psi}_1, \hat{\Psi}_2, \ldots, \hat{\Psi}_k\}$, where $\hat{\Psi}_i = \hat{\sigma}_{ii,r} - \sum_{j=1}^{m} \hat{l}_{ij}^2$, and $\hat{\sigma}_{ii,r}$ is the $(i,\ i)^{\text{th}}$ element of $\hat{\Sigma}_r$. The communalities can be estimated by $\hat{c}_i^2 = \hat{l}_{i1}^2 + \hat{l}_{i2}^2 + \ldots + \hat{l}_{im}^2$. Using this method the error matrix associated with the approximation is equal to $\hat{\Sigma}_r - (\hat{\boldsymbol{L}}\hat{\boldsymbol{L}}' + \hat{\boldsymbol{\Psi}})$, which should ideally be a null matrix. The sum of squared elements of $\hat{\Sigma}_r - (\hat{\boldsymbol{L}}\hat{\boldsymbol{L}}' + \hat{\boldsymbol{\Psi}})$ is always less than or equal to $\hat{\lambda}_{m+1}^2 + \hat{\lambda}_{m+2}^2 + \ldots + \hat{\lambda}_k^2$. Hence the resulting approximation error is determined by the sum of squares of the excluded eigenvalues. According to the solution in Equation (5.3), as the number of common factors or *m* increases the computed factor loadings remain unchanged

In the ML method, on the other hand, it is assumed that the common factors (or $\boldsymbol{F}$) and the specific factors (or $\boldsymbol{\varepsilon}$) are jointly normal. Then, the conclusion is that $\boldsymbol{r}$ is multivariate normal with mean $\boldsymbol{\mu}$ and covariance matrix $\Sigma_r = \boldsymbol{L}\boldsymbol{L}' + \boldsymbol{\Psi}$. Therefore, one can use the ML method to estimate $\boldsymbol{L}$ and $\boldsymbol{\Psi}$ subject to $\boldsymbol{L}'\boldsymbol{\Psi}^{-1}\boldsymbol{L} = \Delta$, which is a diagonal matrix. The sample mean can be considered as a proxy for $\boldsymbol{\mu}$. For a detailed account of this method, see Johnson and Wichern (2002). In this method the number of common factors should be known *a priori*.

5.2.2 Factor Rotation

If $\boldsymbol{P}$ is a $m \times m$ orthogonal matrix the following relations can be written: $\boldsymbol{LL}' + \Psi = \boldsymbol{LPP}'\boldsymbol{L}' + \Psi = \boldsymbol{L}^*(\boldsymbol{L}^*)' + \Psi$ and $\boldsymbol{r} - \boldsymbol{\mu} = \boldsymbol{LF} + \boldsymbol{\varepsilon} = \boldsymbol{L}^*\boldsymbol{F}^* + \boldsymbol{\varepsilon}$ in which $\boldsymbol{L}^* = \boldsymbol{LP}$ and $\boldsymbol{F}^* = \boldsymbol{P}'\boldsymbol{F}$. Under an orthogonal transformation the communalities and the specific variances do not change. Thus, it is possible to find $\boldsymbol{P}$ (an orthogonal matrix) to transform the factor model in such a way that the loadings on the common factors are easier to interpret. This transformation involves rotating the common factors in the *m*-dimensional space. In practice there are many ways for rotating the common factors. The Varimax method is a rotation method which is widely used in the literature and works well in many applications. Let the rotated matrix of factor loadings be $\boldsymbol{L}^* = [\ell^*_{ij}]$ and the i^{th} communalities are shown by c_i^2. Then, $\tilde{\ell}^*_{ij} = \ell^*_{ij} / c_i$ can be defined as the rotated coefficients scaled by the (positive) square root of communalities. In the Varimax method the orthogonal matrix $\boldsymbol{P}$ is chosen in such a manner that it maximizes the quantity of:

$$V = \frac{1}{k} \sum_{j=1}^{m} \left[\sum_{i=1}^{k} (\tilde{\ell}^*_{ij})^4 - \frac{1}{k} \left(\sum_{i=1}^{k} \tilde{\ell}^{*2}_{ij} \right)^2 \right] \tag{5.4}$$

The interpretation of this relation is straightforward. When V is maximized it means that the squares of the loadings on each factor are spread out as much as possible. The aim is to facilitate the interpretations of common factors by finding groups of very large and very small coefficients in any column of the rotated matrix of factor loadings.

5.3 DATA AND EMPIRICAL RESULTS

The data in this study include stock prices (*P*) of the following 13 countries: Australia (AU), Germany (GE), Hong Kong (HK), Indonesia (IN), Japan (JA), Korea (KO), Malaysia (MA), the Philippines (PH), Singapore (SG), Taiwan (TA), Thailand (TH), the United Kingdom (UK) and the United States (US). Monthly data span from December 1987 to April 2007 with a base value of 100 in December 1987. All stock indices were obtained from Morgan Stanley Capital International.

Table 5.1 illustrates the extent to which 13 stock market returns are correlated pairwise in a matrix. Out of 78 cells below the main diagonal there are 61 correlation coefficients (shown in boldface letters) above +0.30 which are also statistically significant. The highest correlation coefficients belong to Singapore-Hong Kong (0.714); Singapore-Malaysia (0.659); Thailand-Singapore (0.645); and the United States-United Kingdom (0.645). It is interesting that pairwise the highest correlation coefficients are between the countries in the same region and/or at a similar stage of economic development.

TABLE 5.1
CORRELATION AND ANTI-IMAGE CORRELATION COEFFICIENTS FOR 13 SELECTED STOCK MARKETS

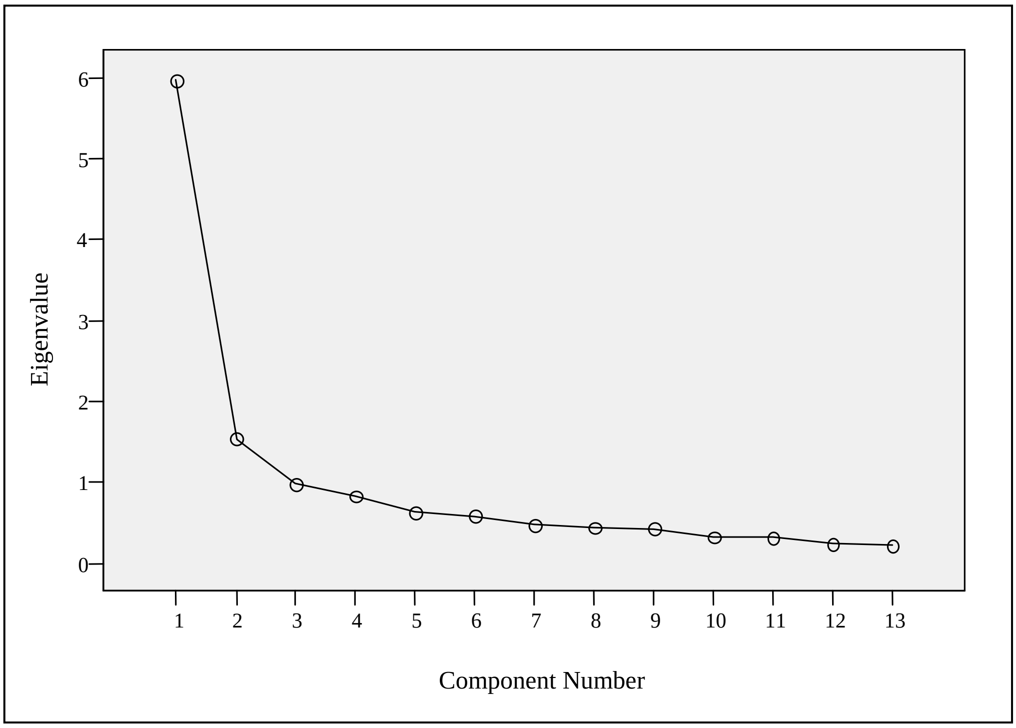
Country	AU	GE	HK	IN	JA	KO	MA	PH	SG	TA	TH	UK	US
Correlation Coefficients													
Australia	1.000												
Germany	**0.458**	1.000											
Hong Kong	**0.476**	**0.408**	1.000										
Indonesia	0.287	0.219	**0.398**	1.000									
Japan	**0.406**	**0.322**	**0.342**	0.146	1.000								
Korea	**0.414**	0.235	**0.332**	**0.340**	**0.453**	1.000							
Malaysia	**0.306**	**0.337**	**0.558**	**0.479**	0.248	**0.319**	1.000						
Philippines	**0.400**	0.291	**0.537**	**0.496**	0.221	0.272	**0.543**	1.000					
Singapore	**0.514**	**0.440**	**0.714**	**0.515**	**0.386**	**0.389**	**0.659**	**0.606**	1.000				
Taiwan	0.260	**0.307**	**0.389**	0.181	0.220	**0.313**	**0.396**	**0.388**	**0.430**	1.000			
Thailand	**0.482**	**0.335**	**0.537**	**0.463**	**0.326**	**0.502**	**0.558**	**0.614**	**0.645**	**0.407**	1.000		
UK	**0.568**	**0.655**	**0.484**	0.161	**0.467**	**0.313**	**0.318**	0.245	**0.492**	0.171	0.298	1.000	
US	**0.504**	**0.608**	**0.506**	0.269	**0.348**	**0.360**	**0.336**	**0.376**	**0.547**	0.299	**0.437**	**0.645**	1.000
Anti-image Correlation Coefficients													
Australia	**0.931**												
Germany	-0.061	**0.871**											
Hong Kong	-0.063	0.042	**0.943**										
Indonesia	-0.022	-0.073	-0.017	**0.876**									
Japan	-0.066	-0.002	-0.019	0.090	**0.892**								
Korea	-0.129	0.117	0.031	-0.200	-0.299	**0.837**							
Malaysia	0.149	-0.070	-0.122	-0.159	0.027	-0.026	**0.915**						
Philippines	-0.107	0.019	-0.116	-0.209	-0.003	0.147	-0.122	**0.914**					
Singapore	-0.075	0.045	-0.319	-0.197	-0.097	0.071	-0.273	-0.101	**0.915**				
Taiwan	0.004	-0.188	-0.090	0.182	-0.022	-0.158	-0.117	-0.121	-0.112	**0.874**			
Thailand	-0.158	-0.038	-0.035	-0.027	-0.012	-0.281	-0.146	-0.272	-0.180	-0.039	**0.912**		
UK	-0.267	-0.395	-0.136	0.132	-0.223	-0.039	-0.080	0.085	-0.114	0.195	0.153	**0.822**	
US	-0.025	-0.265	-0.077	0.001	0.057	-0.103	0.127	-0.062	-0.134	-0.037	-0.079	-0.298	**0.916**

Notes: (a) Boldfaced figures in the correlation coefficient matrix are significant at the 5 percent significance level. (b) The boldfaced elements on the main diagonal of the anti-image matrix are referred to as the measures of sampling adequacy (MSA) and computed as $MSA_i = \sum_{i \neq j} r_{ij}^2 \Big/ \left(\sum_{i \neq j} r_{ij}^2 + \sum_{i \neq j} a_{ij}^2 \right)$ where r_{ij} is the simple correlation coefficient between variables i and j and a_{ij} is the partial correlation coefficient between variables i and j. The minimum acceptable value of MSA is usually above 0.50.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was as high as 0.898 and the Bartlett test of sphericity rejected the null hypothesis that the correlation matrix was an identity matrix. The anti-image correlation coefficient matrix has also been reported in the bottom of Table 5.1 to provide detailed assessment of the sampling adequacy for the individual variables included in factor analysis. As can be seen the elements on the main diagonal of this matrix are above 0.822, which is larger than the acceptable level of 0.50.

In order to obtain a clearer picture of groupings of stock markets based on the co-movement of returns, a factor analysis of the correlation matrix can now be conducted. The resulting eigenvalues for only the first two common factors were greater than unity. The same conclusion has been reached using the Scree plot (presented in Figure 5.1) as a criterion to determine the number of common factors. The proportion (percent) of variance explained by each factor is also shown in Table 5.2, indicating that these two factors altogether account for about 58 percent of the total variance using the PC method (first factor = 46 percent, second factor = 12 percent) and 51 percent of the total variance using the ML method (first factor = 42 percent, second factor = 9.5 percent).

FIGURE 5.1
THE SCREE PLOT



Source: Author's calculations

The resulting factors were then rotated by the Varimax method to facilitate the interpretation of the results presented in Table 5.2. As can be seen the first factor has relatively large weights for all eight Asian countries (the Philippines, Malaysia, Thailand, Singapore, Indonesia, Hong Kong, Taiwan and Korea), but relatively lower loadings for all of the developed countries including Japan which is the only country from Asia. Thus, one can argue that the first factor relating to the eight Asian countries in the sample is geographic proximity. Therefore, an investor may not be able to reduce risk and increase returns substantially by diversifying their financial portfolios through purchasing only the stocks of these countries, because these returns are highly correlated. The second factor, which represents the co-movements of the stock returns in developed countries, has the highest loadings for the United Kingdom, Germany, the United States, Australia and Japan (all classified as more advanced countries) while at the same time having relatively lower weights for the remaining countries.

The results are robust and consistent for both the PC and ML methods. Even excluding countries with communalities less than 0.5 produces highly robust results in that the remaining Asian countries (Indonesia, Hong Kong, Malaysia, the Philippines, Singapore and Thailand) and developed countries (Australia, Germany, the United Kingdom and the United States) exhibit a factor loading distribution similar to that shown in Table 5.2.

TABLE 5.2
FACTOR ANALYSIS OF CORRELATION MATRIX

Country	Rotated factor loadings		Country	Rotated factor loadings	
	Factor 1	Factor 2		Factor 1	Factor 2
Principal Component Method			Maximum Likelihood Method		
Philippines	**0.789**	0.159	Singapore	**0.746**	0.449
Malaysia	**0.767**	0.194	Thailand	**0.740**	0.260
Thailand	**0.763**	0.293	Philippines	**0.726**	0.187
Singapore	**0.744**	0.449	Malaysia	**0.693**	0.248
Indonesia	**0.718**	0.042	Hong Kong	**0.624**	0.452
Hong Kong	**0.637**	0.456	Indonesia	**0.609**	0.108
Taiwan	**0.528**	0.206	Taiwan	**0.482**	0.170
Korea	**0.422**	0.401	Korea	**0.406**	0.308
UK	0.101	**0.884**	UK	0.101	**0.916**
Germany	0.176	**0.760**	Germany	0.207	**0.691**
US	0.289	**0.752**	US	0.325	**0.679**
Australia	0.334	**0.670**	Australia	0.365	**0.578**
Japan	0.171	**0.618**	Japan	0.230	**0.476**
% of variance	45.917	11.859	% of variance	41.741	9.463
Cumulative %	45.917	57.775	Cumulative %	41.741	51.203

Note: The highest factor loadings in each common factor are shown in boldface figures.

5.4 SUMMARY AND CONCLUDING REMARKS

This chapter has used monthly data (1987:M12-2007:M4) to examine the extent to which returns in 13 selected international stock markets (Australia, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, the United Kingdom and the United States) are correlated, and whether these relationships can be analyzed in a meaningful manner for the purpose of cross-country financial diversification. The results derived from a factor analysis, using both the PC and ML procedures, indicate that stock markets are integrated among Asian countries. More specifically, the rotated factor loadings of the first common factor provide ample evidence that the returns in Singapore, Thailand, the Philippines, Malaysia, Hong Kong, Indonesia, Taiwan and Korea enjoy a high degree of linear association. Based on the rotated loadings of the second factor using both the PC and ML methods it was found that the stock returns in all five developed countries (the United Kingdom, Germany, the United States, Australia and Japan) can be represented by a well separated common factor in terms of their co-movements during the period December 1987 to April 2007.

Overall, the results confirm that the cross country co-movements of stock market returns, defined as $\ln(P_t / P_{t-1})$, depend, *inter alia*, on geographical location and/or the level of economic development. Therefore, if the aim of an astute investor is to reduce systematic investment risk across countries, his or her financial portfolio should include a diversified range of international stocks from various continents and from both developed and developing countries with varying degrees of stock market maturities.

CHAPTER 6

THE INFLUENCE OF INTERNATIONAL STOCK MARKETS AND MACROECONOMIC VARIABLES ON THE THAI STOCK MARKET

6.1 INTRODUCTION

The results from the previous chapter confirm that the co-movements of stock markets depend on geographical location and/or the level of economic development. As Bekaert and Harvey (1997) argue, analyzing the possible impact of liberalization on stock market volatility is profoundly important for policymakers and regulators in their deliberations on the costs and benefits of liberalization programs. Thus, besides examining stock market return interdependencies between stock markets of Thailand and international countries, the attention is now placed to the volatility of the Thai stock market before and after the Asian financial crisis and the exploration of the volatility interdependencies across markets.

The purpose of this chapter is to examine the impact of international stock markets and domestic macroeconomic variables on the Thai stock market, in the pre- and post-1997 Asian crisis period, by applying various GARCH models. The main reason to use GARCH pertains to the fact that the variance of forecast errors depends on the size of the preceding disturbances. A generalized form of the conditional heteroscedasticity allows for lagged variances and further lagged values of the error term. Consequently, it is naturally expected that the GARCH model is an efficient way to deal with volatility clustering observed in residuals which usually occur in stock price data. The results presented in this chapter are the first to investigate the impact of international linkages and macroeconomic variables on the Thai stock market, using a GARCH-M model.

Stock market volatility now appears to move rapidly across countries. This has been possibly affected by the liberalization of capital markets in the past two decades. A clearer understanding of stock market determinants is very important for investors, regulators and academic researchers. Therefore, increased knowledge of stock market determinants is necessary in the settlement of pricing, hedging and regulatory policies.

A number of analysts have investigated the impact of macroeconomic variables and international linkages on stock returns. Most of these studies, however, have focused on developed markets by using the Autoregressive Conditional Heteroscedasticity (ARCH) model and the Generalized ARCH (GARCH) model. For instance, Schwert (1989) and Flannery and Protopapadakis (2002) tested the effect of domestic macroeconomic variables on stock volatility for the United States. They found weak evidence that such factors could predict stock market returns, which are inherently volatile.

Moreover, Hamao, Masulis and Ng (1990), Bae and Karolyi (1994) and Susmel and Engle (1994) focused on the international spillover of stock returns volatility between Japan, the United Kingdom and the United States and found some evidence of volatility spillovers between these markets. In addition, the effect of foreign stock markets and macroeconomic news on the Australian stock market were further investigated by Kim and In (2002). The results indicated that the movements of the major stock markets (namely Japan, the United Kingdom and the United States) and some macroeconomic news significantly influence the Australian stock market.

Other studies have examined the impact of macroeconomic variables and international linkages on the Thai stock market. Granger, Huang and Yang (2000) and Phylaktis and Ravazzolo (2005b) employed a cointegration model. Fang (2002) and Caporale, Pittis and Spagnolo (2002) used a GARCH model to analyze the relationship between stock returns and the exchange rate. Most studies find that the exchange rate positively leads stock returns in Thailand.

In addition, Liu, Pan and Fung (1996) and Liu, Pan and Shieh (1998) used vector autoregressive analysis and cointegration models to investigate the international linkages between the stock markets of the United States and Asia-Pacific countries. The results indicated that the United States market influenced the conditional volatility of most Asian markets. Japan and Singapore had a significant and persistent impact on other Asian markets. On the other hand, Ng (2002), Baharumshah, Sarmidi and Tan (2003) and Phylaktis and Ravazzolo (2005a) reported no evidence to indicate that the international linkages among the South-East Asian stock markets was significant. In *et al*. (2001), however, using a GARCH model found significant volatility linkages between Korea and Thailand. Hence there is no consensus on the nature of these relationships.

In the 1990s, most stock markets in Asia experienced considerable growth and turbulence. This process resulted in a profound change in

Thailand's economy. The Stock Exchange of Thailand (SET) significantly influences Thai economic development by providing a mechanism for resource re-allocation between different sectors of the Thai economy. As a rapidly developing emerging market the SET also plays an important role in a worldwide context by affecting international capital flows. The experience of the Thai stock market is probably typical of Asian stock markets in general because of its manageable size and diverse characteristics (Bos, Ding and Fetherston, 1998; Chusanachoti and Kamath, 2002). An understanding of the mechanisms of the Thai stock market's dynamics is, therefore, very important.

The rest of this chapter is structured as follows. Section 6.2 describes the data employed and presents the summary statistics as well as the unit root test results. Section 6.3 briefly discusses the GARCH models from a theoretical perspective in identifying the major determinants of Thai stock price variations. Section 6.4 presents various estimates of a model capturing the volatility of stock price returns and discusses the major findings from this study. Finally, Section 6.5 provides conclusions.

6.2 DATA AND EMPIRICAL METHODOLOGY

This study uses the stock price index of Thailand (TH) which is based on market capitalization, and calculated from the prices of all common stock on the market board. Moreover, 15 other international stock price indices from various regions have been utilized, including the following countries: Argentina (AR), Australia (AU), Brazil (BA), Germany (GE), Hong Kong

(HK), Indonesia (IN), Japan (JA), Korea (KO), Malaysia (MA), the Philippines (PH), Russia (RU), Singapore (SG), Taiwan (TA), the United Kingdom (UK) and the United States (US). Monthly data are used covering the period January 1988 to December 2004 with a base value of 100 in December 1987, except for the stock price index of Russia covering the period December 1994 to December 2004 which has a base value of 100 in December 1994. This different base year has been modified accordingly. All stock indices were obtained from Morgan Stanley Capital International (MSCI).

In addition, the macroeconomic variables selected for Thailand include the consumer price index (CPI), the exchange rate (EX), the interest rate (on money) (MR), the money supply (M2) and oil price (OP) and were obtained from the International Financial Statistics (IFS) database (these five macroeconomic variables will be included in Equation (6.1) in the next section). All variables used are monthly observations spanning the time period from January 1988 to December 2004 and are expressed in terms of growth rates.

Table 6.1 presents the descriptive statistics of the data. Sample means, medians, maximums, minimums, standard deviations, skewness, kurtosis as well as the Jarque-Bera statistics and *p*-values are presented. The highest mean return is 0.013 percent in Russia and the lowest is -0.001 percent in Japan. The standard deviations range from 0.010 percent (the least volatile) for the growth rate of the money supply to 0.232 percent (the most volatile) for the growth of the interest rate. The standard deviations of stock price indices are lowest in the developed economies of the United States, the United Kingdom, Australia, Germany, Japan and Singapore, while, on the other hand, the most volatile are in Russia, Brazil, Argentina, Indonesia, Thailand and Taiwan, respectively. All stock returns have excess kurtosis which means that they have a thicker tail and a higher peak than a normal distribution. The calculated Jarque-Bera statistic and corresponding *p*-value is used to test the null hypothesis that the monthly data follow a normal distribution. Most of the Jarque-Bera statistics and *p*-values reject the normality assumption at any conventional level of significance for all 21 variables, with the only exceptions being the monthly stock returns in Australia, Japan and the United Kingdom.

Figures 6.1 to 6.5 show the plots of the log and growth rates of a number of relevant macroeconomic variables for Thailand. In order to make robust conclusions about the time series properties of the data this study uses the Augmented Dickey-Fuller (ADF) test and the DF-GLS test introduced by Dickey and Fuller (1979) and Elliott, Rothenberg and Stock (1996), respectively. In this study the lowest value of the Schwarz Information Criterion (SIC) is used to determine the optimal lag length in the testing procedure. These lags augment the relevant regressions to ensure the error term is white noise and free of any serial correlation. Based on the results of the unit root tests presented in Table 6.2, the conclusion is that all 21 variables employed in this study are $I(1)$, as they were non-stationary in levels but stationary in first difference form.

TABLE 6.1
DESCRIPTIONS OF THE DATA EMPLOYED

Variable	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	Jarque-Bera	*p*-value
$\Delta \ln P_t^{TH}$	0.003	0.007	0.359	-0.416	0.121	-0.386	4.649	28.164	0.000
$\Delta \ln P_t^{AR} = \Delta \ln P_t^1$	0.012	0.015	0.670	-0.486	0.155	0.617	6.581	121.319	0.000
$\Delta \ln P_t^{AU} = \Delta \ln P_t^2$	0.006	0.005	0.157	-0.166	0.054	-0.225	3.413	3.162	0.206
$\Delta \ln P_t^{BA} = \Delta \ln P_t^3$	0.011	0.023	0.595	-1.107	0.172	-1.366	12.020	751.402	0.000
$\Delta \ln P_t^{GE} = \Delta \ln P_t^4$	0.006	0.008	0.202	-0.279	0.065	-0.691	5.363	63.715	0.000
$\Delta \ln P_t^{HK} = \Delta \ln P_t^5$	0.008	0.007	0.284	-0.344	0.079	-0.195	5.133	39.983	0.000
$\Delta \ln P_t^{IN} = \Delta \ln P_t^6$	0.004	0.007	0.662	-0.525	0.148	0.423	7.077	147.384	0.000
$\Delta \ln P_t^{JA} = \Delta \ln P_t^7$	-0.001	-0.003	0.217	-0.216	0.068	0.100	3.377	1.550	0.461
$\Delta \ln P_t^{KO} = \Delta \ln P_t^8$	0.003	-0.007	0.534	-0.375	0.113	0.341	5.889	74.940	0.000
$\Delta \ln P_t^{MA} = \Delta \ln P_t^9$	0.004	0.007	0.405	-0.361	0.093	-0.206	6.444	102.270	0.000
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	0.002	0.002	0.360	-0.347	0.097	-0.009	4.632	22.644	0.000
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	0.013	0.030	0.477	-0.931	0.195	-0.988	6.934	96.906	0.000
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	0.005	0.008	0.228	-0.231	0.073	-0.483	5.175	48.173	0.000
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	0.004	0.002	0.381	-0.410	0.115	-0.035	4.039	9.220	0.010
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{14}$	0.005	0.004	0.138	-0.111	0.046	0.051	3.047	0.107	0.948
$\Delta \ln P_t^{US} = \Delta \ln P_t^{15}$	0.008	0.012	0.106	-0.151	0.041	-0.570	3.807	16.588	0.000
$\Delta \ln M_t^{CPI} = \Delta \ln M_t^1$	0.003	0.003	0.026	-0.007	0.005	0.847	5.577	80.811	0.000
$\Delta \ln M_t^{EX} = \Delta \ln M_t^2$	0.002	0.000	0.172	-0.154	0.029	1.729	20.795	2793.245	0.000
$\Delta \ln M_t^{MR} = \Delta \ln M_t^3$	-0.006	0.011	0.928	-0.855	0.232	-0.050	5.213	41.715	0.000
$\Delta \ln M_t^{M2} = \Delta \ln M_t^4$	0.010	0.009	0.046	-0.044	0.010	-0.151	6.807	123.981	0.000
$\Delta \ln M_t^{OP} = \Delta \ln M_t^5$	0.004	0.007	0.457	-0.246	0.083	0.568	6.800	133.715	0.000

Sources: (a) Morgan Stanley Capital International, http://www.msci.com/equity/index2.html and (b) International Financial Statistics, http://ifs.apdi.net/imf/logon.aspx

TABLE 6.2
UNIT ROOT TEST RESULTS

Variables	ADF				ERS DF-GLS			
	Constant	Optimal lag	Constant and trend	Optimal lag	Constant	Optimal lag	Constant and trend	Optimal lag
$\Delta \ln P_t^{TH}$	-8.289***	1	-8.266***	1	-1.656*	6	-6.776***	1
$\Delta \ln P_t^{AR} = \Delta \ln P_t^{1}$	-13.721***	0	-13.841***	0	-11.064***	0	-12.470***	0
$\Delta \ln P_t^{AU} = \Delta \ln P_t^{2}$	-15.331***	0	-15.301***	0	-0.255	2	-1.678	2
$\Delta \ln P_t^{BA} = \Delta \ln P_t^{3}$	-16.334***	0	-16.306***	0	-14.416***	0	-15.580***	0
$\Delta \ln P_t^{GE} = \Delta \ln P_t^{4}$	-15.115***	0	-15.105***	0	-14.781***	0	-15.048***	0
$\Delta \ln P_t^{HK} = \Delta \ln P_t^{5}$	-13.425***	0	-13.448***	0	-9.493***	0	-12.321***	0
$\Delta \ln P_t^{IN} = \Delta \ln P_t^{6}$	-11.957***	0	-11.959***	0	-11.927***	0	-12.018***	0
$\Delta \ln P_t^{JA} = \Delta \ln P_t^{7}$	-13.871***	0	-13.836***	0	-3.713***	2	-13.735***	0
$\Delta \ln P_t^{KO} = \Delta \ln P_t^{8}$	-13.644***	0	-13.620***	0	-1.433	5	-2.539	5
$\Delta \ln P_t^{MA} = \Delta \ln P_t^{9}$	-7.317***	1	-7.323***	1	-6.357***	1	-7.163***	1
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	-11.301***	0	-11.396***	0	-11.321***	0	-11.407***	0
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	-9.529***	0	-9.485***	0	-2.127**	3	-8.071***	0
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	-13.900***	0	-13.931***	0	-10.656**	0	-13.153***	0
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	-12.712***	0	-12.708***	0	-2.398**	3	-6.390***	1
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{14}$	-12.112***	1	-12.097***	1	-4.959***	5	-8.944***	0
$\Delta \ln P_t^{US} = \Delta \ln P_t^{15}$	-14.741***	0	-14.796***	0	-2.494**	6	-12.015***	0
$\Delta \ln M_t^{CPI} = \Delta \ln M_t^{1}$	-10.910***	0	-10.544***	1	-3.602***	4	-5.381***	4
$\Delta \ln M_t^{EX} = \Delta \ln M_t^{2}$	-9.879***	0	-9.853***	0	-9.106***	0	-9.630***	0
$\Delta \ln M_t^{MR} = \Delta \ln M_t^{3}$	-15.849***	0	-15.825***	0	-15.373***	0	-15.801***	0
$\Delta \ln M_t^{M2} = \Delta \ln M_t^{4}$	-3.113**	5	-14.073***	0	-0.703	11	-8.823***	0
$\Delta \ln M_t^{OP} = \Delta \ln M_t^{5}$	-10.743***	0	-10.730***	0	-8.291***	0	-10.038***	0

Note: ** and *** indicates that the corresponding null hypothesis is rejected at the 5 and 1 percent significance level, respectively.

Please see print copy for

LOG AND GROWTH RATE OF CONSUMER PRICE INDEX

4.8

Please see print copy for image

Source: International Financial Statistics, http://ifs.apdi.net/imf/logon.asp

FIGURE 6.2
PLOT OF THE LOG AND GROWTH RATE OF EXCHANGE RATE

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Source: International Financial Statistics, http://ifs.apdi.net/imf/logon.asp

FIGURE 6.3
PLOT OF THE LOG AND GROWTH RATE OF INTEREST RATE

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Source: International Financial Statistics, http://ifs.apdi.net/imf/logon.asp

FIGURE 6.4
PLOT OF THE LOG AND GROWTH RATE OF MONEY SUPPLY

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Source: International Financial Statistics, http://ifs.apdi.net/imf/logon.asp

FIGURE 6.5
PLOT OF THE LOG AND GROWTH RATE OF OIL PRICE

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Source: International Financial Statistics, http://ifs.apdi.net/imf/logon.asp

6.3 AN APPLICATION OF THE GARCH MODEL

As discussed earlier, the sample period has been segmented into the pre- and post-1997 Asian crisis. Initially, the following equation was estimated by the OLS method for the two periods separately:

$$\Delta \ln P_t^{TH} = \omega + \sum_{i=1}^{k_1=15} \theta_i \Delta \ln P_t^i + \sum_{i=1}^{k_2=5} \eta_i \Delta \ln M_t^i + u_t \tag{6.1}$$

However, in the pre-1997 period the estimated correlogram of squared residuals of such a model exhibited significant Autoregressive Conditional Heteroscedasticity (ARCH) effects (see Figure 6.6). In order, therefore, to capture any possible ARCH and GARCH effects, a GARCH-in-mean (GARCH-M) has been specified in this chapter. The GARCH model was developed by Bollerslev (1986) from the ARCH model previously introduced by Engle (1982). Both models establish the patterns of time varying volatility in returns. For a detailed account of these models see *e.g.* Bollerslev, Chou and Kroner (1992) and Pagan (1996). The GARCH-M (Bollerslev, 1986; Engle, Lilien and Robins, 1987) specification provides the forecast variance to vary over time and lag values to be included in the variance equation, which is a convenient and robust measure since it connects conditional volatility to the stock price returns in the following manner:

$$\Delta \ln P_t^{TH} = \omega + \sum_{i=1}^{k_1=15} \theta_i \Delta \ln P_t^i + \sum_{i=1}^{k_2=5} \eta_i \Delta \ln M_t^i + \gamma \sqrt{h_t} + u_t \tag{6.2}$$

$$u_t = \varepsilon_t \left(\alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \right)^{1/2} \tag{6.2}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \tag{6.4}$$

where P_t^{TH} P_t^i and M_t^i denote the value of the Thai stock index, the 15 international stock indices (as outlined in the previous section) and the five macroeconomic variables, respectively. Moreover, ω and α_0 are the corresponding intercept terms in the mean and variance equations, respectively, θ_i shows the instantaneous responsiveness of the Thai stock returns to the i^{th} international stock returns, η_i shows the responsiveness of the Thai stock returns to the i^{th} macroeconomic variables, the estimated coefficient γ is referred to as a measure of the risk-return tradeoff in financial econometrics. In this study this term indicates that the conditional mean of $\Delta \ln P_t^{TH}$ depends on the conditional standard deviation obtained from Equation (6.4), h_t is the conditional variance which is dependent on lagged values of squared errors and lagged values of the conditional variance, α_i and β_j are the ARCH and GARCH coefficients, respectively, q is the order of the moving average ARCH term and p is the order of the autoregressive GARCH term. These types of models are usually employed in financial econometrics to test the effect of the expected asset risk on the expected return on an asset. Relevant studies include French, Schwert and Stambaugh (1987), Poon and Taylor (1992), Choudhry (1996b), Engle (2001) and Andersen, Bollerslev, Diebold and Labys (2003) among others.

6.4 EMPIRICAL RESULTS

There are 20 explanatory variables on the right hand side of Equation (6.1). The general-to-specific modeling approach has been utilized to omit the insignificant variables in Equation (6.1) on the basis of a battery of maximum likelihood tests. First, this equation has been estimated for the pre-1997 period. After excluding the insignificant variables a cursory look at the correlogram of residuals (See Figure 6.6) of the estimated parsimonious model, which does not capture the ARCH and GARCH effects, reveals a serious type of volatility clustering. However, once the ARCH and GARCH effects, or the conditional heteroscedasticity in the residuals, are modeled, as described in Equations (6.2) to (6.4), the correlogram of the resulting residuals appear to be more statistically acceptable (see Figure 6.7). Table 6.3 presents the estimation results for Equations (6.1) and (6.2). As can be seen from the results the parsimonious model estimated by OLS does not pass the ARCH test using various lags. However, once the ARCH effects are taken into account the reported GARCH-M model passes the diagnostic tests in Table 6.3. The Lagrange Multiplier (LM) test is used for testing serial correlation. The null hypothesis of the LM test is that there is no serial correlation up to lag order *p* (a pre-specified integer). The results show no serial correlation up to order 12 for the estimated GARCH models.

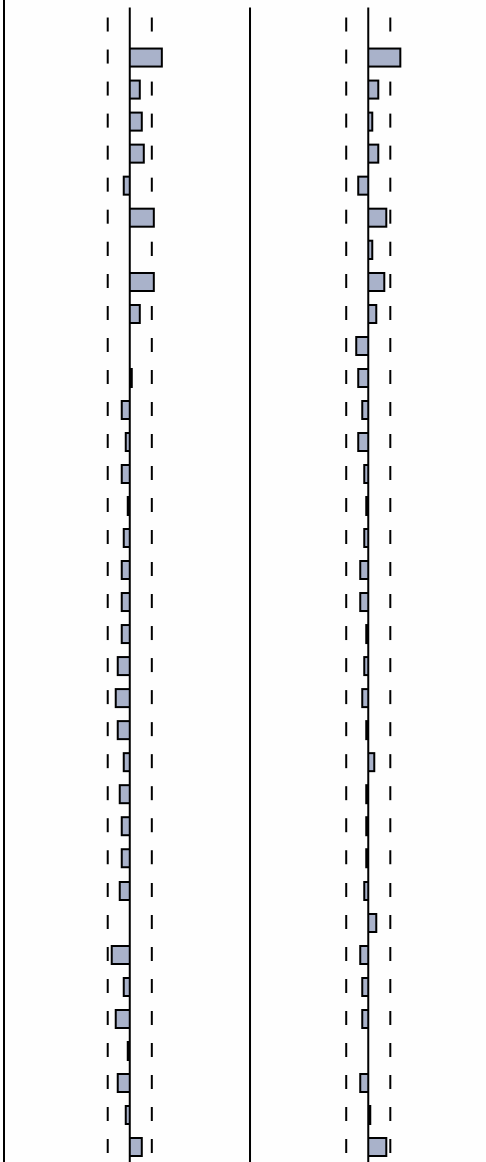
TABLE 6.3
ESTIMATION RESULTS FOR THE THAI MONTHLY RETURN MODEL, $\Delta \ln P_t^{TH}$, IN THE PRE-1997 CRISIS PERIOD

Variables	OLS			GARCH-M		
	Coefficient	*t*-statistic	*p*-value	Coefficient	*z*-statistic	*p*-value
Mean equation						
Intercept	-0.007	-1.117	0.266	-0.030***	-4.022	0.000
$\Delta \ln P_t^{IN}$	0.156***	2.938	0.004	0.122***	2.647	0.008
$\Delta \ln P_t^{MA}$	0.402***	3.204	0.002	0.383***	3.277	0.001
$\Delta \ln P_t^{SG}$	0.588***	3.381	0.001	0.586***	3.851	0.000
$\Delta \ln M_t^{OP}$	-0.234***	-2.811	0.006	-0.207***	-3.670	0.000
$\sqrt{h_t}$	-	-	-	0.379***	2.708	0.007
Variance equation						
Intercept	-	-	-	0.001**	1.991	0.047
u_{t-1}^2	-	-	-	-0.083***	-3.121	0.002
u_{t-2}^2	-	-	-	0.358***	2.703	0.000
h_{t-1}^2	-	-	-	0.423***	2.770	0.006
Adjusted R^2	0.544			0.514		
Log-L	149.370			158.469		
Akaike	-2.406			-2.474		
Schwarz	-2.290			-2.242		
Overall *F*-stat	36.494***		0.000	15.010***		0.000
ARCH LM *F*-stat						
1 lag	0.000		0.987	0.011		0.917
2 lag	6.038***		0.003	0.054		0.948
3 lag	4.388***		0.006	0.054		0.983
4 lag	4.180***		0.003	0.060		0.993
8 lag	2.967***		0.005	0.365		0.938
12 lag	2.965***		0.002	0.448		0.939
Jarque-Bera	0.048		0.976	1.799		0.407

Note: ** and *** indicates that the corresponding null hypothesis is rejected at the 5 and 1 percent significance level, respectively.

FIGURE 6.6
CORRELOGRAM OF SQUARED RESIDUALS BEFORE CAPTURING GARCH EFFECT FOR PRE-ASIAN CRISIS PERIOD

Sample: 1988M01-1997M12
Included observations: 120



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.001	0.001	0.0003	0.987
		2	0.283	0.283	9.9488	0.007
		3	0.089	0.096	10.948	0.012
		4	0.105	0.029	12.333	0.015
		5	0.127	0.085	14.382	0.013
		6	-0.047	-0.096	14.663	0.023
		7	0.211	0.155	20.447	0.005
		8	0.006	0.032	20.452	0.009
		9	0.211	0.132	26.323	0.002
		10	0.086	0.069	27.317	0.002
		11	0.001	-0.109	27.317	0.004
		12	0.022	-0.090	27.381	0.007
		13	-0.059	-0.056	27.860	0.009
		14	-0.030	-0.083	27.987	0.014
		15	-0.080	-0.033	28.880	0.017
		16	-0.016	-0.013	28.916	0.025
		17	-0.045	-0.040	29.210	0.033
		18	-0.076	-0.078	30.043	0.037
		19	-0.062	-0.070	30.602	0.045
		20	-0.077	-0.015	31.470	0.049
		21	-0.105	-0.037	33.113	0.045
		22	-0.118	-0.044	35.179	0.037
		23	-0.103	-0.022	36.775	0.034
		24	-0.044	0.046	37.068	0.043
		25	-0.085	-0.009	38.186	0.044
		26	-0.062	-0.022	38.792	0.051
		27	-0.071	-0.012	39.595	0.056
		28	-0.091	-0.037	40.906	0.055
		29	0.005	0.070	40.911	0.070
		30	-0.153	-0.080	44.721	0.041
		31	-0.046	-0.043	45.069	0.049
		32	-0.115	-0.051	47.265	0.040
		33	-0.015	-0.004	47.302	0.051
		34	-0.101	-0.076	49.030	0.046
		35	-0.029	0.013	49.176	0.056
		36	0.112	0.154	51.367	0.047

Source: Author's calculations.

FIGURE 6.7
CORRELOGRAM OF SQUARED RESIDUALS AFTER CAPTURING GARCH EFFECT FOR PRE-ASIAN CRISIS PERIOD

Sample: 1988M01-1997M12
Included observations: 120

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.010	0.010	0.0114	0.915
		2	0.026	0.026	0.0975	0.952
		3	0.020	0.019	0.1470	0.986
		4	0.024	0.023	0.2195	0.994
		5	-0.022	-0.024	0.2838	0.998
		6	-0.031	-0.032	0.4089	0.999
		7	0.136	0.137	2.7925	0.904
		8	0.059	0.060	3.2519	0.918
		9	0.059	0.054	3.7107	0.929
		10	0.101	0.095	5.0604	0.887
		11	-0.011	-0.025	5.0780	0.927
		12	0.047	0.046	5.3821	0.944
		13	-0.033	-0.027	5.5347	0.961
		14	-0.107	-0.129	7.1082	0.930
		15	-0.071	-0.082	7.8135	0.931
		16	-0.006	-0.019	7.8191	0.954
		17	0.000	-0.027	7.8191	0.970
		18	0.015	0.016	7.8506	0.981
		19	0.009	-0.015	7.8635	0.988
		20	-0.113	-0.136	9.7416	0.973
		21	-0.105	-0.084	11.365	0.955
		22	-0.123	-0.104	13.626	0.914
		23	-0.063	-0.035	14.224	0.920
		24	-0.045	-0.002	14.535	0.934
		25	-0.023	-0.010	14.613	0.950
		26	-0.072	-0.073	15.427	0.949
		27	-0.048	-0.027	15.795	0.957
		28	-0.048	-0.042	16.168	0.963
		29	0.065	0.109	16.841	0.965
		30	-0.113	-0.059	18.903	0.942
		31	-0.020	0.011	18.968	0.955
		32	-0.061	-0.020	19.593	0.958
		33	-0.032	-0.004	19.768	0.967
		34	-0.101	-0.098	21.489	0.953
		35	0.055	0.052	22.016	0.957
		36	0.156	0.131	26.272	0.883

Source: Author's calculations.

FIGURE 6.8
CORRELOGRAM OF SQUARED RESIDUALS BEFORE CAPTURING GARCH EFFECT FOR POST-ASIAN CRISIS PERIOD

Sample: 1998M01-2004M12
Included observations: 84

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.047	-0.047	0.1920	0.661
		2	-0.066	-0.068	0.5749	0.750
		3	0.108	0.102	1.6209	0.655
		4	-0.030	-0.025	1.7028	0.790
		5	-0.083	-0.073	2.3339	0.801
		6	-0.049	-0.071	2.5520	0.863
		7	-0.074	-0.085	3.0642	0.879
		8	0.005	0.005	3.0663	0.930
		9	0.056	0.057	3.3672	0.948
		10	0.061	0.077	3.7345	0.959
		11	-0.068	-0.072	4.1894	0.964
		12	0.013	-0.016	4.2061	0.979
		13	0.000	-0.030	4.2061	0.989
		14	-0.025	-0.004	4.2721	0.994
		15	-0.015	-0.001	4.2959	0.997
		16	-0.064	-0.060	4.7310	0.997
		17	-0.053	-0.061	5.0361	0.998
		18	-0.056	-0.092	5.3777	0.998
		19	0.098	0.092	6.4343	0.997
		20	0.091	0.109	7.3637	0.995
		21	-0.039	-0.007	7.5342	0.997
		22	0.058	0.017	7.9207	0.997
		23	-0.053	-0.109	8.2587	0.998
		24	0.047	0.057	8.5259	0.998
		25	0.098	0.128	9.7005	0.997
		26	-0.113	-0.036	11.285	0.995
		27	-0.057	-0.063	11.701	0.995
		28	0.153	0.090	14.702	0.981
		29	0.090	0.108	15.757	0.978
		30	-0.116	-0.071	17.547	0.965
		31	-0.032	-0.049	17.686	0.973
		32	0.019	-0.030	17.734	0.980
		33	-0.053	-0.035	18.125	0.983
		34	-0.072	-0.086	18.871	0.983
		35	0.103	0.143	20.432	0.976
		36	-0.049	0.012	20.801	0.980

Source: Author's calculations.

Therefore, it is important to capture these effects by a GARCH(p, q) process as in Equation (6.2). Assuming that $\gamma \neq 0$, Table 6.3 presents the econometric results of the GARCH-M model using the maximum likelihood method. One can observe that the estimated γ is highly significant and positive (*i.e.* +0.379) supporting the view that the higher the stock market volatility the higher would be the rate of return. It should be noted that the preferred model has the lowest SIC, the highest adjusted R^2, passes various ARCH tests reported in Table 6.3 and its resulting correlogram is well-behaved (see Figure 6.7). From Bollerslev (1986) the preferred equation also satisfies the stationarity of the parsimonious model, GARCH-M(q = 2, p = 0), as $\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j < 1$. It should be noted that the SIC and significant spikes in the relevant correlogram of squared residuals are used to determine the optimum values of p and q. In order of magnitude the estimated coefficients for Singapore (0.586), Malaysia (0.383) and Indonesia (0.122) were highly significant at the 1 percent significance level, whereas the remaining 12 stock market returns were not statistically significant at any conventional level. Out of the five macroeconomic variables in the model only the oil price was significant, suggesting that higher growth rates in oil price can cause returns on the Thai stock market to plummet. The insignificant variables were excluded from the final reported models.

TABLE 6.4
ESTIMATION RESULTS FOR THE THAI MONTHLY RETURN MODEL, $\Delta \ln P_t^{TH}$, IN THE POST-1997 CRISIS PERIOD

Variables	Coefficient	*t*-statistic	*p*-value
Mean equation			
Intercept	0.002	0.237	0.814
$\Delta \ln P_t^{KO}$	0.411^{***}	5.681	0.000
$\Delta \ln P_t^{PH}$	0.529^{***}	4.678	0.000
$\Delta \ln P_t^{SG}$	0.402^{***}	3.081	0.003
$\sqrt{h_t}$	-	-	-
Variance equation			
Intercept	-	-	-
u_{t-1}^2	-	-	-
h_{t-1}^2	-	-	-
Adjusted R^2	0.679		
Log-L	94.992		
Akaike	-2.166		
Schwarz	-2.050		
Overall *F*-stat	59.420^{***}		0.000
ARCH LM *F*-stat			
1 lag	0.190		0.664
2 lag	0.234		0.792
3 lag	0.711		0.549
4 lag	0.694		0.599
8 lag	0.475		0.870
12 lag	0.878		0.573
Jarque-Bera	1.723		0.423

Note: *** indicates that the corresponding null hypothesis is rejected at the 1 percent significance level.

The OLS method and Equation (6.1) have also been used to model the Thai stock return in the post-1997 crisis, and the results are reported in Table 6.4. As can be seen from Figure 6.8 the correlogram of residuals for this model show no sign of ARCH or GARCH effects. In addition, the estimated model passes the ARCH LM test with various lags and, compared to various estimated models, has the lowest value of the SIC. Therefore, there is no need to use the ARCH and GARCH models for this period. In fact, the estimated ARCH and GARCH and γ coefficients were all insignificant, and as a result they have not been reported in Table 6.4. Finally, the conclusion is that the stock returns in the Philippines (0.529), Korea (0.411) and Singapore (0.402) were the only major variables that instantaneously impacted on the Thai stock market.

Based on Tables 6.3 and 6.4 the major findings of the study can be summarized as follows. First, it appears that Singapore is the only country whose stock returns are positively related to that of Thailand in both the pre- and post-1997 crisis periods. This evidence is not surprising because Singapore is a major regional financial hub with extensive investment throughout the region, a price leader with its dominance in the Asian market and also the major producer of information. Moreover, international investors often overreact to news from Singapore's market and place less weight on information from other Asian markets. Thus, innovations in Singapore could be used as an indicator to predict the performance of the Thai stock market.

Second, apart from Singapore, in the pre-1997 period changes in stock returns in Indonesia and Malaysia were the most significant determinants of the returns in Thailand, but post-1997 the Philippines and Korea replaced these. This shift in importance in the post-1997 period is a result of capital controls imposed in Malaysia during 1998 and the economic turbulence in Indonesia, while Korea has attained more economic integration with Thailand. However, the case of the Philippines is more difficult to explain.

Third, none of the stock markets in other countries outside the region played an important role in explaining the variation of Thai stock market returns before or after 1997. Fourth, consistent with previous studies, the effect of macroeconomic variables on the dependent variable was insignificant, with the only exception being changes in the price of oil. It appears that a rise in oil prices had a negative effect on stock returns prior to 1997 but became insignificant after 1997. Finally, the significant estimated coefficient γ on the time varying conditional variance $\sqrt{h}$ indicates that volatility itself exerted a positive impact on Thai stock market returns in the pre-Asian crisis period only.

6.5 SUMMARY AND CONCLUDING REMARKS

The main purpose of the empirical research undertaken in this chapter has been to investigate how 15 international stock markets and five relevant Thai macroeconomic variables influenced monthly stock market returns in Thailand in the pre- and post-1997 Asian crisis eras. It was found that the Singapore stock market influenced the Thai stock market significantly in both the pre- and post-1997 periods. Before 1997 the Indonesian and Malaysian stock markets were significantly related to the Thai stock market whereas after the crisis Korea and the Philippines played a dominant role in explaining sources of variation in the monthly returns in the Thai stock market. Therefore, to a large extent, one may conclude that the Thai stock market is very much influenced by the performance of its neighboring countries' stock markets, but non regional markets exerted an insignificant effect. This goes some way to explaining why the financial crisis of 1997 remained a primarily regional crisis.

The results of factor analysis presented in the previous chapter also led to the same conclusion.

CHAPTER 7

SUMMARY AND CONCLUSION

7.1 INTRODUCTION

This thesis has empirically examined the stock market integration of Thailand and other international countries, namely Argentina, Australia, Brazil, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Russia, Singapore, Taiwan, the United Kingdom and the United States. Two main definitions of stock market integration have been adopted in the literature. The first definition views stock market integration from the perspective of asset pricing models. According to these models, stock markets are considered to be integrated if securities with the same risk characterization are similarly priced. The second definition is related to recent studies which adopt an alternative view of stock market integration. They tend to rely on recent time series econometric techniques, such as Granger causality analysis, cointegration test, factor analysis and GARCH models, to investigate the co-movement among stock markets. This thesis adopted these econometric techniques to examine the extent and nature of stock market integration of Thailand and international countries.

In this final chapter, Section 7.2 summarizes the study and the main findings from previous chapters. Section 7.3 outlines the specific contributions made by this study. Section 7.4 provides policy implications from the empirical results presented with respect to international stock market integration and the effectiveness of international portfolio diversification. Suggestions for future studies are presented in the last section.

7.2 SUMMARY OF MAJOR EMPIRICAL FINDINGS

The thesis started with an overview of empirical studies on stock market integration in Chapter 2. The main purpose of the chapter was to examine the literature concerned with the stock market integration. Most early studies used various versions of the asset pricing models to investigate the degree of stock market integration. However, these models will run into the joint test problem because a rejection of the test could be due to either the failure of the models or the rejection of stock market integration. Recent studies tend to rely on econometric techniques, such as cointegration test, factor analysis and GARCH models, to investigate the co-movement among stock markets.

Chapter 3 tested the unit root hypothesis using both conventional unit root tests and the unit root tests in the presence of structural breaks. The chapter started by presenting the descriptive statistics of the data. The results of the ADF test and the DF-GLS test suggest that almost all stock prices follow a random walk hypothesis. By applying the Zivot and Andrews (1992) one break unit root test and the Lumsdaine and Papell (1997) two break unit root test similar results were obtained, supporting the view that the random walk hypothesis is again applicable for the majority of countries.

The most significant break occurred during various months in the period 1996-1998 for seven and 10 countries in the Zivot and Andrews test and the Lumsdaine and Papell test, respectively. Two other important breaks across various markets occurred in 1991-1993 and 2000-2002, which coincided with two world-wide recessions. Based on the Zivot and Andrews test, in two countries the structural break occurred in 1991-1993 and in six countries the structural break occurred in 2000-2002. On the other hand the Lumsdaine and Papell test results reveal that in five countries the first break occurred in 1991-1993, and for 12 countries the second break was identified in 2000-2002. Apart from the 1997-1998 Asian crisis and the above two global recessions, there have been several other country-specific events which caused turbulence in financial markets.

Chapter 4 examined the long-run and short-run relationships between the stock prices of Thailand and its major trading partners, namely Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States. The conventional Engle–Granger two-step procedure was used as well as the Gregory and Hansen (1996) cointegration procedure, which allows for a structural break in the cointegrating vector. Gregory and Hansen argue that structural breaks have important implications for cointegration analysis because these breaks can decrease the power of the cointegration tests, and lead to spurious results for the null hypothesis of no cointegration.

The Engle–Granger two-step procedure and the Gregory and Hansen (1996) test results consistently indicated that there was no evidence of a long-run relationship between the stock prices of Thailand and its major trading partners considered in this study. These results are also consistent with previous findings of no cointegration between the Thai stock market and some regional stock markets, including those of South-East Asia (Ng, 2002) and the Pacific Basin (Chang, 2001; Climent and Meneu, 2003). More importantly, the structural break in the cointegrating vector for most countries occurred in 1998, the year after the 1997 Asian financial crisis.

However, in the short run there were three pair-wise unidirectional Granger causalities running from returns in Hong Kong, the Philippines and the United Kingdom to returns in Thailand. On the other hand, there were two unidirectional Granger causalities running from returns in Thailand to returns in Indonesia and the United States. Finally, evidence of bidirectional Granger causality between the stock returns in Thailand and those of three of its neighboring countries, Malaysia, Singapore and Taiwan was found.

Chapter 5 explored the relationship between the stock market returns of 13 selected countries. The chapter started with a preliminary descriptive analysis of the statistical characteristics of the stock price indices. Based on the correlation matrix, it was found that the highest correlation coefficients belong to Singapore-Hong Kong; Singapore-Malaysia; Thailand-Singapore; and the United States-United Kingdom. It is interesting to note that pairwise the highest correlation coefficients are between the countries in the same region and/or at a similar stage of economic development.

The results derived from a factor analysis, using both the principal component and maximum likelihood methods, indicated that stock markets move together among the Asian countries. In addition, the rotated factor loadings of the first common factor provide sufficient evidence that the returns in Singapore, Thailand, the Philippines, Malaysia, Hong Kong, Indonesia, Taiwan and Korea have a high degree of linear association. Based on the rotated loadings of the second factor, the results indicated that the stock returns in the United Kingdom, Germany, the United States, Australia and Japan can be represented by a well separated common factor in terms of their co-movements.

Finally, Chapter 6 investigated how 15 international stock markets and five relevant Thai macroeconomic variables influenced monthly stock market returns in Thailand in the pre- and post-1997 Asian crisis eras, using various GARCH models. The main reason to employ GARCH pertains to the fact that the variance of forecast errors depends on the size of the preceding disturbances. A generalized form of the conditional heteroscedasticity allows for lagged variances and further lagged values of the error term. Consequently, it is naturally expected that the GARCH model is an efficient way to deal with volatility clustering observed in residuals which usually occur in stock price data.

The results found that the stock market in Singapore influenced the stock market in Thailand significantly in both the pre- and post-1997 periods. Before 1997 the stock markets in Indonesia and Malaysia were significantly related to the stock market in Thailand, whereas after the crisis the stock markets in Korea and the Philippines played an important role in explaining sources of variation in the monthly returns in Thailand. Out of the five macroeconomic variables in the model only the oil price was significant, suggesting that higher growth rates in oil price can cause returns on the Thai stock market to plummet.

7.3 CONTRIBUTIONS OF THE STUDY

This thesis has made three significant contributions to the analysis of integration between stock markets of Thailand and international countries. First, this is the first study to address the issue of structural breaks when testing for the unit root hypothesis in the Thai stock market. After conducting an inclusive review, no study has addressed this issue. As mentioned earlier, the conventional unit root tests, such as the ADF and PP tests, can be erroneous in rejecting the null hypothesis if a structural break in a time series is ignored. In performing unit root tests in the presence of structural breaks, this study employed the Zivot and Andrews (1992) one-break-unit-root test and the Lumsdaine and Papell (1997) two-break-unit-root test. The results indicated that the key structural break in most of the cases points to the Asian crisis over the period 1996-1998.

Second, this study employed a larger sample of stock markets than that of previous studies and also addressed the issue of volatility clustering particularly in the context of the Thai stock market returns. Sample data included in this study are stock prices from the following 16 countries: Argentina, Australia, Brazil, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Russia, Singapore, Taiwan, Thailand, the United Kingdom and the United States. Seven of these markets are categorized as a developed market (*e.g.* Australia, Germany, Hong Kong, Japan, Singapore, the United Kingdom and the United States) and the remainder are regarded as an emerging market. In addition, the period of the study has been conducted over a longer period than previous studies.

Finally, no previous study has examined the possibility that the long-run relationship between the stock markets have been subject to a structural break. In addition to the Engle–Granger two-step procedure this study employed the Gregory and Hansen (1996) cointegration test, which allows for a structural break in the cointegrating vector. Structural breaks have important implications for cointegration analysis because these breaks can decrease the power of cointegration tests, and lead to the under-rejection of the null hypothesis of no cointegration.

7.4 POLICY IMPLICATIONS

Some key policy implications from this study are as follow. In Chapter 3 the finding that the majority of emerging stock market price indices are $I(1)$ rather than $I(0)$, even after accounting for possible endogenous structural breaks, has several implications for researchers and investors. This finding is consistent with that of Narayan and Smyth (2005) who find that most OECD stock markets are characterized by a random walk. Evidence of most of the stock price series following a random walk process implies that current prices are not predictable based on past prices, thus supporting the weak form of the efficient market hypothesis in the majority of stock markets.

In Chapter 4, the empirical findings can shed important light on the effectiveness of international portfolio diversification and financial market efficiency. The results indicate that there is no evidence of a long-run relationship between the stock prices of Thailand and its major trading partners considered in this study. Therefore, international portfolio diversification has still its merit since stock markets are not integrated in a statistical sense. The implication is that investors can enjoy long-run diversification benefits when investing in the stock market of Thailand and its major trading partners namely Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the United Kingdom and the United States. On the other hand, in the short-run the scope of these opportunities is rather limited due to systematic and transitory fluctuations, which are inherent to stock markets as evidenced by the causality test results.

In Chapter 5, the results confirm that the cross country co-movements of stock market returns are based on geographical location and/or the level of economic development. Therefore, if investors aim to reduce systematic investment risk across countries, their financial portfolio should include a diversified range of international stocks from various continents and from both developed and developing countries with varying degrees of stock market maturities.

In Chapter 6 the results presented suggested that Singapore is the only country whose stock returns are positively related to that of Thailand in both the pre- and post-1997 crisis periods. This evidence is not surprising because Singapore is a major regional financial hub with extensive investment throughout the region, a price leader with its dominance in the Asian market. In addition, as the major producer of information, international investors often overstate the news from Singapore's market and place less weight on information from other Asian markets. Thus, innovations in Singapore could be used as an indicator to predict/analyze the performance of the stock market of Thailand.

7.5 SUGGESTIONS FOR FUTURE STUDIES

This study has used cross country stock price indices to test for market integration. Although the empirical results indicate that the stock markets studied are not integrated in the long run, it would be interesting to see whether different industries in those countries are integrated. For example, rather than focusing on general stock markets, one can study whether real estate or financial industries are integrated in those markets and compare the diversification benefits they provide.

With respect to Chapter 3, in order to test the robustness of the results from the Zivot and Andrews (1992) test and the Lumsdaine and Papell (1997) test, Narayan and Smyth (2007) argued that a limitation on the endogenous break unit root tests is that the critical values are derived while assuming no break under the null. On the other hand the LM unit root test has the advantage that it is unaffected by structural breaks under the null. Therefore, future studies could employ the Lee and Strazicich (2003) one break and two break LM unit root tests.

Chapter 4 used the Engle-Granger two-step procedure and the Gregory and Hansen (1996) test, residual-based cointegration technique, to investigate long-run relationships between stock markets. Saikkonen and Lutkepohl (2000) have proposed a cointegration analysis which allows for possible exogenous structural breaks in the mean of the data generating process. They argued that structural breaks can distort standard inference procedures substantially and, therefore, it is necessary to make appropriate adjustments if structural breaks are known to have occurred or are suspected. While earlier approaches like the Gregory and Hansen test considered structural breaks in a single equation, the Saikkonen and Lutkepohl approach examines the consequences of structural breaks in a system context based on a multiple equation framework. Thus, testing the cointegrating rank of a VAR process that may have a deterministic linear trend would be desirable.

Finally, the GARCH-M model was employed in Chapter 6. However many different GARCH models such as IGARCH, EGARCH, AGARCH and TGARCH are discussed in the financial literature. A comparison of these different models can be useful for analysis of stock markets. Furthermore, the extensions of the GARCH model can include the possible asymmetric effects in multivariate GARCH models and the effects of stock price regulations.

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