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Time-varying financial integration and contagion

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Time-varying Financial Integration and Contagion

By

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A Thesis

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Abstract

This thesis examines the evolution of the financial integration and contagion of international stock and bond markets. We focus on integration at the portfolio level, which is constructed by the stock market value, BE/ME ratio, and the bond maturity respectively, in addition to those at the aggregate national market level. The aim is to examine whether these asset characteristics (size effect, BE/ME, and bond maturities) are conductive to the systematic discrepancies in integration between these portfolios with the world market respectively. For financial contagion, this study attempts to investigate whether there exists any financial variables that are competent for identifying the crisis period, whether the contagion coefficient can be expressed as a function of these variables, and whether the contagion level is constant over time.

To examine these issues, we model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. The likelihood ratio test shows that our GARCH-filter model, which combines the Kalman filter and GARCH effect, is indeed more efficient than the traditional Kalman filter system.

The main results show that large (/growth) stock portfolios are more integrated with the world than small (/value) portfolios. They also show bond portfolios with longer maturities are always more integrated with the world than short-term bonds. For testing contagion, focusing on the transmission of price shocks at times of financial crisis, we find that the conditional variance of assets returns and the increased level of integration are excellent variables for identifying the crisis period. Furthermore, the contagion levels based on these two variables vary dramatically all the time, but are significantly different from zero over time for most cases in our sample. Thus, this study offers more opportunities for investors and portfolio managers, who can benefit from new insight into the co-movements among different asset portfolios in different international markets. The study also provides a consistent platform for measuring financial contagion.

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Zhaoqi Fei

Chapter 1

Introduction

Financial globalization has been the most profound financial phenomenon during the last two decades. Due to the rapid expansion of international financial transactions and explosive growth of capital flows, the comovement of financial markets around the world has increased significantly since the late 1980s. And this increased comovement is largely contributed by the increasing financial integration, which refers to the fundamental economic and financial links;[1] in addition, financial contagion is also an important factor, which focuses on the correlation beyond the fundamental links.[2]

1.1 Integration and contagion: An important issue?

Financial market integration and contagion are of major importance for both research and practice. Deepening financial integration is generally agreed to be beneficial on the whole:

1. Risk sharing and diversification. Portfolio diversification is usually achieved by two strategies: investing in different kinds of assets or similar assets in multiple markets. The key point of these two strategies is to reduce the correlation of different assets of the portfolio. Deepening financial integration increases the set of financial instruments and the cross-ownership of assets, which should provide more

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[1] Bekeart and Harve y (1997)
[2] Bekeart, Harve y, and Ng (2005)

opportunities for investors to diversify their portfolio and share regional idiosyncratic risks. However, on the other hand, increased integration makes the comovement of international markets closer than before, which reduces the benefit of risk sharing obtained by investors to some extent. Thus, increased integration plays a controversial role in achieving risk sharing and diversification.

2. Better allocation of capital and economic growth. With the depth of integration, the formal barriers to trading and financial transactions will be reduced to the greatest extent. Therefore, investors are allowed to invest their funds abroad much more easily, and funds are allocated to the most productive investment opportunities. Better allocation of capital among investment opportunities is therefore achieved. Therefore, deepening integration will increase the supply of funds for investment opportunities in the integrating area, and increase competitive pressure, thereby increasing the efficiency of the financial system of less developed countries. Given that greater efficiency spurs the demand for both funds and financial services, this should also cause financial markets increase in size. On the other hand, financial development can lead to a more efficient allocation of capital and can reduce the cost of capital. Hence more funds will be allocated to more profitable projects, and the productivity of the economy will increase. Therefore, financial integration positively impacts on financial development, which in turn has a positive impact on economic growth.

However, deepening financial integration may also have less positive effects:

1. The rapid increase of capital inflows caused by financial openness may weaken the local macroeconomic stability through a rapid increase of liquidity, pressures of inflation and real exchange rate appreciation, and growing external imbalances.

2. A high degree of financial integration may lead to a high degree of volatility in capital movements because many developing countries are usually able to obtain capital inflows in good times, but this condition will be contrasting in bad times due to their credit constraints.

3. A high degree of financial integration may be conductive to contagion during the

crisis period. For instance, the Mexico crisis of 1994 severely affected several Latin American countries that share close economic or financial links with Mexico, but the broader international impact was limited. However, one interesting issue is that the high degree of integration is not a necessary condition for all contagion phenomena. After Thailand's devaluation, many countries in Southeast Asia were seriously attacked, but the United States did not avoid the attack of Asian Flu in 1997. According to Rigobon (2002), some Latin American stock markets, for example Argentina, Brazil, Mexico and Venezuela, fell between 10 and 30 percent during the period of Asia crisis. Surprisingly, these countries had almost no direct trading relationships with the Southeast Asian countries. Thus, one interesting question arises: why these crises that began from a specific country quickly affected other countries around the globe, regardless of economic or financial links among these countries.

As a consequence, it is extremely important to monitor and understand the process of financial market integration and contagion.

1.2 Motivations of the research

Given the significance mentioned above, much attention has been paid to financial market integration. However, a very important issue is that financial integration may exhibit strong variations over time. Thus, various econometric approaches for measuring time-varying integration have emerged over the years.

A. Early attempts to test for this variation focus on estimating and comparing integration levels in different sub-periods (e.g. Longin and Solnik, 1995, Bodart and Reding, 1999). However, this approach may neglect much of the time variation and also may miss the causes of continuous improvement in integration since the degree of integration may often change frequently and exhibit high

volatility.

B. Fratzscher (2001) employs the rolling estimation; however, the biggest weakness of this approach is the well-known overlapping data problem.

C. Some studies adopt the dynamics cointegration analysis (e.g. Rangvid, 2001, Muckley et al., 2005). However, this analysis only shows whether some markets are heavily inter-related or not in the long-term, and it is hard to capture the short-term variation in integration.

D. Some studies employed their respective models containing time-varying coefficients through fundamental variables to capture time-varying integration (e.g. Bekaert and Harvey, 1995; Ng 2000). However, this approach only focuses on a very small set of variables, which may partly explain the time variation in integration. This kind of approach can be very problematic because the included variables may pick up effects of other excluded variables.

Therefore, the literature, with a more promising approach, focusing on time-varying financial integration is expected all the same.

The second motivation is that most previous research measuring financial integration focuses on the national market index level. Although the same class of assets within one national market shares a similar economic and financial environment, different assets may have different characteristics. For the stock market, Banz (1981) finds that small stocks usually produce higher returns than big stocks; and Rosenberg, et al. (1985) find that firms with high ratios of book value to market value have higher returns than firms with low book-to-market ratios. For the bond market, it is widely accepted that long-term bonds are more sensitive to changes in inflation and interest rates (Campbell and Ammer, 1993; Bodie, Kane, and Marcus, 2002). Thus, bonds with longer maturities need pay more than shorter maturities since investors of long-term bonds have to bear a higher risk caused by expectations of changes in interest and inflation rates. These characteristics inspire us to sort all stocks within one national market into several portfolios according to their market value and

book-to-market ratio, and sort all government bonds into several portfolios according to their different maturities, and then estimate and compare the integration of these portfolios with the world market respectively. In the academic research, compared with the whole national market, assets sorting like this own more similar risk, by which we may obtain relatively accurate results about the integration level. In practice, if the discrepancies in integration between these relevant portfolios do exist, our research will provide more opportunities for investors who can benefit from new insight into the co-movements among different portfolios in different international markets.

Thirdly, the identification of crisis periods of testing for financial contagion has been a difficult problem. Most studies wish to clearly distinguish between the period of turmoil, during which the local financial market is in crisis, and the tranquil period; and consider the historical crisis period of a specific country to be the only standard to distinguish them. However, two serious problems arise: first, this method may mask other periods when markets exhibit high volatilities; furthermore, even during the period of crisis, temporary smooth markets may exist. Second, the results of the contagion test may be seriously affected by the size of the 'crisis' and 'non-crisis' periods because the 'crisis' period usually contains very few or relatively few observations, which may seriously affect the power of the test. Therefore, the method of identifying the 'crisis' period needs to be improved. On the other hand, all previous studies of testing for contagion only investigate whether the contagion phenomena exist or not during a specific crisis period. However, the contagion level may be time-varying rather than constant if the contagion phenomenon does exist. Thus, studies examining whether contagion is constant or not are expected.

1.3 Contributions to the literature

Our research seeks to contribute to the existing literature in several ways. The first

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contribution is our dynamic model; we model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. Although the Kalman filter provides a convenient framework for estimating the time-varying coefficient through inference from data, it defines the variance of the error process to be constant (homoscedasticity). However, the error process, especially the data with high frequency, of financial models usually exhibit systematic change. And any attempt to model integration without considering this problem, heteroscedasticity, will yield biased results. Therefore, extending the Kalman filter system to allow for the GARCH effect in the innovations is expected. And this combination is a very new technique in the area of Economics and Finance; very few studies apply this technique for researching integration; my study will fill this gap. Furthermore, we examine the ability of these two alternative models (our GARCH-filter and the traditional Kalman filter) in capturing the time-variation of parameters. And, we employ Likelihood Ratio test to examine whether our GARCH-filter model is more efficient than the traditional Kalman filter system.

The second contribution is that we focus our study about integration on the portfolio level, in addition to those at the aggregate national market level. This analysis enables us to investigate whether growth (large) stock portfolios are more integrated with the world than value (small) ones; and whether bond portfolios with longer maturities are more integrated than short-term bonds. On the other hand, Fama and French (1993) propose a three-factor model that contains factors related to firm size and BE/ME ratios to describe returns, and they find that their model can capture the average return on the US portfolios formed on size and BE/ME. Thus, we add the risk factors related to firm size and BE/ME ratio to our model, and examine whether the discrepancies in integration between these relevant portfolios tend to disappear.

The third contribution is to study potential macro economic factors that may drive time variation in bond market integration. Most previous research focuses on studying the impact of variables on the stock market. Very few studies examine these

influences on the integration of bonds markets.

The fourth contribution to the literature is that we introduce two variables to identify the crisis period for testing contagion: the conditional variance of the local assets returns, and the increased level of the integration level of the national market with the world (regional) market. Furthermore, we introduce these two variables into our model and express the coefficient of contagion as a function of them, by which we can obtain the time-varying level about contagion. Our method is expected to provide a consistent platform for measuring contagion.

1.4 Key research questions of the thesis

My thesis focuses on studying the following research questions:

1. Is our GARCH-filter model more efficient than the traditional Kalman filter framework?

2. Is the growth (large) portfolio more integrated with the world than the value (small) portfolio? And is this phenomenon persistent or significant?

3. Do the discrepancies of integration levels between these portfolios tend to disappear when SMB and HML are added to our model?

4. Is the long-term bond portfolio more integrated with the world market than others?

5. Do any potential macro economic variables have explanatory power as to the volatility in the integration of bond markets?

6. Is any financial variable capable of identifying the crisis period of testing contagion?

7. Is the financial contagion level constant?

1.5 Organization of the thesis

This thesis consists of six chapters, organized as follows. Chapter 2 reviews the relevant literature about financial integration and contagion, and includes a survey of literature on potential benefits and costs of increased integration; various methods for measuring integration; potential variables for explaining time-varying integration; channels of contagion, definitions and measures of contagion. In addition, this chapter briefly reviews the CAPM and the corresponding anomalies, the three-factor model, the framework of the Kalman filter and GARCH models.

Based on our GARCH-filter model, Chapter 3 examines whether the growth (large) stock portfolio is more integrated with the world than others.

Chapter 4 further examines whether the bond portfolio with longer maturity is more integrated with the world than others.

Based on the GARCH-filter model of measuring integration, and new variables we introduced into the model of testing contagion, Chapter 5 provides the first study of measuring time-varying contagion.

Chapter 6 concludes the thesis.

Chapter 2

Literature Review

2.1 Financial integration

2.1.1 Potential benefits and costs of increased financial integration

International financial integration has increased dramatically in the last two decades. While it is generally agreed that deepening financial integration is beneficial on the whole, it may have less positive effects. In particular, empirical evidence regarding some benefits of deepening integration is still mixed. This section begins by reviewing its potential benefits and then less positive effects.

2.1.1.1 Potential benefits

A. Risk sharing and diversification

It is argued that increased financial integration facilitates greater capital mobility through increasing financial instruments and cross-ownership of assets, which is expected to provide additional opportunities for international investors to diversify their portfolios and share idiosyncratic risks. However, on the other hand, with the depth of international integration, the co-movement of markets is closer than before, and hence the diversification obtained by investors will decline.

Most early works show the benefit of international diversification through risk sharing of assets. Grubel (1968) examines stock excess returns of eleven major

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markets over the period 1959 to 1966. He finds that investors can achieve better risk sharing and more return opportunities through investing their portfolios abroad. Levy and Sarnat (1970) investigate the European and US stock markets from 1951 to 1967, and show that risk sharing and higher returns can be achieved through investing in both developed and developing stock markets.

However, increased financial integration in the last two decades make the benefits of diversification mixed. Bai and Zhang (2005) examine 21 industrial countries and 19 developing countries from 1973 to 1998. They model increased financial integration as a decrease in the cost of borrowing, and find that financial integration increases dramatically over time. However, they do not find substantial improvement in the degrees of international risk sharing during this period.

Using data over 150 years of capital markets, Goetzmann et al. (2005) find that correlations among international stock markets vary dramatically over the past 150 years. They decompose benefits of diversification into two components: one from variation in the correlation across international markets, and another from the variation in investment opportunity. They show that both benefits and drawbacks are possible for investors with deepening integration, which expands the opportunity set, but as a result, the achievement of diversification depends more on investing in emerging markets. Furthermore, the diversification benefits are not constant over time.

B. Improved capital allocation

Increased financial integration is expected to allow a better allocation of capital. The formal barriers to trading and financial transactions will be reduced as integration increases, allowing investors to invest their funds abroad much more easily, and choose the most productive investment. A reallocation of funds to the most productive investment opportunities will also take place.

Stultz (1999) surveys evidence on capital cost under globalization, and shows that increased financial integration will reduce the cost of capital. Henry (1998) proposes an event study of liberalizations based on stock markets in 12 emerging markets. He finds average abnormal returns of 3.3 percent per month during an eight-month window leading up to the implementation of a country's initial stock market liberalization. Hardevoulis, et al (1999) examine European stock market integration, and find that European Monetary Union (EMU) accelerates the integration of the stock market, and the average saving in the cost of capital from integration in Europe over the period 1992 to 1998 is estimated at around 2 percent. Through a cross-sectional time-series model, Bekaert and Harvey (2000) assess the impact of market liberalization in emerging stock markets on the cost of capital, and they find that the cost of capital always decreases after the liberalization with the effect varying between 5 and 75 basis points. Among these studies, Martin and Rey (2000) provide a relatively comprehensive analysis on the impact of integration on asset return and the breadth of financial markets. They propose a three-country macroeconomic model and model financial integration as the decrease in transaction costs between two financial markets. They find that increased integration increases asset prices in the area, and induces agents to develop more risky projects, raises the number of assets, and thus, increases the investment opportunity set and induces a better allocation of capital. A similar result is obtained by Stultz (1999) and Lombardo and Pagano (1999).

C. Economic growth

As mentioned above, the financial integration process will increase the supply of funds for investment opportunities, and raise competitive pressure, thereby increasing the efficiency of the financial system and improving capital allocation. Hence more funds will be allocated to more profitable projects, and the productivity of the economy will increase. From the point of view of the macroeconomy, the capacity to save is limited by a low level of income in less-developed countries. As long as marginal return to capital from investment is more than the cost of capital,

net foreign capitals would inflow and supplement the local saving, and thereby stimulate local economic growth.

Through the functional approach, Levine (1997) examines the role of the financial system in economic growth. Aspects of his study include facilitating the trading of risk, allocating capital, monitoring managers, mobilizing savings, and easing the trading of goods, services, and financial contracts. He states that these functions may facilitate economic growth through capital accumulation and technological innovation. Levine (2001) states that international financial liberalization may accelerate economic growth because it tends to improve stock market liquidity and the efficiency of domestic banking systems, in turn, accelerating productivity growth. Artera, Eichengreen, and Wyplosz (2001) investigate the relationship between financial openness and economic growth; in their studies, financial openness is proxied by the degree of capital account liberalization, which is measured by an index of capital account restrictions. They find some evidence for a positive relationship between financial openness and economic growth. Borensztein, Gregorio, and Lee (1998) test the effect of foreign direct investment (FDI) on economic growth in a cross-country regression framework based on 69 developing countries during the period 1970 to 1989, and find positive links between FDI and growth; furthermore, that the contribution of FDI to economic growth is greater, in relative terms, than domestic investment.

However, there is also some disappointing evidence about financial integration and economic growth. Klein and Olivei (1999) find that capital account liberalization has no discernible effect on economic growth in less-developed countries. Prasad et al. (2003) state that it is hard to establish a robust relationship between financial integration and economic growth.

2.1.1. 2 Potential costs

A. Net capital flows have declined for emerging markets

Theory predicts that net foreign capitals should inflow into emerging markets and supplement the local saving as long as marginal return to capital from investment is at least equal to the cost of capital. However, the reality has been totally different. Häusler (2003) studies the private external financing of emerging markets, and finds that net private external flows of emerging markets have declined by about 50 percent (140 billion dollars) from their peak, 285.5 billion dollars in 1997 to 143.3 billion dollars in 2002. Within this decline, net FDI reduces from 169.3 billion dollars (1997) to 143.0 billion dollars (2002), net portfolio equities from 26.7 to 9.3 billion dollars, and net debt-creating flows decrease from 89.1 to -9.0 billion dollars. These marked decreases in net capital flows of emerging markets may be caused by the widening current account deficit of developed countries since 1997, and the deficit has been financed by current account surpluses and capital outflows from emerging to developed countries. There has also been a net transfer of resources from developing to developed countries. Alfaro, Kalemli, and Volosovych (2003) examine the reason for the lack of flows of capital from rich to poor countries in an empirical framework, and find that institutional quality, human capital, and asymmetric information play a role as determinants of capital inflows.

B. Weakened macroeconomic stability

The rapid increase of capital inflows caused by financial openness may weaken local macroeconomic stability. Fernandez-Arias and Montiel (1996) examine the surge in capital inflows to developing countries in the first half of the 1990s from an analytical overview, describing the characteristics of capital inflows and assessing their causes and likely sustainability. They find that some countries with a surge in capital inflows suffer some potential problems of macroeconomic, including a rapid increase in liquidity, pressures of inflation and real exchange rate appreciation, and growing external imbalances.

C. Volatility of capital flows

A high degree of financial integration may result in a high degree of volatility in

capital movements. Developing countries are usually able to obtain capital inflows in good times, but the situation is different in bad times due to their credit constraints. Bruwer (2000) studies the capital flows in East Asia during the financial crisis. He finds that capital flows flip from an inflow of over 100 billion dollars in 1996 to outflows of over 55 billion dollars in 1998, and furthermore the flows to Latin America of two decades ago were abruptly reversed in the early 1980s. Chang and Velasco (2000) state that large reveals of short-term capital flows increase the risk of foreign borrowers since they have to face liquidity risks; in that case, short-term debt is cheaper than long-term debt. Dadush, Dasgupta, and Ratha (2000) examine the role of short-term debt in recent crises; they find that the rapid rise of short-term debt is a key factor in financial crises, including Mexico in 1994, East Asia in 1997, Russia and Brazil in 1998. They state that great volatility in capital inflows is strongly conducive to exchange rate instability, large fluctuations in official reserves, and currency crises.

On the whole, increased financial integration is beneficial, whereas its cost cannot be neglected. Financial integration must be carefully managed to ensure that benefits outweigh risk. Therefore, it is extremely important to monitor and understand the process of financial market integration.

2.1.2 Measuring financial integration

The literature of measuring financial integration can be classified into three parts: testing the integration of financial markets through the international Capital Asset Pricing Model (CAPM), testing the extent and determinants of changes in the correlation or co-integration structure of markets, and the more recent literature that recognizes the essentially static nature of these tests and derives time-varying measures of integration.

2.1.2.1 CAPM and international CAPM

Early attempts to test for financial integration focus on assuming financial markets

are completely segmented, or alternatively assuming completely integrated, and then testing the restrictions generated by asset pricing models. An example of the asset pricing study that assumes markets are segmented is one that testing the Capital Asset Pricing Model (CAPM) of Sharp (1964) and Lintner (1965). In this assumption, risk refers to exposure to only local factors. Another class of asset pricing studies assumes that world markets are completely integrated. The CAPM of Sharp (1964) and Lintner (1965) is extended to the world CAPM. Rejection of this kind of model can be viewed as a rejection of the fundamental asset pricing model, or a rejection of financial market integration.

With the assumption that capital markets are fully integrated, Harvey (1991) examined 17 developing and developed markets, and defined country risk as the conditional sensitivity of the country return to a world stock return and the reward per unit of sensitivity is the world price of covariance risk. He found that for most countries, a single source of risk appears to adequately describe the cross-sectional variation in returns across different countries.

However, based on a sample of securities, including equities and currencies, Dumas and Solnik (1995) found that the classic Asset Pricing Model (APM) of Harvey (1991) is rejected in his sample. Dumas and Solnik (1995) make the classic APM contain additional terms to reward exchange-rate risk in its conditional form; they found that foreign exchange risk premia are needed chiefly in order to explain rates of return on currencies. Once these risk premia are included in the APM, no evidence of segmentation between currency markets and stock markets is found.

Through examining the world latent factor model and predictability of excess returns on US and Japanese equity markets, Campbell and Hamao (1992) studied the long-term capital market integration in these two counties. They found that similar variables, including the dividend price ratio and interest rate variables, help to predict stock returns in the US and Japan markets in the 1970s. The US variables

have a significant ability to forecast excess Japanese stock returns in the 1980s. This evidence implies integration of long-term capital markets between the US and Japan.

Ferson and Harvey (1994) empirically examined multiple beta models for the returns and expected returns on eighteen national equity markets using a set of factors chosen to measure global economic risks. They found that when the measures of risk were expanded to include some variables as exchange rates, oil prices and long-term inflationary expectations, then much of the seemingly abnormal average performance of the Japanese and Hong Kong markets may be explained as compensation for global economic risk, and the joint hypothesis of full integration and the APM cannot be rejected.

However, there is a problem for the joint hypothesis of full integration and the APM. Current APMs can be employed as only the two extremes of integration or segmentation, and both of these will be rejected if markets are only partially integrated. Just like the findings of Campbell and Hamao (1992), they reject at the 5 percentage level the hypothesis that excess stock returns in the US and Japan are completely correlated, however, their estimates showed that the common international component of excess returns explained more than 70 percent of the variance of returns in the US, and 60 percent of the variance of returns in Japan. This result indicated partial integration of the US and Japan markets. The difficulty about partial integration is presented in Harvey (1991) and Ferson & Harvey (1994). Within Harvey's (1991) framework of international asset pricing model and hypothesis of fully integration, his model's restrictions are consistently rejected for Japan. Japan's covariance risk explains some – but not all – of its performance, while the multiple beta model of Ferson & Harvey (1994) is not rejected for Japan. The question arises: which factor causes Japan's return to be rejected: the one factor model, the model's restriction – completed integration – or both?

With this problem, Errunza, Losq and Padmanabhan (1992) explained most past

studies test the polar case of full integration and/or complete segmentation. Although the formal statistical procedures test the null hypothesis of market integration versus non integration, at times the rejection of integration has been interpreted as a proof of segmentation. Errunza, et al. (1992) tested the competing hypothesis of integration, mild segmentation and segmentation for a group of emerging markets. Their results provide strong evidence in favour of a non-polar structure, which means that the world financial market is neither fully integrated nor completely segmented. In the model of Errunza, et al. (1992) the polar integrated/segmented cases are not assumed. However, another problem is that the degree of integration or segmentation is fixed through time, while in reality some financial markets become more integrated or segmented through time.

2.1.2.2 Correlation and Cointegration

Numerous papers examined financial integration from the perspective of increasing correlations in their returns over time. This approach focuses on examining whether the correlation structure is stable over time. If the correlation exhibits instability and if the trend is towards increased correlation, this implies greater integration.

Several early studies supported a stable relationship across equity markets. Watson (1980) examined the stability of the correlation coefficients between the monthly excess returns of market indices from eight countries (Australia, Denmark, Germany, Japan, New Zealand, South Africa, UK, and the US) over the period 1970 – 1977. Their tests showed that the inter-country correlation coefficients did not vary significantly with time. Similar results about stable correlation are supported by Panton et al. (1976), and Philippatos et al. (1983).

In contrast with previous studies, using the daily data from 1986 to 1988, Fischer and Palasvirta (1990) measured the interdependence of the world's stock markets by using the average mean coherence of one stock market index with each of the other 22 market indices. They showed the level of interdependence measured by the

co-movement of index prices in the world's stock markets has grown dramatically from 1986 to 1988. In addition, they found the US market appears to lead almost every other stock market in the world.

Login and Solnik (1995) studied the correlation of monthly excess returns for seven major equity markets over the period 1960 – 1990. For capturing the evolution in the conditional covariance structure they employ a multivariate GARCH(1,1) model with constant conditional correlation. They found that the international covariance and correlation are not stable over time based on the rejection of the hypothesis of a constant conditional correlation. Their model implies an increase in the international correlation between markets over the past 30 years, and the correlations increase during periods when the conditional volatility of markets is large.

Departure from these two camps, Kaplanis (1988) examined the stability of the co-movement measures of international equity index returns based on monthly excess returns over the period 1967 to 1982 for ten major equity markets. They found that there is some evidence that the correlation matrix of international stock returns is stable over time, but the covariance is not.

Meric and Meric (1988) studied the inter-temporal stability of international stock market co-movements based on 17 national stock market indices from 1973 to 1987. They divided the sample period into ten 1.5-year, five 3-year, three 5-year, and two 7.5-year sub-periods and Box's M statistical tests were applied to pairs of consecutive sub-periods. They tested the null hypothesis that the correlation matrix of a given sub-period is the same as those of the preceding sub-periods. Their results implied that the international stock market relationship is more stable with the longer time period, and they found unstable correlation for shorter periods, but stability over longer periods.

However, the problem of this approach is that higher correlation is neither a

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necessary nor a sufficient condition for greater market integration. If markets are fully integrated there are no arbitrage opportunities, returns on different assets can be divided into a common component and an idiosyncratic one. The latter factor, however, may be enough to drive the correlation level to rather low. On the other hand, correlations are usually higher during periods of high volatility, which are often associated with business cycle troughs. Therefore, an increase in correlation may be caused by the cycle, rather than structural changes in the financial system.

Another contribution to the literature is to employ cointegration measures to assess the degree of financial integration. This approach stems from Bernard (1991), who stated that n-1 co-integration vectors in a system of n indices are a necessary condition for complete integration.

Kasa (1992) presented evidence about the number of common stochastic trends in five major equity markets (the US, Japan, UK, Germany, and Canada) from 1974 to 1990. Through computing Johansen (1988) tests for common trends, he found a single common trend driving these countries' equity markets, thus, only one cointegration vector exists among these markets. Based on Bernard's (1991) view, Kasa's (1992) results imply low levels of integration.

Using Johansen's cointegration test, Chan, et al. (1997) examined integration of international stock markets by including eighteen countries and covering a 32-year period from 1961 to 1992. They found that only a small number of stock markets exhibit cointegration evidence with others. Over the whole sample, only a single cointegration vector is detected for four Asian markets (Japan, India, Pakistan, and Australia), and no evidence for other markets. When examining in sub-periods, they found two vectors for the UK, Germany, France, and Italy markets, a single vector for the UK, Germany, France, Switzerland, and Belgium markets, and for the Japan, India, Pakistan, and Australia markets during period 1980 – 87. And they did not detect any vector during other sub-periods. All of these results indicate low

integration levels.

However, employing the more sophisticated Johansen multivariate approach, Manning (2002) examined nine equity markets in South East Asia over the period 1988 to 1999. Manning found a minimum of two common trends in these markets, which indicates partial convergence of the indices, and provides stronger evidence of integration.

However, the result from the cointegration approach is just a long-term relationship, which cannot provide further information about the integration level of a relatively short-term nature, and cannot capture the time variation of the integration level. Hence, this method, in practice, cannot satisfy the requirement both of investors and policy makers.

2.1.2.3 Time-varying estimates

One common problem in studies mentioned above is that they focus on comparative statics, however, financial integration may exhibit strong variations over time. Some studies showed that the risk premium on equities is indeed time varying (Campbell, 1987, Harvey, 1991), and any attempt to model the integration of markets without considering this variation may yield biased results.

A. Compare different sub-periods

Early attempts to capture the time variation in integration focus on comparing integration levels in different sub-periods. Bodart and Reding (1999) examined whether there were statistical differences in volatilities and international correlations across alternative episodes of European Monetary System (ERM) exchange rate variability. They used daily returns in the Germany, France, Belgium, Italy, UK, and Sweden markets over the period Jan. 2 1989 to Dec. 19 1994, and both bond and stock markets are included. They use a bivariate model with time-varying conditional variance but constant conditional correlation, and the model is specified

as:

$$R_t = a_0 + a_1 * R_{t-1} + e_t ,$$

$$h_t = c_0 + c_1 * e_{t-1}^2 + c_2 * h_{t-1} ,$$

$$h_t^{i,G} = r * [h_t^i * h_t^G]^{0.5} ,$$

$$e_t | \Omega_{t-1} \rightarrow N(0, h_t)$$

Where R_t is the 2*1 vector of daily excess returns of a given stock or bond market, e_t is the corresponding vector of residuals with assumption of conditionally normal distribution with zero mean and time varying conditional variance vector h_t. $h_t^{i,G}$ is defined as the conditional covariance among given market returns. r is the constant conditional correlation between returns. They divided the whole period into three parts according to the ERM exchange rate regime: sub. 1 = Jan. 2 1989 – Sep. 14 1992, sub. 2 = Sep. 14 1992 – Aug. 2 1993, sub.3 = Aug. 2 1993 – Dec. 19 1994. They first investigated the effect of the exchange rate regime on international market correlations. They augmented the covariance model by incorporating dummy variables into the covariance model:

$$h_t^{i,G} = [r + d2 * ERM_2 + d3 * ERM_3] * [h_t^i * h_t^G]^{0.5}$$

Where $ERM_2 = 1$ in the second sub-period and zero otherwise, and $ERM_3 = 1$ in the third sub-period and zero otherwise.

They found, for most markets, that coefficients of ERM are significant, which indicated that ERM exchange rate variability had an impact on the cross-market correlations. Then they examined and compared the correlation in different sub-periods, and found that correlations indeed vary across alternative episodes of ERM exchange rate variability.

With a similar method to that of Bodart and Reding (1999), Login and Solnik (1995) studied the correlation of monthly excess returns for seven major equity markets over the period 1960 – 1990, and they also concluded that international correlation

changes, moreover, increases over time.

Although this approach can provide the proxy for long-term changes of integration through estimating and comparing different sub-periods, it may neglect much of the time variation and also may miss the causes of continuous improvement in integration since the degree of integration may often change frequently and exhibit high volatility.

B. Dynamics cointegration analysis

To avoid the problems mentioned above, Muckley et al. (2005) examined the integration of European equity markets over 1985-2002 using three dynamics techniques that measure the extent of time-varying equity market integration from complementary perspectives.

The first approach is the dynamic cointegration analysis. The essence of cointegration is that the time series cannot diverge far from each other, and implies that there exists a long-term relationship between them. If national stock prices are driven by the same relatively few common stochastic trends, they could be considered as somewhat converged and integrated in the sense that they are driven by the same permanent shocks. Muckley et al. (2005) plots the values of selected test statistics from the Johansen-Juselius (JJ) approach to investigate the time-varying integration of European equity markets. What they want to test are the largest value of the λ_{trace} statistics (which is a test of the general question of whether there exist one or more co-integration vectors), and λ_{max} (whi ch is used to test the precise number of co-integration vectors). Increasing numbers of co-integrating vectors implies the convergence of a set of series. To capture the time-varying integration, Muckley et al. (2005) employ the recursive co-integration approach, which in essence runs a traditional co-integration analysis for an initial period, and thereafter updates as new data are added.

However, this analysis only shows whether some markets are heavily inter-related or not, but says nothing about whether these linkages are constant, or whether they have tended to increase over time. Therefore, Muckley et al. (2005) employ the dynamic Haldane and Hall – Kalman Filter methodology to be the complementary approach. Haldane and Hall's (1991) equation is:

$$\ln(E_{jt} / E_{Bt}) = \alpha_t + \beta_t \ln(E_{jt} / E_{Xt}) + \varepsilon_{jt}$$

E_{Xt} is external market, such as the US, and E_{Bt} is the dominant local market, such as Hong Kong in the Asia market. The α_t paramet er is a stochastic constant which partials out all systematic influences on $\ln(E_{jt} / E_{Bt})$ other than that resulting from $\ln(E_{jt} / E_{Xt})$. Negative values of β_t indicate divergence, as does a tendency to move further from zero. Muckley et al. (2005) estimated the time varying β_t through Kalman filter to capture the trend of convergence of examined markets. For example, if we consider the US to be the external market and Hong Kong to be the base Asian market, then the time varying coefficient b in equation should tend to zero as convergence among Asian markets occurs.

However, one drawback of the HH approach is that the conclusion may differ according to which markets are chosen as the common external and the within-group base market. An alternative approach again is to capture the time varying nature of the eigenvalue. Another complementary approach is Dynamic eigenvalue analysis, which captures interdependencies of a relatively short-term nature. This method is to do a regression of the national stock market index on the common trends, and obtain the value of R^2. And they plot the cumulative R^2 of the first eigenvalue by rolling estimation. Thus, the larger an eigenvalue estimate the higher the estimate of multilateral correlation in the system.

Muckley et al.'s (2005) analysis based on the latter two complementary methods

largely support the result provided by the dynamic cointegration technique, and they concluded that there had been an increased degree of integration among European equity markets, especially during the important 1997-1998 period-which saw a greatly increased level of integration.

Rangvid (2001) employed the similar approach – recursive cointegration test – to examine co-movement of three major European stock markets (France, Germany, and UK) based on quarterly share indices over the 1960 – 1999 period. He also found that these three stock markets were being increasingly integrated throughout the 1980s and 1990s.

C. Make models contain time-varying coefficient through fundamental variables

To avoid the problem caused by dynamics cointegration analysis, some studies employed their respective models containing time-varying coefficient through fundamental variables to capture time-varying integration.

Bekaerk and Harvey (1995) proposed a measure of market integration arising from a conditional regime-switching model. Their method allows them to describe expected returns in countries segmented from world capital markets in one part of the sample and become integrated later in the sample. Therefore, they allow conditional expected returns in a country to be affected by their covariance with a world benchmark portfolio when the market is perfectly integrated, and by the variance of the country (local) returns when it is completely segmented. The model is conditional in the sense that predetermined information is allowed to affect the expected returns, covariance, variance, and the integration measure. They applied this model to a group of emerging capital markets including Korea, Taiwan, Malaysia and Thailand over the period 1975 to 1992. They found that integration was substantial for the entire period. In addition, they found that most financial markets experience changing levels of integration and that some markets became

more segmented shortly after liberalization.

More recent studies proposed a method to examine whether the common news part in stock returns is increased (Bekaerk and Harvey, 1997; Ng, 2000; Fratzscher, 2001; Baele, 2003). These studies based on news-based measures, and they assumed that complete integration requires asset prices to only react to common news. If there are no barriers among international markets, purely local shocks should be diversified away through investing from different regions, and should not constitute a systematic risk. Thus, in a complete integration region, asset returns from different countries but with the same risk characteristics should depend on common news rather than local news. These studies assumed the price movements of the world (or the US) market are a good proxy of all relevant common news. Key models are expressed as follows:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t}$$

$$\varepsilon_{i,t} = \gamma_{i,t-1}^{w} \varepsilon_{w,t} (+\gamma_{i,t-1}^{reg} \varepsilon_{reg,t}) + e_{i,t}$$

$$h_{i,t} = \text{var}(e_{i,t} | \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1} e_{i,t-1}^2 + \alpha_{i2} h_{t-1} + \alpha_{i3} \xi_{i,t-1}^2$$

Where stock excess return $r_{i,t}$ is divided into two parts: an expected part $\mu_{i,t-1}$ and an unexpected part $\varepsilon_{i,t}$. Bekaerk and Harvey (1997) let the unexpected return $\varepsilon_{i,t}$ to be determined by a purely lock shock $e_{i,t}$ and a reaction to the world news $\varepsilon_{w,t}$. Ng (2000), Fratzscher (2001), and Baele (2003) extended his model, and let the unexpected return $\varepsilon_{i,t}$ to be determined by a purely lock shock $e_{i,t}$, a reaction to the world news $\varepsilon_{w,t}$, and a reaction to the regional news $\varepsilon_{reg,t}$. All of these studies limit the evolution of the conditional second moments of excess returns to the TGARCH(1,1) process. $\gamma_{i,t-1}^{w}$ and $\gamma_{i,t-1}^{reg}$ represent the country-dependent sensitivities to world and regional equity market innovations.

To capture time variation in integration, Bekaerk and Harvey (1997) expressed the

coefficient $\gamma_{i,t-1}^w$ as a function of macro-economic information variable, and these variables includes a constant, the stock return, the exchange rate change, the dividend yield, the ratio of equity market capitalization to GDP, and the ratio of trade to GDP, and all of variables are lagged. They examined monthly stock excess returns for 20 emerging markets for the period Jan. 1976 to Dec. 1992, and they found that capital market liberalizations often increase the integration between local markets and the world market.

Ng (2000) used two approaches to express coefficients $\gamma_{i,t-1}^w$ and $\gamma_{i,t-1}^{reg}$. First they express them as a function of liberalization dummy variables which equal 1 for days after the liberalization events and 0 otherwise. Second, coefficients are represented by a set of variables: a constant, exchange rate changes, the number of DR listings, the total exports from and imports to the US (Japan) as ratio to GDP. They examined weekly data for seven Asian stock markets over the period 1975 to 1996. They found that there are significant spillovers from the region to most of the Pacific Basin countries except for the impact of the world factor, and these spillovers, including those from the region and the world, vary dramatically over time. In addition, liberalization events, exchange rate change, number of DR listings, size of trade, and country fund premium were shown to affect the relative importance of the world and regional market factors over time.

Baele (2003) made the spillover model include the possibility of regime switching between states and they used weekly stock excess returns from eight EMU countries, three European Union countries, and two countries from outside the EU. He found that integration with the EU and US had increased over the 1980s and 1990s; the increase is more pronounced for EU spillovers.

However, the focus of Bekaerk and Harvey (1995) is to specify explicitly the relevant local and common information variables, and then test whether the local or

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common variables have any statistically significant power to explain asset returns. The problem is that there may be considerable uncertainty about which information variables should be included, and how they relate to asset returns. This problem will result in partly explaining the time variation in integration. Like Bekaerk and Harvey (1995), this problem also exists in other studies mentioned above, which employed their respective models containing time-varying coefficients through instrumental variables to capture the variation of financial integration (Bekaerk and Harvey, 1997; Ng, 2000; Fratzscher, 2001; Baele, 2003).

D. Rolling estimation

Using similar models to those of Ng (2000) and Baele (2003), Fratzscher (2001) adopted rolling estimation to capture the time-varying integration. He took a 12-month regression window, starting from Jan. 1986 – Jan. 1987, and moved this 12-month window forward by one month at a time. He examined daily data for a set of 16 countries including 11 European markets and 5 major stock markets from outside Europe from 1986 to 2000. He found that European stock markets had become highly integrated only since 1996, and that the Euro area market had taken over from the US as the dominant market in Europe.

However, the biggest weakness of rolling estimation is the well-known overlapping data problem.

2.1.3 Explaining time-varying financial integration

Regarding the empirical financial integration, much work focuses on investigating the possible causes of such integration and examining the possible changes in such relationships over time.

A. Real economic convergence

Fama and French (1989) define the default spread as a business-conditions variable. They find that this spread is high during periods when business is persistently poor,

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and low during periods when the economy is persistently strong. The dividend yield is correlated with the default spread and moves in a similar way to long-term business conditions. Their conclusion suggests that the implied variation in expected returns is largely common across securities, and is negatively related to long- and short-term variations in business conditions. They conclude that the degree of real integration, measured by the correlation of business cycle, has a strong effect on financial integration.

Bracker (1999) investigates how and why different pairs of national equity markets display differing degrees of co-movement over time, and they interpret a greater degree of co-movement to reflect greater stock market integration. They hypothesize the extent of stock market integration may depend upon certain macroeconomic variables that characterize and influence the degree of economic integration between two countries, and these significant factors include the two measures of bilateral import dependence, the geographical distance between markets, the size differential across markets, time trend and dummy variables for different blocks of countries whose trading hours overlap. They find that equity market integration varies systematically as the degree of economic integration varies over time for a given pair of countries.

Ferson and Harvey (1991), Bachman and Choi (1996), and Jagannathan and Wang's (1996) investigations reach a similar conclusion about the impact of real economic convergence.

B. Monetary convergence
Many studies have shown that monetary convergence has a strong effect on financial integration. The approach for investigating the impact of monetary convergence on integration can be generally classified into two parts.

The first approach is to express coefficients of a dynamic model as a function of

local information variables proxied by the monetary convergence. Fratzscher (2002) uses the correlation of inflation rates to reflect monetary linkage and includes it into his trivariate GARCH model. He finds that the integration of European stock markets is in large part explained by the uncertainty in the process of monetary unification.

Baele (2003) uses excess inflation calculated as the local inflation in excess of the EU-15 inflation average to proxy monetary convergence and includes this variable into his spillover model. He finds that low inflation has contributed to the increase in EU stock spillover intensity.

Hunter (2005) chose two variables: interest differential (change in absolute value of the local deposit rate in excess of the US deposit rate), and inflation differential (change in absolute value of the local inflation rate in excess of the US inflation rate). Through a multiple asset pricing model, he makes the time variation in the risk prices for each asset consist of these variables. He examines the stock markets of Argentina, Chile, and Mexico, and finds that the state of the currency market significantly affects the level of segmentation.

The second approach is to obtain the time varying integration level from the theoretical model, and then regress the integration level on relevant information variables. Kim et al. (2005) use a bivariate EGARCH model with time-varying conditional variance and correlation to estimate the time-varying integration of European Union markets. Then they regress the estimated integration level on relevant information variables through Seemingly Unrelated Regression Estimates (SURE). Kim et al. (2005a) examined stock markets and used rolling correlations in nominal short-term interest rates with Euro area GDP weighted average to proxy monetary convergence. Kim et al. (2005b) examined stock and bond markets and use rolling correlations in nominal short-term interest rates, rolling correlations in seasonally adjusted consumer price inflation, and rolling correlations in real

short-term interest rates with the corresponding Euro area equivalent respectively to proxy monetary convergence. Kim et al. (2005) find that these variables reflecting monetary linkages play some role in driving time variation in integration.

C. Exchange rate volatility

In addition, there is evidence that exchange rate uncertainty can have a large effect on financial market integration because exchange rate risk is an important source of risk priced on international capital markets. Bodard and Reding (1999) examined the behaviour of domestic daily returns on bond and stock markets with the objective of identifying whether there exist significant differences in the patterns of volatilities and international correlations between ERM and non-ERM countries and across alternative episodes of ERM exchange rate variability. Their analysis showed that an increase in exchange rate volatility is accompanied by a decline in international correlations between bond and stock markets. Dumas and Solnik (1995) found that the classic APM is rejected with the null hypothesis that markets are fully integrated; however, when the classic APM contain additional terms to reward exchange-rate risk, no evidence of segmentation between currency and stock markets is found.

To proxy exchange rate volatility, Fratzscher (2002), Baele (2003), and Kim et al. (2005) estimate conditional variance from a GARCH(1,1) model for local currency to the world or regional exchange returns, and Hunter (2005) estimates daily standard deviation of changes in bilateral exchange rate. All of them also find that exchange rate volatility significantly affects the level of integration.

D. Capital liberalization

Regarding the effect of capital liberalizations on financial integration, Bekaerk and Harvey (2000) proposed a cross-sectional time-series model to assess the impact of market liberalizations in emerging equity markets on the cost of capital, volatility, beta, and correlation with world market returns. They stated that the liberalization of these markets has beneficially affected the cost of capital, but it is extremely hard to

identify when market integration really occurs.

However, Bekaerk, Harvey and Lumsdaine (2002) studied the interrelationship between capital flows, returns, dividend yields and world interest rates in 20 emerging markets. They found that equity flows increase by 1.4% of market capitalization after the liberalization. They stated that the equity markets of the developing countries became integrated within three years after their official liberalization. This empirical work is consistent with Phylaktis (1999) and Johnson and Soenen (2002), who found these markets became more integrated in recent times. This is inconsistent with Bekaert and Harvey (1995), who found these markets experience changing levels of integration and that some markets became more segmented shortly after liberalization.

To solve this problem, using a test of integration that captures its variation through time, Hunter (2005) examined how the level of integration has evolved over the post liberalization period for three of Latin America's largest equity markets. He found that these markets experience time-varying integration and are still not highly internationally integrated and in fact have become increasingly segmented over the post-liberalization period.

From reviewing literature, we find that most former research focuses on studying the impact of information variables on the integration of stock markets. However, very few studies examine these impacts on the bond markets.

2.2 Financial contagion

2.2.1 Channels (or causes) of contagion

Many studies have examined how contagion transmits across countries, or what

causes contagion. The literature regarding this issue can be generally classified into two parts. In the first part, contagion is linked to observed changes in macroeconomic or other fundamentals. The second part states contagion is the result of the behaviour of investors.

2.2.1.1 Fundamental links

A. Trade and competitive devaluations

Trade links and competitive devaluations are instruments of transmission, by which local shocks of one country can influence the macroeconomic fundamentals of other countries. When a country is in a period of currency depreciation, it will reduce the cost of the local goods relative to foreign goods, which will make the local goods own competitive dominate compared to that of the foreign country (this country's major trading partner), which, in turn, will result in a decline in exports of the foreign country. To keep the balance of trade, the foreign country has to devalue its currency. Gerlach and Smets (1995) propose a model for two countries with bilateral trade to explain the contagion effects of speculative attacks against fixed exchange rate regimes during the European exchange market turmoil during 1992 to 1993. They show that the forced depreciation of one currency affects the competitiveness of other countries through trade links, and the contagion effect in their model is stronger the higher the degree of trade integration between the two countries. Corsetti et al. (1999) find that the devaluation of a country has a negative welfare effect on its trading partners due to the decline in their export profits and the increase in disutility from the higher labour effort for any level of consumption.

B. Common shocks

Some studies have found that many common shocks can result in market adjustment at the international level, and these shocks are exogenous to the country under examination. Calvo and Reinhart (1996) examine how small open countries are affected by economic developments in other countries. They find that both international movements and the balance on the capital account are significantly

affected by the change in interest rates in the US, and increases in the US interest rate are associated with capital outflows from Latin America. Corsetti, Pesenti, and Roubini (1998) investigate the causes of the Asian currency and financial crisis. They find that the sharp appreciation of the US dollar relative to other currencies since the second half of 1995 weakened cost-competitiveness and reduced exports in most Asian countries whose currencies were pegged to the dollar. This is one of the most import factors that led to the 1997 Asian Crisis.

C. Financial links

A financial crisis in one country can have a direct financial impact on its neighbours through direct cross-country investment, capital flows, etc. For instance, a devaluation of the US dollar drives stock prices down in China because it imposes losses on Chinese firms investing in the US, and reduces Chinese foreign currency reserves, which weakens the stability of the Chinese financial system.

2.2.1.2 Investor behaviour

A. Liquidity and incentive problems

A financial crisis in one country makes international investors suffer from large capital losses, and forces investors to sell off securities in other countries to increase funds with the expectation of a higher frequency of repayment. To examine emerging markets contagion, Valdes (1997) develops a model, which combines countries faced with illiquidity problems with investors' required liquidity, and its intuition is that if a country fails to satisfy the requirement of investors for liquidity, then investors will seek cash in a second country. He finds a negative relationship between the probability of repayment of one country and the degree of illiquidity of other countries.

The incentive problem can also induce investors to reduce their holdings in capital markets. A negative shock or crisis in one country will drop its assets markets, fund managers will have to pull resources out from other countries in order to maintain

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fixed weights of this country's asset in their portfolios. Schinasi and Smith (2000) use the value-at-risk portfolio management rules to explain portfolio rebalance and contagion; they find that investors usually sell many assets with higher risk when a shock affects one of those assets; furthermore, portfolio diversification and leverage are sufficient to explain this phenomenon.

B. Information asymmetries

This channel presumes that investors have imperfect information about the condition of each country as it affects their investments. Thus, as a financial crisis takes place in one country, investors may believe that this crisis may result in similar crises in other countries according to their limited information, which may or may not reflect the true state of other countries. Calvo (1999) examines the potential channel that may lead to contagion in emerging markets, he finds that rational but imperfectly informed investors usually try to extract information from informed investors' trade; however, if informed investors sell securities just for meeting margin calls, it may mislead uninformed investors to think returns in emerging markets are low.

C. Multiple equilibriums

The implication of this channel is that investors' expectations on the economic condition of one country are subject to the condition on another country regardless of whether these two countries are related or not. A crisis taking place in one country may induce investors to change their thinking and expect bad equilibrium in another country even through these two countries are not related. Thus, investors may shift another country from good to bad equilibrium through reducing investment, etc, which may result in further crises. To examine emerging market crises in 1994 and in 1997, Masson (1998) develops a two-country model that is used to illustrate the role of multiple equilibrium and contagion effects. He finds that contagion is a consequence of sudden shifts in market expectations, for instance a jump between equilibrium triggered by a crisis elsewhere. He argues that only models that admit multiple equilibriums are able to produce true contagion.

2.2.2 Definitions and measures of financial contagion

The definition of the term contagion has varied considerably across the literature. Among all the extant descriptions about contagion, two definitions are widely employed.

2.2.2.1 Shift contagion

The first defines contagion as a change in the strength of the propagation of shocks during the period of crisis compared with the tranquil period. Kemper and Dudley (2002) define this type of contagion as 'shift contagion'.

Based on this definition, King and Wadhwani (1990) examine stock markets in London, New York, and Tokyo around the 1987 crash from Jul. 1987 to Feb. 1988, and they measure whether the correlation of stock returns between two markets significantly increases during the 1987 crash relative to other periods. They find that correlations indeed increase significantly during the 1987 crash period, which implies contagion. Calvo and Reinhart (1996) test correlations shifts of emerging stock markets in Asia and Latin America during the 1994 Mexican peso crisis. They find that the degree of co-movement of returns following the 1994 Mexico crisis increases in both Asia and Latin America, furthermore, regional contagion may be more than the global.

However, Forbes and Rigobon (2002) analyze whether correlation coefficients across stock markets increase significantly after the 1997 East Asia crisis, the 1994 Mexican peso devaluation, and the 1987 US stock market crash. They find that the correlation coefficient is conditional on market volatility, and stock market volatility rises during the crisis period, which results in increased correlations. After correcting for this volatility during the crisis, they do not find evidence of significantly increased correlations.

The main advantage of this definition is that it is easier to be tested. However, there are two serious problems besides the one described by Forbes and Rigobon (2002). First, it is difficult to detect when the source of contagion is always present. This definition requires a significant increase in correlations from the tranquil to the crisis period. If contagion is always present over the test sample, correlations would keep at a relatively high level, but a significant increase is not necessary. Thus, a significant increase in correlations would not be detected even though contagion exists. Second, the high degree of correlations cannot be considered as proof enough of contagion.

If markets are highly correlated, then a sharp change caused by a crisis in one market will result in a corresponding change in other markets. If a significant increase in correlations during the crisis does not occur, then these international markets only react to each other, which is usually considered as interdependence between markets, rather than contagion.

2.2.2.2 Pure contagion

The second definition is proposed by Eichengreen and Rose (1995) and Eichengreen, Rose and Wyplosz (1996), who consider contagion as the co-movement of excess returns of two markets after controlling for the effects of fundamentals. Kemper and Dudley (2002) define this type of contagion as 'pure contagion'. The common feature of pure contagion is that transmissions through fundamentals are not identified as contagion, and the transmission takes place beyond these fundamental transmissions is considered as contagion. Thus, contagion is actually defined relative to a particular set of fundamentals. However, one question arises: how can one identify the fundamental channels? In most empirical studies, controlling for the role of fundamentals is achieved through the residual of a regression, and the residual is the part not explained by the model with the specified fundamental channels.

Baig and Goldfajn (1998) use daily data from 1995 to 1998 to test for evidence of

contagion of currency and sovereign spreads in the Southeast Asian countries. They construct some dummy variables based on daily news to capture the impact of own news and other fundamentals and consider the correlation of the remaining unexplained parts as potential contagion. They find, after controlling for the fundamental, that correlations of currency and equity markets respectively among these countries increase substantially during the crisis in contrast to other periods, which implies contagion. To control for normal interdependence Favero and Giavazzi (2000) construct a structural simultaneous model for the determination of interest rate spreads, and they find evidence of contagion in interest rate residuals based on data of interest rate spreads on German rates for seven European countries from 1988 to 1992; furthermore, they show that contagion within the ERM is a general phenomenon with the exception of France. Based on monthly data from 1970 to 1980, Kaminsky and Reinhart (2000) control for the trade and financial fundamentals and then examine whether a crisis elsewhere increases the probability of a crisis at home. They find some evidence of contagion for countries in Asia, Europe, and Latin America. Pesaran and Pick (2003) critically analyze 'shift contagion', which does not involve any market specific variables, and show that this approach ignoring interdependence can result in an upward bias in the estimate of contagion. They use trade flow data and control for a range of fundamentals to eliminate the influence of market interdependencies, and then examine contagion as transmission above that. They examine data on European interest rate spreads during the ERM and find an asymmetry in the contagion effects of sharp rises and falls.

From the literatures mentioned above, we find that studies employ various approaches to control for fundamentals. The problem is that the result of contagion is very sensitive to these fundamentals, and will be biased if any fundamental channel is misidentified. However, there is still no consensus on the appropriate set of fundamentals to use as control variables, which suggests that any model dependent heavily on a specific set of fundamentals may not be effectively operational. In this respect, the latent factor model exhibits its advantage and provides a convenient

framework for identifying the common component by the dynamic interrelationships between asset returns, which does not require the specification of the fundamental relationships (Dungey, et al., 2003; Bekaert, Harvey, and Ng, 2005).

Dungey, et al., (2003) suggest that interdependencies captured through directly controlling for fundamentals are not general enough. Based on the framework of a latent factor model, they use different approaches to study contagion in the 1994 Mexico crisis, and they find strong evidence of contagion between the stock markets of Argentina, Chile, and Mexico. By the latent factor model Corsetti, Pericoli, and Sbracia (2005) examine contagion effects in ten emerging markets in Southeast Asia and some developed markets during the period of the 1997 Asia crisis. They find some evidence of contagion from the Hong Kong market to the Singapore, Philippines, France, Italy, and UK markets.

However, contagion is usually associated with short-term movements, and the data is characterized by strong unconditional and conditional heteroscedasticity. Thus, any attempt to model contagion without considering heteroscedasticity will produce biased results. The most popular approach to capture this phenomenon is to include the GARCH structure into the model.

Bekaert, Harvey, and Ng (2005) propose a two-factor model and allow for local factors to be priced.

$$r_{i,t} = \delta_i Z_{i,t-1} + \beta^{us}_{i,t-1}\mu_{us,t-1} + \beta^{reg}_{i,t-1}\mu_{reg,t-1} + \beta^{us}_{i,t-1}e_{us,t} + \beta^{reg}_{i,t-1}e_{reg,t} + e_{i,t}$$

$$e_{i,t}\big|I_{t-1} \mapsto N(0,\sigma^2_{i,t}),$$

$$\sigma^2_{i,t} = a_i + b_i\sigma^2_{i,t-1} + c_i e^2_{i,t-1} + d_i\eta^2_{i,t-1}$$

$r_{i,t}$ is the excess return of the national equity index of country i. μ represents the conditional expected returns. $e_{i,t}$ is the idiosyncratic shock of any market i. $Z_{i,t-1}$ contains a constant and the local dividend yield, which helps to estimate the

expected return of market i. The dividend yields are lagged by 1 month. To solve the problem caused by heteroscedasticity, they limit the evolution of the conditional second moment of excess returns to the TGARCH(1,1,) model. The sensitivity of equity market i to foreign news factors is measured by the parameters β. They model these risk parameters to be time-varying through expressing them as a function of some information variables including the world and local.

Bekaert, Harvey, and Ng (2005) measure contagion by measuring the correlation of the model's idiosyncratic shocks or unexpected returns. Their tests involve the time-series cross-section regression model:

$$\hat{e}_{i,t} = w_i + v_{i,t}\hat{e}_{g,t} + u_{i,t}$$

$$v_{i,t} = v_0 + v_1 D_{i,t}$$

$\hat{e}_{i,t}$ and $\hat{e}_{g,t}$ are the estimated idiosyncratic return shocks of market i and region g, respectively. $D_{i,t}$ is a dummy variable that represents some crisis periods.

Thus, this framework gives them the ability to decompose the increased correlation of returns into two components: the part the asset pricing model explains and the part the model does not explain. The explained part provides potential insights about market integration through the movements in the betas. They define contagion as the correlation of the unexplained portion.

They examine monthly stock excess returns of countries in three regions: Europe, Southeast Asia, and Latin America. Their results show that there is no evidence of contagion during the period of the 1994 Mexico crisis; however, they find some evidence of contagion during the 1997 Asia crisis.

Based on the basic model of Bekaert and Harvey (1997), Baele (2003) use the approach of regime switching to capture interdependence between markets; then

they estimate the correlation of residuals from regression to measure contagion. Their sample includes weekly excess returns of eight EMU countries from Jan. 1980 to Aug. 2001. They find a significant correlation between local residuals and those of the US market during the crisis; however, they do not find evidence of contagion between different EMU countries and the regional European market.

2.2.2.3 Identifying crisis periods

The identification of crisis periods has been a particularly difficult problem in the literature of financial contagion. Ideally, most researchers wish to clearly distinguish between the period of turmoil, during which the local financial market is in crisis, and the tranquil period.

Much research about contagion identifies the turmoil period according to the historical crisis period. For instance, Bekaert, Harvey, and Ng (2005) extract two crisis periods within their sample through setting the dummy variable according to the historical crisis period, say, the Mexico crisis period is from Nov. 1994 to Dec. 1995, and the Asia crisis period is from Apr. 1997 to Oct. 1998. However, Dungey, Fry, and Martin (2001) define the 1997 Asia crisis from Oct. 1997 to Dec. 2001. Dungey, et al. (2003) define the 1994 Mexico crisis from Dec. 19, 1994 to Mar. 2, 1995. Thus, the determination of crisis periods is very artificial. One problem arises immediately: which identification would be more accurate? Through examining the US stock market crash, Dungey and Zhumabekova (2001) find that significant evidence of contagion would appear if the crisis sample period was extended, and this significance would disappear with the shorter crisis period. Thus, the result of contagion is very sensitive to the extent of crisis periods, and may exhibit the opposite condition according to differently artificial crisis periods. Another potential problem is that this approach may mask other periods when markets exhibit high volatilities. Furthermore, even during the period of crisis, temporary smooth markets may exist. Therefore, a more scientific procedure for identifying crisis periods based

on the data characteristics is expected.

2.3 Stock market: small vs. large, value vs. growth

2.3.1 CAPM and its challenges

Sharpe (1964), Lintner (1965), and Black (1972) propose the well-known asset pricing model, based on the market beta (the slope in the regression of a stock return on the benchmark's return). They argue that this beta in their asset pricing model is sufficient to describe the stock market's return.

However, there are many empirical contradictions to the asset pricing model of Sharpe (1964), Lintner (1965) and Black (1972). Using daily stock return of the US from Jul. 1962 to Dec. 1979, Reinganum (1981) examines empirically whether stocks with different estimated betas systematically exhibit different average return. He finds that the stock average return with high beta is not reliably different from the return of the low beta stock, and estimated betas from the asset pricing model of Sharpe (1964), Lintner (1965) and Black (1972) are not systematically related to average returns across stocks.

Banz (1981) examines the relationship between the stock return and its corresponding market value based on monthly return of common stocks quoted on the NYSE from 1926 and 1975. He finds that smaller stocks exhibit higher risk adjusted returns on average compared to large stocks within his sample. Average returns on small stocks are too high compared to their beta estimates from the asset pricing model of Sharpe (1964), Lintner (1965) and Black (1972), and average returns on large stocks are too low, which implies that the capital asset pricing model may be mis-specified.

Another contradiction of the model of Sharpe (1964), Lintner (1965) and Black (1972) is the leverage effect proposed by Bhandari (1988), who examines the relationship between stock returns and the ratio of debt to equity. He finds that the estimated coefficient of the ratio of debt to equity is 0.13 percent per month including January and 0.09 percent per month excluding January within his sample, and concludes that expected returns on common stocks are positively related to the ratio of debt to equity controlling for betas and firm size.

Basu (1983) investigates the relationship between earnings-price rations (E/P), firm size and stock returns based on common stocks in the NYSE from 1962 to 1978. He finds that stock returns are related to E/P and firm size, and stocks with high E/P appear to have higher risk-adjusted returns than those with low E/P firms, and similar to results from Banz (1981) that small firms appear to have earned higher returns than large firms. Furthermore, he finds that this E/P effect is still significant after controlling for the firm size; in contrast, the size effect eventually disappears after controlling for differences in risk and E/P effects.

Rosenberg, Reid, and Lanstein (1985) provide another evidence against the CAPM by showing that the US stocks with high ratios of a firm's book value of common equity to its market value (BE/ME) have significantly higher returns than stocks with low BE/ME. Based on stocks in the Tokyo Stock Exchange from 1971 to 1988, Chan, Hamao, and Lakonishok (1991) examine the effect of four variables on stock returns: earning yield, firm size, book to market ratio (BE/ME) and cash flow yield. They find that all of these variables exhibit a significant impact on expected returns, and among these four variables, the book to market ratio and cash flow yield have the most significant impact on returns. Fama and French (1998) provide international evidence for the BE/ME factor, studying stock returns on market, value and growth portfolios for the US and twelve major countries located in Europe, Australia, and the Far East from 1974 to 1994. They find that value stocks (high BE/ME) sustain higher returns than growth stocks (low BE/ME) in markets around the world.

A psychological study conducted by Kahneman and Tversky (1982) show that investors are irrational and overreact to unexpected and dramatic news events regardless of whether these events are good or bad. This is an important issue because overreaction to information may result in a predictable return of security prices to fundamental values. The empirical work of DeBondt and Thaler (1985) confirmed that investors tend to overweight the information relevant to the valuation of securities and drive securities' prices away from fundamental values. They found that prior losers consistently outperform prior winners in the long term since investors overreaction to information. However, Jegadeesh and Titman (1993) find stocks that performed well in the past will continue to exhibit a good return in the following period in the short term, and stocks with higher returns in the previous 12 months tend to have higher future returns.

2.3.2 Size, book-to-market factor, and the three-factor model

Fama and French (1992) examine the respective and joint effects of market beta, size, leverage, E/P, and BE/ME on the average stock returns based on stocks of non-financial firms in the US from 1926 to 1989. They find that beta of the traditional asset pricing model has little explanatory power to average stock returns regardless of whether it is alone or combined with other variables. On the other hand, the role of size, leverage, E/P, and BE/ME in stock returns is significant respectively; furthermore, they find that size and BE/ME appear to have the ability to proxy the effects of leverage and E/P on average returns. They conclude, among these variables, that size and BE/ME have the best explanatory power to capture the average stock returns.

Fama and French (1995) examine whether the behaviour of stock prices grouped on size and BE/ME is consistent with the behaviour of earnings. They provide evidence that firms with low BE/ME usually produce more profit than high BE/ME firms, and

high BE/ME is typical of firms that are relatively distressed. They argue that differences in returns caused by firm size and BE/ME must be driven by some common risk factors if stocks are priced rationally.

Thus, Fama and French (1993) propose a three-factor-model, and the three factors are the market return in excess of a risk-free rate (EMR), the average return on small-size firms minus average returns on big-cap firms (SMB), and the average return on high book-to-market firms minus the average return on low book-to-market firms (HML). They provide evidence that their three factor model has sufficient ability to capture the cross-section of average returns on the US stocks. Fama and French (1996) clear up anomalies generated in CAPM, such as size, book-to-market, earnings/price, and cash flow/price. In view of FF's choice of the factor portfolios, their 3-factor-model can absorb the size and book-to-market effects, as well as other effects that bear an obvious relation to size and book-to-market. Furthermore, what makes their model more appealing is that the three factors are able to explain short-term and long-term return reversal. Fama and French explained that the crux of the reason why CAPM fails to capture these anomalies is the univariate market beta, which shows little relationship with variables such as MV and BE/ME that are strongly related to the average return.

2.4 The GARCH family and Kalman filter framework

2.4.1 The GARCH family

2.4.1.1 Univariate GARCH model

A usual characteristic of financial return models is that the error process may not satisfy a full set of IID properties, which is the basic assumption of the ordinary least squares (OLS) estimate. For instance, highly frequent financial time series usually exhibit 'long memory', which means that the significant correlation between

observations of the time series is present. On the other hand, the financial time series usually exhibit the property of 'heteroscedasticity' other than 'homoscedasticity'; particularly, if the variance of the error process changes over time in a systematic way, the testing procedure may be biased, and a spurious result estimated by the OLS will be obtained.

Given these problems, Engle (1982) proposes a new class of stochastic processes named autoregressive conditional heteroscedastic (ARCH). In this ARCH process the conditional variance is allowed to be time-varying, while the unconditional variance is constant. The specification of the ARCH(1) process is:

$$\varepsilon_{i,t} = \eta_t h_t^{1/2}$$

$$h_t = \text{var}(\varepsilon_t | \Omega_{t-1}) = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2$$

Where, $\alpha_0 > 0$, and $\alpha_1 \geq 0$ are restricted to insure that h_t is positive. Ω_{t-1} represents the relevant information set at time t-1. η_t satisfies the property of independent and identical distribution (IID) with zero mean and unit variance. In his empirical work studying inflation in the UK, he finds that the ARCH effect is significant; furthermore, this estimated conditional variance increases dramatically within his sample.

However, some empirical studies find that many lagged conditional variance terms in the variance equation of the ARCH model are found to be significant. With this puzzle, Bollerslev (1986) extends the ARCH model and propose the generalized autoregressive conditional heteroscedastic (GARCH) model through allowing for past conditional variance in the current conditional variance equation. The specification of the GARCH(1,1) process is:

$$\varepsilon_{i,t} = \eta_t h_t^{1/2}$$

$$h_t = \text{var}(\varepsilon_t | \Omega_{t-1}) = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$$

Where, $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$ are restricted to insure that h_t is positive.

Another issue is that time series usually exhibit the 'asymmetry effect', also known as the leverage effect, which means that a negative shock tends to increase volatility more than a positive shock. However, the problem is that the GARCH model is not able to capture this effect because the lagged error terms in the conditional variance equation are squared, which means that the positive and negative errors have the same impact on the conditional variance. To solve this problem, the two most popular asymmetric GARCH models are proposed: the exponential GARCH model proposed by Nelson (1991), and the GJR-GARCH model proposed by GLosten, Jagannathan, and Runkle (1993).

The variance equation of Nelson's (1991) EGARCH model is expressed as following:

$$\ln(h_t) = w + \beta \ln(h_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right]$$

Where, the term multiplied by γ allows the asymmetry effect to be considered.

Although the EGARCH model allows the sign of the error to affect the conditional variance, it changes the specification of the original GARCH framework. Thus, GLosten, Jagannathan, and Runkle (1993) introduce a dummy variable to the variance equation and propose the GJR-GARCH model, which is expressed as:

$$h_t = \text{var}(\varepsilon_t | \Omega_{t-1}) = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta h_{t-1} + \gamma \varepsilon_{t-1}^2 I_{t-1}$$

Where, $I_{t-1} = 1$ if $\varepsilon_{t-1} < 0$, and $I_{t-1} = 0$ otherwise. Thus, the coefficient γ would be significantly positive if the asymmetric effect exists.

2.4.1.2 Multivariate GARCH model

When studying more than two financial time series, one problem of the univariate

GARCH model arises: there may be some relationship between the conditional variances, which cannot be captured by the univariate GARCH model. Thus, the multivariate GARCH model appears, similar to the univariate GARCH model except that the former also specifies the equation for how the conditional covariance move over time.

This multivariate GARCH model refers to a model for a multivariate time series, in which the conditional variances of the individual series and the conditional covariances between the series are estimated simultaneously by the method of maximum likelihood. In the family of multivariate GARCH models, many studies proposed numerous different representations of the multivariate GARCH model, among which some of the most popular multivariate GARCH models include Bollerslev, Engle and Wooldridge's (1988) VECH model of diagonal VECH model, and Engle and Kroner's (1995) BEKK model.

The VECH model lets the conditional variance H_t be a 2*2 matrix, and transfers this matrix to the 'upper triangular' form $H_t = \begin{bmatrix} h_{11t} \\ h_{22t} \\ h_{12t} \end{bmatrix}$. The specification of the VECH model (in the two-asset case here) can be expressed as:

$$\begin{bmatrix} h_{11t} \\ h_{22t} \\ h_{12t} \end{bmatrix} = \begin{bmatrix} c_{11} \\ c_{22} \\ c_{12} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{23} & a_{33} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 \\ u_{2t-1}^2 \\ u_{1t-1}u_{2t-1} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} h_{11t-1} \\ h_{22t-1} \\ h_{12t-1} \end{bmatrix}$$

Due to this specification this model requires 21 parameters to be estimated (C has 3 elements, both A and B have 9 elements). However, parameters' estimation in the GARCH model is by maximum likelihood which requires the numerical maximization of the likelihood function. Therefore, estimating a large number of parameters and obtaining the optimization convergence would be a difficult task, even though only two assets are considered.

The diagonal VECH model improves the VECH model since fewer parameters are required to be estimated in the diagonal representation. Bollerslev, Engle and Wooldridge (1988) impose some restriction on the VECH model's conditional variance-covariance matrix through assuming A and B to be diagonal, which reduces the number of parameters to be estimated at 9 (A and B each have 3 elements). Thus, the specification of the diagonal VECH model can be expressed as:

$$
\begin{bmatrix} h_{11t} \\ h_{12t} \\ h_{22t} \end{bmatrix} = \begin{bmatrix} c_{11} \\ c_{12} \\ c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 \\ u_{1t-1}u_{2t-1} \\ u_{2t-1}^2 \end{bmatrix} + \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix} \begin{bmatrix} h_{11t-1} \\ h_{12t-1} \\ h_{22t-1} \end{bmatrix}
$$

However, this specification of the diagonal VECH model loses information on certain inter-relationships; furthermore, it is still required to impose some restrictions to ensure the positive definiteness of the covariance matrix.

Engle and Kroner's (1995) BEKK model improves on both the VECH and diagonal model because it not only guarantees the conditional covariance matrix to be positively defined, but also allows for the inter-relationship effects to be considered. Furthermore, compared to 21 parameters estimation in the VECH model, only 11 parameters are required to be estimated in the BEKK model. The specification of the BEKK model can be expressed as:

$$
\begin{bmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{12} & a_{22} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 & u_{1t-1}u_{2t-1} \\ u_{1t-1}u_{2t-1} & u_{2t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{12} & a_{22} \end{bmatrix}
$$
$$
+ \begin{bmatrix} b_{11} & b_{12} \\ b_{12} & b_{22} \end{bmatrix} \begin{bmatrix} h_{11t-1} & h_{12t-1} \\ h_{12t-1} & h_{22t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{12} & b_{22} \end{bmatrix}
$$

However, similar to the univariate GARCH model, one problem of the multivariate GARCH model is the asymmetric effect. Kroner and Ng (1998) introduce a dummy vector to the BEKK model and propose an asymmetric version of the BEKK model, which is specified as follows:

$$
\begin{bmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{12} & a_{22} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 & u_{1t-1}u_{2t-1} \\ u_{1t-1}u_{2t-1} & u_{2t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{12} & a_{22} \end{bmatrix}
$$

$$+ \begin{bmatrix} b_{11} & b_{12} \\ b_{12} & b_{22} \end{bmatrix} \begin{bmatrix} h_{11t-1} & h_{12t-1} \\ h_{12t-1} & h_{22t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{12} & b_{22} \end{bmatrix} + \begin{bmatrix} d_{11} & d_{12} \\ d_{12} & d_{22} \end{bmatrix} \begin{bmatrix} \eta_{1t-1}^2 & \eta_{1t-1}\eta_{2t-1} \\ \eta_{2t-1}\eta_{1t-1} & \eta_{2t-1}^2 \end{bmatrix} \begin{bmatrix} d_{11} & d_{12} \\ d_{12} & d_{22} \end{bmatrix}$$

Where η_t represents the vector of negative shocks with $\eta_t = \min\{0, u_{i,t}\}$.

2.4.2 The Kalman filter framework

Kalman (1960) proposes a new approach to linear filtering and prediction problems, which is named the 'Kalman filter'. The Kalman filter framework provides an efficient recursive approach to estimate the state of the data process through minimizing the mean of the squared error (MSE).

The most noteworthy advantage of the Kalman filter is that it allows time-varying parameters and latent factors to be taken explicitly into account, and the time-varying latent factor can be inferred from the data.

Consider the following model:

$$y_t = \pi_t + \varepsilon_t$$

$$\pi_t = \pi_{t-1} + \gamma_{t-1} + \zeta_t$$

$$\gamma_t = \gamma_{t-1} + w_t$$

Such models may be estimated using the Kalman filter, with the measurement equation:

$$y_t = x_t' \beta_t + \varepsilon_t$$

and the transition equation:

$$\beta_t = T\beta_{t-1} + \eta_t$$

Where, $x' = [1 \quad 0]$, $\beta_t = (\pi_t \quad \gamma_t)'$, $\eta_t = (\zeta_t \quad w_t)'$. The variance of all of error terms are constant, and these error terms are uncorrelated with each other and across all time periods.

In these models only y_t can be observed. To obtain the time-varying β_t, the key question is how to use the new information on y_t to update the information of π_t. Two important equations are the updating equation

$$\pi_t = \pi_{t-1} + k_t(y_t - \tilde{y}_{t|t-1})$$

and the Kalman gain

$$k_t = (\sigma_0^2 + \sigma_\zeta^2)/(\sigma_\varepsilon^2 + (\sigma_0^2 + \sigma_\zeta^2))$$

Thus, when the initial estimation of $\pi_{1|0}$ and k_t are known, the updating equation provide a recursive formula for updating π_t as new information on y_t is obtained.

However, one problem of the traditional Kalman filter framework is that the variance of the error process is defined to be constant (homoscedasticity). As mentioned in Section 4.1.1, the testing procedure may be biased, and a spurious result will be obtained if the variance of the error process changes over time in a systematic way.

Through examining the time varying betas of the market model, Faff, et al. (2000) test and compare some of the most popular models, which include GARCH type, the Schwert and Seguin extended market model, and the Kalman filter. They find that betas estimated using the Kalman filter algorithm are consistently most efficient among the methods examined. At the same time, they point out that a combined method that incorporates the information contained in the volatility of asset returns into the Kalman filter system is expected to be more powerful than any one estimation method in isolation, and they state that this is an area worthy of further investigation.

Emerson, et al. (1997) combine the Kalman filter and a standard GARCH-M model. Since the mean equation (the measurement equation of the Kalman filter) of the GARCH-M model contains the conditional variance, the transition equation is

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consisted of two parts: one is the time-varying beta, and another is the variance equation of the GARCH model. They express the conditional variance term as the form of the GARCH model in the transition equation. However, their method is restricted to the form of the standard GARCH-M model. The approach of combining the Kalman filter framework and the GARCH effect is expected all the same.

Chapter 3

Time-varying Financial Integration: Value vs. Growth, and Small vs. Large

3.1 Introduction

Researchers have long been interested in the study of stock market integration around the world, and various studies have found that international stock market integration is currently at a high level.[3] However, financial integration may show strong variations over time. Most previous research about financial integration either ignored this issue entirely or only focused on different sub-periods to obtain information about the evolution of integration.[4] Although we can get the proxy for the long-term changes in integration through estimating and comparing different sub-periods, it may neglect much of the time variation and also may miss the causes of continuous improvement in integration since the degree of integration may often change frequently and exhibit high volatility. To solve this problem, some studies employed their respective models containing time-varying coefficients through instrumental variables to capture the variation of financial integration.[5] However, a common feature of approaches depending on several fundamental variables is that they only focus on a very small set of macroeconomic variables, and the limited amount of variables may partly explain the time variation in integration; furthermore, the included variables may pick up effects of other excluded variables. Therefore, the

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[3] See, e.g. Fratzscher (2 001)
[4] See, e.g. Longin and Solnik (1995), Bodart and Reding (1999)
[5] See, e.g. Bekaert and Harvey (1995), Ng (2000)

literature, with a more promising approach, focusing on time-varying financial integration, is expected all the same.

On the other hand, financial markets are integrated if assets with similar risk have identical expected returns regardless of the domicile. According to this definition, the characteristics of assets we use must be comparable. However, assets do not usually have enough similar characteristics in reality, even if the similar class of assets. The systematic discrepancies in characteristics may result in differences in systematic risks of assets. Therefore, we have to control the systematic risk and take into account other important characteristics before measuring integration. Generally, if the systematic risk factors that affect asset returns were identified, we could estimate and eliminate their systematic impact through the corresponding asset pricing model.

Based on the asset pricing model of Sharpe (1964), Lintner (1965) and Black (1972), Banz (1981) finds that market equity, ME (a stock's price times shares outstanding), has a power to explain the cross-section of average returns. Average returns on small (low ME) stocks are too high given their beta estimates, and average returns on large stocks are too low. Rosenberg, et al. (1985) find that firms with high ratios of book value to market value of common equity have higher returns than firms with low book-to-market ratios. Because these patterns in average returns are not able to be explained by the CAPM, they are typically called anomalies. Fama and French (1993) showed that size and BE/ME proxy for sensitivity to risk factors that capture strong common variation in stock returns and help explain the cross-section of average returns. Thus, size and BE/ME are considered as some sources of systematic risk. The problem is that the capital asset pricing models (CAPM) of Sharp (1964) and Lintner (1965) fail to explain this pattern in average returns, which means that we cannot estimate and filter out these systematic risks through CAPM. These characteristics inspire us to sort all stocks within one market into several portfolios according to their market value and book-to-market ratio, and then examine and compare the integration of these portfolios with the world market respectively. In the

academic research, comparing the whole national market, stocks sorting like this, for instance value/growth stocks and small/large stocks, own more similar risk, by which we may obtain relatively accurate results about the integration level. In practice, large portfolios are likely to be held by more international investors. Because stocks with low BE/ME ratios are strong on fundamentals such as earnings and sales, while high BE/ME stocks tend to have weak fundamentals, international investors like growth rather than value portfolios. Therefore, growth (large) portfolios are expected to be more integrated with the world than others. Therefore, the investigation for this will provide more opportunities for portfolio managers and investors, who can benefit from new insight into the co-movements among different portfolios in different international markets.

Therefore, we seek to contribute to the existing literature in two ways:

The first contribution is the focus on stock returns at the portfolio level (formed according to firm size and book to market value), in addition to those at the aggregate national market level. This analysis enables us to investigate whether growth (large) portfolios are more integrated with the world than others. And whether shifts or time-varying integration is a broad-based phenomena across different portfolios It might be the case that a specific group of portfolios drives the shift of integration of the aggregate level (the whole national stock market level).

The second contribution to the literature is our dynamic model. We model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. The most distinguish advantage of the Kalman filter model is that it allows time-varying parameters and latent factors to be taken explicitly into account. This is just what we want, because the degree of financial integration cannot be observed directly. Rather, it is possibly time-varying latent factor which can be inferred from the data. This method can effectively avoid the problems of much previous research, for instance, rolling estimation of Fratscher

(2001); basing on a very small set of fundamental variables, Bekaert and Harvey (1995), etc. The problem is that the framework of Kalman filter assumes the variance of the error process to be constant (homoscedasticity). However, a usual characteristic of financial return models is that the error process may not satisfy a full set of NIID properties. Particularly, if the variance of the error process changes over time in a systematic way, the testing procedure may be biased, and the spurious evolution of financial integration may be obtained. Therefore, extending the Kalman filter system to allow for the GARCH effect in the innovations is expected. Very few studies applied the combination of Kalman filter with a GARCH model to capture the time variation of financial integration, and this is just our contribution. Furthermore, we propose a new method to combine the system of Kalman filter and GARCH models through the iteration between prediction errors from the Kalman filter and conditional variances from GARCH models.

The rest of this chapter is organized as follows: Section 3.2 describes the equity market data used in this study, including the construction of different portfolios according to the market value and BE/ME ratio, and the information set to form conditional expected returns of different portfolios. Section 3.3 describes the framework of measuring integration in this study, proposes our GARCH-filter model (combining the Kalman filter and TGARCH(1,1) model) for examining the time variation in integration, and proposes the estimation approach for our GARCH-filter model. Empirical results are presented in Section 3.4. Section 3.5 briefly concludes this chapter.

3.2 Data

3.2.1 Data description

In this study, we examine some representative capital markets in the world, and they

are the UK market in Europe, the Japan, Hong Kong, and Singapore markets in Asia, the Brazil and Mexico markets in Latin America, and the US market. For each country we consider both the market index and all stocks within the corresponding market to form different portfolios. We use the monthly data because it can effectively avoid problems of non-synchronous trading hours and thin trading. All data used here is in the US dollar. Based on the availability of data from Datastream, the sample ends on June, 2006, and the start times are: the UK (July, 1974), Japan (July, 1985), Hong Kong (July, 1985), Singapore (July, 1985), Brazil (July, 1993), and Mexico (July, 1990).

The indices used for respective countries are FTSE All Share price index (London), the Tokyo Stock Price index (Japan), the Hang Seng index (HK), Straits Times index (Singapore), Brazil BOVESPA price index (Brazil) and Mexico IPC price index (Mexico). In addition, the Standard and Poor's 500 Index of the US is employed to be the world market portfolio because this price index comprises over 70% of the total market value of all stocks traded in the US market. Furthermore, this price index not only consists of simply the 500 largest US stocks. Instead, it is comprised of leading firms from a wide variety of different economic sectors (over 100 unique sectors today). Thanks to its diversified sector coverage and its market value weighting, the Standard and Poor's 500 Index of the US is considered as the benchmark of the world portfolio.

The US three-month Treasury bill rate is selected to be the risk free rate of the respective market.

3.2.2 Construct portfolios

Except for examining the national markets, we also investigate the integration of different portfolios formed on market value and BE/ME ratios with the world. Thus, according to the availability of data from Datastream, stocks used to form portfolios

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for respective markets are: 662 stocks (by the end of June, 2006) of FTSE All Share constitutes (UK), 1725 stocks of Tokyo securities (Japan), 1272 stocks of all domestic and foreign stocks (Hong Kong), 789 stocks of Singapore all quoted securities (Singapore), 609 all research stocks (Brazil), and 160 all research stocks (Mexico). To form different portfolios based on market value and BE/ME ratios, at the end of June of each year t, stocks mentioned above of each market are allocated to two groups (small or big) based on whether their June market value (stock price times shares outstanding) is in the top 30 percent, or the bottom 30 percent. Similarly, stocks of each market are allocated in an independent group to two sorts based on the top 30 percent and the bottom 30 percent of the values of BE/ME ratios. The monthly returns on the portfolios are calculated from July to the following June. Similar to Fama and French (1996), we do not use stocks with negative BE value when forming the BE/ME portfolio.[6]

3.2.3 The summary statistics of Data

The summary statistics are presented in Table 3.1 for the total available data for each country and the corresponding portfolios formed on size and BE/ME ratios. The statistics include observations (sample size), the average monthly return, standard

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[6] The number of stocks in each market constructed for portfolios whose market value or BE/ME ratios are available in each year are as follows: 1, UK: a. market value, 197 firms in 1974, and 197, 198, 198, 198, 200, 200, 202, 208, 216, 225, 236, 251, 264, 283, 294, 311, 322, 329, 343, 368, 388, 411, 444, 459, 469, 482, 504, 518, 527, 551, 580 firms for each of the remaining years. b. BE/ME ratios, 42 firms in 1974, and 43, 43, 43, 43, 42, 110, 114, 119, 125, 147, 162, 179, 219, 258, 273, 287, 297, 305, 321, 338, 353, 377, 402, 421, 439, 456, 483, 492, 507, 534, 560 firms for each of the following years until June, 2006. 2, Japan: a. market value, 748 firms in 1985, 749, 750, 971, 1047, 1162, 1200, 1232, 1244, 1276, 1320, 1361, 1402, 1435, 1468, 1512, 1557, 1596, 1622, 1654, 1679 firms for each of the remaining years. b. BE/ME ratios: 678 firms in 1985, 688, 698, 825, 925, 1039, 1127, 1151, 1166, 1196, 1226, 1264, 1300, 1384, 1414, 1474, 1508, 1548, 1578, 1621, 1650 firms for each of the following years until June, 2006. 3, Hong Kong: a market value, 73 firms in 1985, 76, 88, 194, 216, 226, 249, 298, 355, 421, 447, 475, 542, 592, 615, 687, 766, 860, 935, 1010, 1062 firms of the following years. BE/ME ratios, 41 in 1985, 43, 51, 65, 70, 81, 100, 118, 123, 162, 256, 336, 377, 390, 414, 575, 712, 809, 884, 948, 998 firms for the remaining years until June, 2006. 4, Singapore: a. market value, 74 in 1985, 75, 79, 88, 95, 98, 112, 124, 134, 155, 178, 195, 227, 249, 276, 343, 402, 427, 471, 537, 615 firms for the following years until June, 2006. b. BE/ME ratios, 23 firms in 1985, 23, 29, 32, 34, 38, 61, 70, 71, 91, 138, 153, 164, 171, 181, 287, 368, 388, 427, 488, 563 firms for the remaining years. 5. Brazil: a. market value, 65 firms in 1993, 161, 200, 215, 266, 310, 344, 379, 394, 404, 416, 425, 445 firms for the following years. b. BE/ME ratios: 49 firms in 1993, 67, 94, 112, 125, 151, 319, 371, 374, 360, 382, 387, 387 firms for the remaining years until June, 2006. 6. Mexico: a. market value, 27 firms in 1990, 32, 49, 56, 79, 84, 84, 98, 105, 111, 117, 120, 126, 127, 130, 134 firms for the following years. b. BE/ME ratios, 9 in 1990, 12, 18, 19, 38, 43, 47, 56, 75, 89, 98, 105, 113, 119, 121, 124 firms for the remaining years until June, 2006. Thus, four sorts of portfolios (small and large, low and high) for each national market are constructed based on the available data for each year in Datastream.

deviation, the value of Skewness and extra Kurtosis for the normality test, and the test for first-order autocorrelation.

The sample mean of the market monthly return is 0.16 percent for the US, 0.262 percent for UK and 0.072 percent for Japan, and the average return for emerging markets are 0.519 percent for Hong Kong, 0.314 percent for Singapore, 0.840 percent for Brazil, and 0.729 percent for Mexico. In each national market, we find that small portfolios produced higher returns than big portfolios with the exception of Singapore and Mexico, and that portfolios with high BE/ME ratios produced higher returns than low book-to-market equity portfolios with the exception of Mexico. The corresponding returns of small and big portfolios in each market are: 0.642% (small) and 0.131% (big) for UK, 0.370% and -0.065% for Japan, -0.141% and -0.428% for Hong Kong, -0.483% and -0.855% for Brazil. The corresponding returns of low and high portfolios in each market are: -0.012% (low) and 0.706% (high) for UK, -0.421% and 0.527% for Japan, -1.333% and 0.654% for Hong Kong, -0.621% and 0.407% for Singapore, -1.963% and 0.936% for Brazil. These findings support the view of Fama and French (1996), who observe that small and high book-to-market equity stocks have higher returns than big and low book-to-market equity stocks.

Returns of emerging markets are characterized by high volatility. It can be seen from table 1, that standard deviations are 4.450 percent for the US, 6.289 percent for UK, and 6.796 percent for Japan, which are much lower than those of emerging markets: 8.256 percent for Hong Kong, 7.465 percent for Singapore, 13.568 percent for Brazil, and 10.235 percent for Mexico. In the UK, Japan, Hong Kong, and Singapore, as expected, returns on different portfolios are more volatile than the return on the corresponding national market index, as the national market index represents a more diversified portfolio.

At the national market level, there is only one country with first-order

autocorrelation that exceeds 10 percent: 10.8% for Japan. The market with the lowest autocorrelation in our sample is the Standard and Poor's 500 Index of the US, -0.1%. From the perspective of portfolio level, we find that small portfolios are much more autocorrelated than big portfolios in each national market: 26.4% (small) and 8.7% (big) for the UK, 13.1% and 5.5% for Japan, 26.7% and 7.9% for Hong Kong, 19.7% and 10.1% for Singapore, 14.9% and 5.2% for Brazil, and 26.8% and 12.8% for Mexico. This suggests that the returns of small portfolios are more predictable than big portfolios based on past return alone.

The values of excess Kurtosis show that the return series of all portfolios and the corresponding national market indices are relatively leptokurtic with respect to the normal distribution, which means that large shocks are more frequent than small shocks. Most countries except for the UK show negative skewness, which means that negative shocks are more frequent than positive shocks. JB test shows, for most portfolios and market indices, that the normal distribution of the time series is rejected.

Table 3.2 shows the unconditional correlations of the six national markets with the world, represented by the US S&P 500 Index, for the aggregate national market index as well as different portfolios. For the market index level, the highest level of correlation is Singapore with 0.576, followed by Hong Kong (0.575), UK (0.564), Brazil (0.563), Mexico (0.508), and the lowest one is Japan with 0.311. For the portfolio level, we find, for all markets, that the correlation level of big portfolios is much higher than that of small portfolios, and the correlation level of low portfolios is higher than that of high portfolios.

3.2.4 The information set to form conditional expected returns

The key that forms conditional expected returns is the selection of the conditioning information set. However, it is impossible to know the full set of information that

investors have employed to form their expectations. One method inspired by Principal Component Analysis is to use some limited market fundamentals to approximate this information set, and these variables are expected to proxy the information that investors are able to obtain to set prices.

Following Harvey (1991), the following information variables are employed to form conditional expected returns of the world market: a constant, a dummy variable for the month of January, the lagged excess returns on the S&P 500 index portfolio, the S&P 500 index dividend yield in excess of the 30-day Eurodollar rate, the change in the term structure spread (US ten years bond yield minus three months Treasury Bill yield), and the default spread (Moody's Baa yield minus Aaa bond yield). All of these information variables are lagged. The first information variable is the lagged excess return, many studies have showed the evidence of the autocorrelation in stock returns, which are consistent with our results about the first order correlation in Table 3.1. Some research shows that stock returns are disproportionately larger in January than those of other months in many countries (Keim 1983, Gultekin and Gultekin 1983). Therefore, as the second information set, January dummy variable is included. The third information variable is the dividend yield. Fama and French (1988) find that dividend yield is a valuable variable to predict excess returns in the US. This view is consolidated by Cutler et al. (1989), they find this variable also has explanatory power to international stock returns. Compbell and Hamao (1989) show that the spread of the term structure also has some explanatory power to expected returns in the US and Japan, therefore, the term structure spread is also chosen in this study. The last information variable is the default risk. Fama and French (1989) show this variable can capture some variation on stock returns. The default spread risk is measured as the difference between Moody's Baa bonds yield and Aaa bonds yield.

The information set for the local national markets includes a constant, a dummy variable for the month of January, the lagged excess returns of the national market index, the dividend yield in excess of the 30-day Eurocurrency rate, and the change

of the term structure.

For the portfolios, we select a constant, the lagged excess returns of the portfolio, and the world and corresponding national market variables as our information set to form conditional expected return at the portfolio level.

3.3 Methodology

3.3.1 Investigating financial integration in the framework of news-based measures

Within the framework of news-based measures, only common news has the determinate power for asset returns in the integrating area. If barriers among international markets do not exist, local shocks of asset returns can be eliminated through regional diversification. Therefore, returns of assets from different markets but with similar risk should be determined by common news rather than local news. Thus, when examining integration, we assume asset returns of different markets share the same common news, and they are allowed to have different sensitivities (betas) to common shocks. These betas measure how much of the world return shocks are transmitted to the local market. We interpret that the part of local returns not explained by common factors are due to local news.

With this thought, measuring financial integration is transferred into measuring how much proportion of asset price changes is explained by common news. Thus, we need to find a proxy for common news. Fama (1970) states that price should always fully reflect the available information relevant to the valuation of securities, and when markets are strong efficient private and public information is fully reflected in prices. Therefore, in this study we assume that the price movements of a benchmark asset are a good reflection of all relevant common news. Given that the world market

is strong efficient, we let the price movement of the world market index represent the world common news. In this study, the world portfolio is represented by Standard and Poor's 500 Index of the US.

The presumption of measuring financial integration is that assets have the similar systematic risk. The risk of an asset's return can be classified into two parts: the systematic risk and idiosyncratic risk. While the idiosyncratic part can be diversified away, the systematic part cannot. Fama and French (1993) showed that size and BE/ME proxy for sensitivity to risk factors that capture strong common variation in stock returns. Thus, the portfolios formed on size and BE/ME ratios should have different systematic risks although they are in the same domicile market. If so, the integrations of small (high) portfolios must be different with that of big (low) portfolios. Given that big portfolios are likely to be held by more international investors, and growth portfolios are preferred due to their strong fundamentals such as earnings and sales, our central hypothesis to test is that big (growth) portfolios are more integrated with the world than others. On the other hand, if the systematic risk factors affecting asset returns were identified, we could estimate and filter out their systematic impact before testing the integration level. Fama and French (1993, 1996) propose some factors related to size (market capitalization) and BE/ME ratios, and state that size and BE/ME effects can be captured by these factors (SMB and HML). Thus, after examining the integration of different portfolios, we will control the risk caused by size and BE/ME effect through these risk factors proposed by Fama and French (1993, 1996), and then test the integration of different portfolios again. It is expected that these discrepancies in integration between big (growth) and small (value) portfolios tend to disappear.

3.3.2 Conditional expected stock returns

It is generally accepted that stock returns are predictable, and the main source of this predictability stems from the compensation that investors require for accepting a

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risky payoff. However, one issue arises: whether this compensation is driven by local factors, or world factors. If capital markets are fully integrated, then financial assets with similar risk characteristic should have identical expected returns regardless of the domicile because the compensation required by investors is only driven by the world factors. Alternatively, if markets are completely segmented, this compensation is only driven by local factors. This study employs information variables to predict expected returns because asset prices of these variables contain information about expected returns.

Thus, we assume that the excess return for country i or a specific portfolio i is linearly related to the local and world information variables as follows:

$$r_{i,t} = a_i + b_i^L Z_{i,t-1}^L + b_i^W Z_{i,t-1}^W + \varepsilon_{i,t} \tag{3.1}$$

where $r_{i,t}$ is the excess return, the difference between the random real return of country i and the risk free real rate of interest. Z^W represents the world information set and includes the following variables: a constant, a dummy variable for the month of January, the lagged excess returns on the S&P 500 index portfolio, the S&P 500 index dividend yield in excess of the 30-day Eurodollar rate, the change in the term structure spread, and the default spread. Z^L repr esents the local information set and includes a constant, January dummy variable, the lagged excess return, the market index or a specific portfolio dividend yield in excess of the 30-day Eurocurrency rate. $\varepsilon_{i,t}$ repres ents the unexpected component of returns. This equation includes any level of integration. The term of local variables should be absent from this equation if a capital market is fully integrated; alternatively, the term of world variables should be absent from this equation if the market is completely segmented.

3.3.3 The model for testing the financial integration level

Based on news-based measures some studies have proposed an interesting framework and similar models to examine whether markets evolve towards greater

integration (Bekaert and Harvey 1997; Ng 2000; Fratzscher 2001; and Baele 2003). This study adopts their ideas as the starting point, and model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. Furthermore, for comparing the relative importance of the corresponding national market with that of the world, we extend the model of Bekaert and Harvey (1997) into a two-factor model by introducing the risk factors of the corresponding national market into the original model.

3.3.3.1 Starting from the model of Bekaert and Harvey (1997)

Bekaert and Harvey (1997) proposed the following model:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t}$$

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t}$$

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2$$

where $r_{i,t}$ is the excess return on the national equity index of country i. $\mu_{i,t-1}$ is the conditional mean return for country i, and the unexpected part of country i's return is represented by $\varepsilon_{i,t}$, which is driven by the world shocks $\varepsilon_{w,t}$, and a purely idiosyncratic shock $e_{i,t}$. The dependence of local shocks on world shocks is determined by $\gamma_{i,t-1}$, which is considered as the proxy of the stock markets' integration. The data generating process for $\varepsilon_{w,t}$ is a special case of model described above, with $i = w$, $\gamma_{i,t-1} = 0$, and the conditional mean return of the world market, $\mu_{w,t}$ is expressed as a function of a set of world information variables.

As markets become more integrated, the conditional mean return of country i should not only be determined by the local information variables, but also by the world factors. Therefore, many studies mentioned above expressed the conditional mean

return of country i to be linear in the information variables as follows:

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_w X_{w,t-1}$$

where, $X_{w,t-1}$ represents the world information variables, and $X_{i,t-1}$ represents the local information variables.

To capture the time variation in integration, some studies let the spillover weight parameters be driven by some local information variables as follows:

$$\gamma_{i,t-1} = q_i X_{i,t-1}$$

where, Bekaert and Harvey (1997) let $X_{i,t-1}$ include a constant, market capitalization to GDP, and exports plus imports divided by GDP. Ng (2000) let $X_{i,t-1}$ include a constant, exchange rate change, the number of Depositary Receipts (DR) listings, the total trade with the US per GDP, and closed-end country fund premium. However, the method that let the spillover weight parameters be driven by the local information set may not always be efficient because some macroeconomic effects such as political events are very difficult to be measured directly. On the other hand, the information set used by these studies may not be enough. For instance, as a measure of trade openness, exports plus imports divided by GDP are usually considered as a factor affecting integration. If so, why is the factor measuring investability openness (the ratio of the market value of investable stocks to the market value of all stocks) neglected? Furthermore, even though we could obtain all possible variables that affect integration, there may be a high degree of correlation among many macro or micro variables, which may directly result in multicollinearity and generate spurious results.

3.3.3.2 The model of measuring financial integration

We follow the basic models of Bekaert and Harvey (1997) as follows:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{3.2}$$

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t} \tag{3.3}$$

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{3.4}$$

where $r_{i,t}$ is the excess return on the national equity index or a specific portfolio of country i with the US dollar currency. $\mu_{i,t-1}$ is the corresponding conditional mean return, and the unexpected part of return is represented by $\varepsilon_{i,t}$. As described before, the unexpected return $\varepsilon_{i,t}$ is decomposed into a purely local shock $e_{i,t}$, and a reaction to world news represented by the world shocks $\varepsilon_{w,t}$. Following Bekaert and Harvey (1997), the dependence of local shocks on world shocks is determined by $\gamma_{i,t-1}$, which is considered as the proxy of the stock markets' integration. We model the conditional variances in our GARCH model as GARCH (1,1) process, as the empirical literature has found that this specification adequately captures the persistence in second moments of frequency stock returns. On the other hand, another issue is that time series usually exhibit 'asymmetry effect', which means that an unexpected decrease tends to increase volatility more than an unexpected increase of the same magnitude. However, the problem is that the GARCH model is not able to capture this effect because the lagged error terms in the conditional variance equation are squared, which means that the positive and negative errors have the same impact on the conditional variance. To solve this problem we choose the TGARCH(1,1) model, which introduces a dummy variable into the conditional variance equation to control and measure this asymmetry effect. Thus, $e_{i,t}$ is the idiosyncratic shock of any market i, Ω_{t-1} includes all the information available at time t-1, and $\xi_{i,t}$ is the dummy variable used to measure the negative return shock of country i. The estimated value of α_{i3} is expected to be positive if the asymmetry effect does exist.

The conditional mean return of country i (or a specific portfolio) is expressed as:

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_w X_{w,t-1} \qquad /$$

$$\mu_{i,t-1} = \delta_p X_{p,t-1} + \delta_i X_{i,t-1} + \delta_w X_{w,t-1} \tag{3.5}$$

X represents a set of information variables, $X_{w,t-1}$ represents the world information set, and $X_{i,t-1}$ represents the local information set. $X_{p,t-1}$ represents the information set of a specific portfolio, and includes a constant and the lagged excess return of this portfolio.

To estimate these equations, we need to know the data generating process for $\varepsilon_{ix,t}$. For this, we introduce the following equation:

$$r_{w,t} = \mu_{w,t-1} + \varepsilon_{w,t} \tag{3.6}$$

$$h_{i,t} = var(\varepsilon_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{3.7}$$

where $r_{w,t}$ is the excess return of the US S&P 500 market index, which is the difference between the real return and the US three months Treasury Bill rate. $\varepsilon_{w,t}$ represents the unexpected return of the world market.

3.3.3.3 Model for examining size and value effects

It is widely accepted that there are some relationships between realized average returns on common stocks and firm characteristics, such as firm size and book-to-market ratio. Especially, Fama and French (1993, 1996) propose a three-factor model that contains factors related to size (market capitalization) and BE/ME ratios to describe returns, and they find that this model can capture the average returns on US portfolios formed on size and BE/ME. Thus, we add the factors related to firm size and book-to-market ratio into model (3.3):

$$r_{i,t} = \mu_{i,t-1} + s_{ix}SMB_{x,t} + h_{ix}HML_x + s_{iUS}SMB_{US,t} + h_{iUS}HML_{US,t} + \varepsilon_{it}^* \tag{3.8}$$

$$\varepsilon_{i,t}^* = \gamma_{i,t-1}e_{w,t} + e_{i,t}^* \tag{3.9}$$

$$h_{i,t} = \text{var}(e^*_{i,t} \mid \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e^{*2}_{i,t-1} + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi^2_{i,t-1} \qquad (3.10)$$

where, $\varepsilon^*_{i,t}$ represents the unexpected and risk-adjusted return of a specific portfolio i.

In order to construct factors $SMB_{ix,t}$ and $HML_{ix,t}$ in the corresponding national market x, all stocks whose market value and book-to-market ratio are available in the stock market are selected every year. At the end of June of each year t, stocks in the corresponding national market are allocated to two groups (small or big) based on whether their June market value (stock price times shares outstanding) is below, or above the median ME of the aggregate market. Similarly, stocks of each market are allocated in an independent group to two sorts based on the top 50 percent and the bottom 50 percent of the values of BE/ME ratios. The monthly returns on the portfolios are calculated from July to the following June. The factor SMB is computed as the difference of the returns of the high and low capitalization portfolios. According to the previous year's book-to-market ratio, the factor HML is constructed by the same methods with SMB.

This research investigates and compares the integration of each portfolio in the corresponding market. Through estimating model (3.2)-(3.7), we intend to test whether growth (big) portfolios are more integrated with the world than others, and whether this phenomena is persistent or significant. If so, we expect that this discrepancy will disappear when estimating model (3.5)-(3.10) because the risk factors of SMB and HML are expected to capture size and BE/ME effects.

3.3.3.4 The relative importance of the world market and national market

The model we propose to examine and compare the relative importance of the world market with that of the corresponding national market is an extension of Bekaert and Harvey (1997), in a sense we distinguish between two sources of shocks (the national market shock and the world shock respectively) instead of one world shock. This idea is inspired by the world of Ng (2000), Fratzscher (2001) and Baele (2003).

When investigating integration at the national level, these studies divide the world shock into two parts: a shock from a particular region and a global shock from the US. In this study, the unexpected return on a specific portfolio is influenced not only by news originating from itself but also by two external shocks: a shock from the corresponding national market and a global shock from the US.

Bivariate model for the US and national market

In order to examine the integration level of a specific portfolio with the world and the corresponding national market, we first describe a bivariate model for the US market and a national market return. Then the estimated innovations for the US and the national market are used as inputs for the univariate model.

The joint process for the US and a national market returns is governed by the following bivariate GARCH(1,1) model:

$$\begin{bmatrix} R_{x,t} \\ R_{w,t} \end{bmatrix} = \begin{bmatrix} \alpha_{x,0} \\ \alpha_{w,0} \end{bmatrix} + \begin{bmatrix} \alpha_{x,1} & \alpha_{x,2} \\ \alpha_{w,1} & \alpha_{w,2} \end{bmatrix} \begin{bmatrix} X_{x,t-1} \\ X_{w,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{x,t} \\ \varepsilon_{w,t} \end{bmatrix} \tag{3.11}$$

$$\varepsilon_t \big| \Omega_{t-1} \to N(0, H_t)$$

where $R_{x,t}$ is the excess return on the national equity index of country x, $R_{w,t}$ is the excess return of the US S&P 500 index. $X_{x,t-1}$ represents the information set of country x, $X_{w,t-1}$ represents the information set of the world. $\varepsilon_t = \begin{bmatrix} \varepsilon_{x,t} & \varepsilon_{w,t} \end{bmatrix}$ is a vector of innovations. We limit the evolution of the conditional second moments of excess return to the asymmetric version of the BEKK model of Engle and Kroner (1995) (ABEKK). This BEKK model not only guarantees the conditional covariance matrix to be positively defined, but also allows the inter-relationship effects to be considered. Furthermore, compared to 21 parameters estimation in VECH model of Bollerslev, Engle and Wooldridge (1988), only 11 parameters are required to be

estimated in the BEKK model. The specification of the ABEKK model can be which is expressed as:

$$
\begin{bmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 & u_{1t-1}u_{2t-1} \\ u_{1t-1}u_{2t-1} & u_{2t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}
$$

$$
+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} h_{11t-1} & h_{12t-1} \\ h_{12t-1} & h_{22t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}
$$

$$
+ \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix} \begin{bmatrix} \eta_{1t-1}^2 & \eta_{2t-1}\eta_{1t-1} \\ \eta_{1t-1}\eta_{2t-1} & \eta_{2t-1}^2 \end{bmatrix} \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix}
$$

$$(3.12)$$

where η represents the vector of negative return shocks with $\eta_{i,t} = \min\{0, u_{i,t}\}$

Univariate spillover model

When examining integration at the portfolio level, we allowed the unexpected return of a specific portfolio to be driven by innovations in the US and the corresponding national market returns. The model is specified as:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{3.13}$$

$$\varepsilon_{i,t} = \gamma_{iw,t-1}e_{w,t} + \gamma_{ix,t-1}e_{x,t} + e_{i,t} \tag{3.14}$$

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{3.15}$$

where $r_{i,t}$ is the excess return of a specific portfolio i with the US dollar currency.

$\mu_{i,t-1}$ is the conditional mean return, and the unexpected part return is represented by

$\varepsilon_{i,t}$. This model allows the unexpected return on a specific portfolio to be influenced not only by news originating from itself but also by two external shocks: a shock from the corresponding national market and a global shock from the US. The conditional variance $h_{i,t}$ is modeled as the TGARCH(1,1) process.

Model (3.11) – (3.15) allows us to compare and evaluate the relative importance of

the world market with that of the corresponding national market. However, there may be common news that drives both the world market and the national market. Similar to Ng (2000), and Baele (2003), the innovations from the world and national market are orthogonalized by assuming that the national return shock is driven by a purely idiosyncratic shock and by the world return shock. The orthogonalized world and national innovations are represented by $e_{w,t}$ and $e_{x,t}$, and are expressed as:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{x,t} \\ \varepsilon_{w,t} \end{bmatrix} = \begin{bmatrix} 1 & k_{t-1} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} e_{x,t} \\ e_{w,t} \end{bmatrix} = K_{t-1}e_t \tag{3.16}$$

$$\varepsilon_t | \Omega_{t-1} \rightarrow N(0, H_t)$$

$$e_t | \Omega_{t-1} \rightarrow N(0, \sum t)$$

$$\sum t = \begin{bmatrix} \sigma^2_{x,t} & 0 \\ 0 & \sigma^2_{w,t} \end{bmatrix}$$

where $k_{t-1}, \sigma^2_{x,t}$, and $\sigma^2_{w,t}$ are computed such that $H_t = K_{t-1} \sum t K'_{t-1}$. According to this calculation, k_{t-1} can be expressed as the covariance between the world and national innovations divided by the variance of world innovations:

$$k_{t-1} = \frac{H_{x,w,t}}{H_{w,t}} = \frac{Cov_{t-1}(\varepsilon_{x,t}, \varepsilon_{w,t})}{Var_{t-1}(\varepsilon_{w,t})} \tag{3.17}$$

3.3.4 Estimation

3.3.4.1 Assumption and some implications:

To complete the model, we follow the method of Bekaert and Harvey (1997), and assume that the idiosyncratic shocks of the world market, the national market, and the specific portfolio are uncorrelated.

$$E[e_{i,t} e_{j,t} | \Omega_{t-1}] = 0, \quad \forall i \neq j \tag{3.18}$$

$$E[e_{i,t} \varepsilon_{w,t} | \Omega_{t-1}] = 0, \quad \forall i \tag{3.19}$$

where, i represents the aggregate national market index or a specific portfolio, and w represents the US S&P 500 market index.

As a result, the model implies the following variance and covariance expressions:

$$E[\varepsilon_{i,t}^2 | \Omega_{t-1}] = h_{i,t} = \gamma_{ix,t}^2 \sigma_{x,t}^2 + \gamma_{iw,t}^2 \sigma_{w,t}^2 + \sigma_{i,t}^2 \qquad (3.20)$$

$$E[\varepsilon_{i,t} e_{w,t} | \Omega_{t-1}] = \gamma_{iw,t} \sigma_{w,t}^2 = \sigma_{iw,t} \qquad (3.21)$$

$$E[\varepsilon_{i,t} e_{x,t} | \Omega_{t-1}] = \gamma_{ix,t} \sigma_{x,t}^2 = \sigma_{ix,t} \qquad (3.22)$$

The conditional covariance equation (3.21) implies that first, a specific portfolio's covariance with the world market return is positively related to the dependence of local shocks on world shocks, $\gamma_{iw,t}$. Second, higher volatility in the world market can result in higher covariance between the world market and a specific portfolio with the assumption that $\gamma_{i,t}$ is positive. Equation (3.22) implies the similar relationship between a specific portfolio and the corresponding national market.

In order to examine the proportion of the variance of a portfolio return explained by world shocks and national market shocks, the following variance ratios are computed:

$$VR_{iw,t} = \frac{\gamma_{iw,t}^2 \sigma_{w,t}^2}{h_{i,t}} \qquad (3.23)$$

$$VR_{ix,t} = \frac{\gamma_{ix,t}^2 \sigma_{ix,t}^2}{h_{i,t}} \qquad (3.24)$$

3.3.4.2 Estimation

One approach is to impose a specific portfolio (the national market index) and the world market on bilateral models directly. However, since a large number of parameters are required to be estimated in the system, we follow the method of Bekaert and Harvey (1997), Ng (2000) and Baele (2003). The estimation is

simplified as:

A. Estimate model (3.2)-(3.5) country by country (or portfolio by portfolio) conditioning on estimates of the world market model (3.6) and (3.7).

B. Estimate model (3.13)-(3.15) for different portfolios conditioning on estimates of the bivariate GARCH(1,1) model (3.12), (3.16), and (3.17).

3.3.5 Examining time-varying financial integration:

Kalman filter combined with the TGARCH(1,1) model

Many studies let the spillover weight parameters $\gamma_{i,t-1}$ be driven by the local information set to capture the time variation in integration. Given the problems mentioned in section 3.3.3.1, as the alternative to this method, we model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. In this section, we first introduce the framework of the traditional Kalman filter. Second, we describe the process of combining the Kalman filter and TGARCH(1,1) model.

3.3.5.1 The framework of Kalman filter

Consider the key model for testing financial integration as follows:

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t} \tag{3.3}$$

Such model may be estimated using Kalman filter, with the measurement equation:

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t}$$

and the transition equation:

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t}$$

where $\eta_{i,t} \rightarrow i.i.d.(0,\sigma_{\eta,i}^2)$. These transition equations imply that the time-varying coefficient follows a random walk process, hence, the only source of variation

in $\gamma_{i,t}$ is due to the variation of the error term, $\eta_{i,t}$. $e_{i,t}$ of measurement equation and $\eta_{i,t}$ of transition equations are assumed to be distributed normally and uncorrelated with each other and across all time periods.

For estimating the Kalman filter model, two steps are used: first, at the end of time t-1, the optimal predictor of $\varepsilon_{w,t-1}, \varepsilon_{w,t|t-1}$ is determined based on all available information up to time t-1. Second, when $\varepsilon_{w,t}$ is observed at the end of time t, the prediction error is calculated by the equation: $v_t = \varepsilon_{i,t} - \varepsilon_{i,t|t-1}$. Then, this prediction error is used to provide additional information about $\gamma_{iw,t}$. Therefore, the estimate of $\gamma_{i,t}$ can be updated with the equation: $\gamma_{i,t} = \gamma_{i,t|t-1} + K_{i,t} v_t$, where $K_{i,t}$ is known as the Kalman filter gain and presents the weight assigned to new information about $\gamma_{i,t}$. Thus, given an initial estimation $\gamma_{i,1|0}$ and knowing $K_{i,t}$, equation $\gamma_{i,t} = \gamma_{i,t|t-1} + K_{i,t} v_t$ provides a recursive estimate for updating $\gamma_{i,t}$ as new information on $\varepsilon_{i,t}$ arrives.

To take these two steps, the computations will be carried out by the following six equations:

$$\gamma_{t|t-1} = T_t \gamma_{t-1},$$

$$P_{t|t-1} = T_t P_{t-1} T_t^{'} + Q,$$

$$v_t = \varepsilon_{i,t} - \varepsilon_{i,t|t-1} = \varepsilon_{i,t} - \gamma_{t|t-1} \varepsilon_{w,t},$$

$$F_t = \varepsilon_{w,t} P_{t|t-1} \varepsilon_{w,t}^{'} + \sigma^2,$$

$$\gamma_t = \gamma_{t|t-1} + P_{t|t-1} \varepsilon_{w,t}^{'} F_t^{-1} v_t,$$

$$P_t = P_{t|t-1} - P_{t|t-1} \varepsilon_{w,t}^{'} \varepsilon_{w,t} P_{t|t-1} F_t^{-1}$$

where, $\gamma_{i,t-1}$ is the time-varying coefficient, v_t is the prediction error, F_t is the

covariance matrix of the prediction error, σ^2 is the constant variance of the measurement equation, Q is the constant variance of the transition equation, and $P_{t|t-1} = E[(\gamma_t - \gamma_{t|t-1})(\gamma_t - \gamma_{t|t-1})']$ denotes the covariance of γ_t conditional on information up to time t-1.

The log-likelihood for observation t for the Kalman filter is given by:

$$l_t = -\frac{1}{2}\ln(2\pi) - \frac{1}{2}\ln(F_t) - \frac{1}{2}v_t'F_t^{-1}v_t$$

3.3.5.2 Combining Kalman filter and GARCH models

A usual characteristic of financial return models is that the error process may not satisfy a full set of NIID properties. If the variance of the error process changes over time in a systematic way, the testing procedure may be biased, and spurious evolution of financial integration may be obtained. However, the problem is that the framework of Kalman filter assumes the variance of the error process to be constant (homoscedasticity). Hence, as a more efficient method for capturing the evolution of financial integration, the framework of combining Kalman filter and GARCH models is expected.

Using four bank shares from the Sofia Stock Exchange, Emerson, et al. (1997) examine how the efficiency of a young financial market changes over time through combining Kalman filter and GARCH-M model. However, their method is restricted to the GARCH-M model; they let the conditional variance term enter into the measurement equation of Kalman filter, and then express one of transition equations as the form of the variance equation of the GARCH(1,1) model. Hence, this method cannot be widely adopted in other GARCH models.

Key points of combining Kalman filter and the GARCH model

1. As with Emerson, et, al. (1997), we use the one-step-ahead forecast error v_t to represent an estimate of the residual ε_t, and adjust the conditional variance h_t of the measurement equation through v_t.

2. The GARCH-filter will produce a new prediction error v_{t+1} as new information on the conditional variance, h_t, arrives.

Before combining these two models we need to review some key steps of implementing the Kalman filter model described above and find, at the end of time t-1, that we could obtain all of information up to time t-1, by which we could form an optimal predictor of $\beta_{i,t|t-1}$. Therefore, the prediction error at time t can be calculated and obtained by $v_t = y_t - y_{t|t-1}$ at the end of time t-1. Thus, we obtain the prediction error v_t by the Kalman filter at time t-1. And then, as the representation of residual ε_t, v_t is estimated by the variance equation of the GARCH-filter model to produce the conditional variance h_t at time t. Then, the GARCH-filter will produce a new prediction error v_{t+1} as new information on h_t arrives at time t. After that, v_{t+1} is estimated by the variance equation of the GARCH-filter to produce the conditional variance h_{t+1} at time t+1. Thus, the estimation will forward until time T.

In this procedure, the original prediction error v_t is estimated by the Kalman filter rather than our GARCH-filter. This is similar with the estimation of many models, take the GARCH model as an example: A big issue for estimating the GARCH model is the choice of where to start the estimation. The standard way is to estimate a linear regression model for the mean equation of the GARCH model, and then use the estimated parameters as the starting value for the GARCH optimization. Thus, we consider the prediction error v_t estimated by the Kalman filter as the initial value

of our GARCH-filter.

3.3.6 Whether the discrepancies of the integration level of small (high), and big (low) portfolios are persistent or significant?

Through the combination of Kalman filter and GARCH models, we are able to capture the time variation in financial integration of different portfolios with the world market. However, the key question is whether growth (big) portfolios are more integrated with the world than others, and whether these phenomena are persistent or significant?

In order to test the statistics significance of the discrepancy in the integration level of small (high), and big (low) portfolios, more specifically, whether the differences created by $\gamma_{big,t} - \gamma_{small,t}$, or $\gamma_{low,t} - \gamma_{high,t}$ are statistically different from zero, the following t-statistics is used:

$$T = \frac{\dfrac{1}{N}\sum_{t=1}^{N}(\gamma_{big,t} - \gamma_{small,t})}{S_t / \sqrt{N}}$$

$$\text{where } S_t = \sqrt{\frac{\sum_{t=1}^{N}(\gamma_{D,t}^{big,small} - A\gamma_{D,t}^{big,small})^2}{(N-1)}}$$

where $\gamma_{D,t}^{big,small} = \gamma_{big,t} - \gamma_{small,t}$, $A\gamma_{D,t}^{big,small} = (\sum_{t=1}^{N}\gamma_{D,t}^{big,small})/N$

N = sample size.

The null hypothesis is, $H_0 : \gamma_{big,t} = \gamma_{small,t}$, and the alternative hypothesis is, $H_1 : \gamma_{big,t} \neq \gamma_{small,t}$. Thus, the null hypothesis $H_0 : \gamma_{big,t} = \gamma_{small,t}$ can be rejected at the 5% significance level if $|T| > 2.086$. Otherwise, we do not reject the null hypothesis, or the discrepancy between $\gamma_{big,t}$ and $\gamma_{small,t}$ is not significant.

3.3.7 The integration level: An analysis of alternative modeling techniques

We examine the ability of alternative models in capturing the time variation of the integration level. Through testing the ability of GARCH type, the Schwert and Seguin extended market model, and Kalman filter, Faff, et al. (2000) and Mergner, et al. (2005) examine the time varying betas of the market model, and they showed that betas estimated using the Kalman filter algorithm were consistently more efficient than all other methods. At the same time, Faff, et al. (2000) state that a combined method that incorporates the information contained in the conditional volatility of asset returns into the Kalman filter algorithm would be more powerful than any one method in isolation, and they state that is an area worthy of future investigation. In this study, our analysis focuses on two alternative approaches to modeling the integration: the approach of Kalman filter, and our GARCH-filter (the framework of combining Kalman filter and GARCH model) model. Models of alternative approaches are as follows:

1. The framework of Kalman filter:

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t} \qquad \text{(measur ement equation)}$$

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t} \qquad \text{(transition equation)}$$

where, $e_{i,t} \rightarrow i.i.d.(0,\sigma_e^2), \eta_{i,t} \rightarrow i.i.d.(0,\sigma_{\eta,i}^2)$.

2. The framework of GARCH-filter

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t} \qquad \text{(measurement equation)}$$

$$h_{i,t} = var(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2$$

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t} \qquad \text{(transition equation)}$$

where, $\eta_{i,t} \rightarrow i.i.d.(0,\sigma_{\eta,i}^2)$.

In this study, we adopt the likelihood ratio tests to compare these two techniques. Likelihood ratio tests are a powerful statistics test of the goodness-of-fit between two models and usually used to test model assumptions. Many model assumptions can be viewed as putting restriction on the parameters in a likelihood expression. Through likelihood ratio test, a relatively more complex model (some additional parameters are added) is compared to a simpler model to examine whether it fits a particular dataset with a better significance. However, one problem may arise when additional parameters do not make improvement in fit of a model to a particular dataset. The likelihood ratio test provides one efficient criterion for selecting among alternative models. The equation of the LRT can be expressed as:

$$LR = 2 * (\ln(L1) - \ln(L2))$$

where, $L1$ and $L2$ ar e the likelihood value of alternative models respectively. LRT statistics are assumed to follow a chi-square distribution. To determine whether the discrepancy between the two models is significant or not, the degree of freedom is required to be considered. In the framework of LRT, the degree of freedom is the number of additional parameters added in the more complex model. According to this information, the critical value of LRT statistics can be obtained from standard statistics tables.

In our case, the framework of Kalman filter assumes the variance of the error process to be constant, and our GARCH-filter model limits the evolution of the error term to a TGARCH(1,1) process through adding 3 additional parameters, which is the relatively more complex model. Thus we set the degree of freedom to equal 3 when comparing Kalman filter and GARCH-filter models. Under this condition of degree of freedom,

LRT critical value (P=0.005)=12.8381. If our computed LR value is more than 12.8381, we can infer that the GARCH-filter model is significantly better than the one without the TGARCH errors with 99.5% probability.

3.4 Result

This study of examining financial integration focuses on stock returns at the portfolio (formed according to firm size and book to market value) level, in addition to those at the aggregate national market level. The main objective is to investigate:

1. whether big (growth) portfolios are more integrated with the world market than others,

2. whether this phenomenon is persistent or significant,

3. how much of the shock of a specific portfolio is driven by a world factor, and how much is left to be explained by the corresponding national market factor, and the relative importance of the world market with that of the national market.

3.4.1 Predictability of returns and some evidence on financial integration

We examine the extent and sources of predictability in local and world stock returns through estimating model (3.1). Furthermore, we separately test the null hypothesis that the coefficients of the local and world variables are zero, then the hypothesis that the coefficients are jointly zero are tested. The results are reported in Table 3.3.

At the aggregate national market index level, the R^2 s range from 2.84% in Hong Kong to 9.91% in Brazil, which indicates a considerable degree of the predictability. The estimate for the US dollar returns based on the world and local factors are also reported separately. When only local instruments are estimated R^2 of Brazil is the highest one in our sample with value of 3.91%, the following R^2 s are 2.80% in Mexico, 1.66% in the UK, 1.30% in Japan, 1.10% in Singapore, and 1.02% in HK. When only world factors are examined, the R^2 s range from 2.11% in Hong Kong to 5.10% in Japan. Comparing the local models and world models, we can find that the R^2 of the local model increases dramatically when estimating the world models in

the UK (1.66% to 2.94%), Japan (1.30% to 5.10%), Hong Kong (1.02% to 2.11%), Singapore (1.10% to 2.73%), and Brazil (3.91% to 4.20%).

At the portfolio level, LR statistics shows that for most small portfolios, their coefficients of instrumental variables can be rejected to equal zero. Furthermore, small portfolios' R^2s are much higher than other portfolios for any market: 18.51% for Brazil, 12.62 for UK, 10.54% for Singapore, 10.22% for Mexico, 9.69% for Hong Kong, and 6.47% for Japan. Comparing the local models and local-world models, the increasing trend in R^2 of small portfolios is relatively lower: 8.48% to 12.62% in the UK, 3.15% to 6.47% in Japan, 7.55% to 9.69% in Hong Kong, 7.37% to 10.54% in Singapore, 9.27% to 18.51% in Brazil, and 5.86% to 10.22% in Mexico. In contrast, R^2s of big portfolios increase dramatically: 2.60% to 4.21% in the UK, 1.78% to 6.11% in Japan, 2.20% to 6.18% in Hong Kong, 2.30% to 6.19% in Singapore, 3.01% to 10.63% in Brazil, and 2.85% to 9.46% in Mexico. For more clear purpose of comparing the explaining power of local models and local-world models, we compute the increased level of R^2 from local models to local-world models through equation $\dfrac{R_2^2 - R_1^2}{R_1^2}$, where R_1^2 repr esents the R^2 of local model, and R_2^2 repr esents the R^2 of local-world models. It can be seen from the last column of Table 3.3, that this increased level of R^2 are: 48.82% for small and 62.11% for big in the UK, 105.50% and 243.39% in Japan, 28.20% and 180.40% in Hong Kong, 42.86% and 169.23% in Singapore, 99.74% and 253.00% in Brazil, and 74.47% and 231.50% in Mexico. The similar case exists between some low and high portfolios: 213.80% for low and 111.78% for high in Hong Kong, 157.88% and 150.48% in Singapore, and 178.93% and 134.22% in Brazil. These increasing levels of R^2s show that the world instrumental variables have more relative explanatory power on all big and some low portfolios, which implies that big (low) portfolios may be more integrated with the world market than small (high) portfolios.

3.4.2 The level of financial integration

Model (3.2) - (3.7) for the aggregate national market (or the specific portfolio) constrains the integration level to be constant over time. The estimation results are presented in Table 3.4. The integration levels of the aggregate national market in our sample range from 0.45 in Japan, to 1.62 in Brazil. Brazil is followed by 1.25 in Mexico, 0.97 in Hong Kong, 0.96 in Singapore, and 0.71 in the UK. This integration level shows, take the UK as an example, that a shock of 1 percent in the world market, represented by the Standard and Poor's 500 Index of the US, leads on average to a change in returns of 0.71 percent in the UK market. When focusing on the national market level, we find that the integration levels of emerging markets (Hong Kong, Singapore, Brazil and Mexico) with the US are much higher than those of developed markets (the UK and Japan). These results are reasonable: Brazil and Mexico of Latin America are now considered fully accessible to US investors, especially for Mexico, US investors own 27 percent of Mexican equities, which result in a considerable financial integration level of these countries with the US. Furthermore, these results are consistent with much empirical evidence that external shocks are far more important in developing economies than in developed countries.

The striking results about different portfolios show, for all markets within our sample, that:

1. The integration levels of big portfolios with the world market are much higher than those of small portfolios. The levels of big and small portfolios with the world market are: 0.786 (big) and 0.585 (small) in the UK, 0.349 and 0.306 in Japan, 0.892 and 0.323 in Hong Kong, 1.012 and 0.699 in Singapore, 0.783 and 0.178 in Brazil, and 1.310 and 0.233 in Mexico.

2. Similar discrepancies are also found between low and high portfolios for all markets: 0.753 (low) and 0.689 (high) in the UK, 0.389 and 0.288 in Japan,

0.752 and 0.692 in Hong Kong, 1.183 and 0.936 in Singapore, 0.504 and 0.420 in Brazil, and 0.761 and 0.487 in Mexico. The discrepancies between low and high portfolios are smaller than discrepancies between big and low portfolios. These results are consistent with our central hypothesis that the level of big (growth) portfolios is higher than others.

3. When comparing the relative importance of the world market and the national market, we find, in the developed markets, that the corresponding national markets are the dominant forces for different portfolios. Take the big portfolio as the example, the integration levels with the world and national market are: 0.713 (the world market) and 1.003 (the national market) in the UK, 0.445 and 0.883 in Japan. In contrast, in the emerging markets, the world market dominates most portfolios compared with the national market. Taking the big portfolio as the example, the integration levels with the world and national market are: 0.965 (the world market) and 0.749 (the national market) in Hong Kong, 0.998 and 0.843 in Singapore, 0.969 and 0.602 in Brazil, and 1.077 and 0.850 in Mexico [see Table 5 about results of other portfolios].

4. Parameters estimates of variance equation of TGARCH model are also included in Table 3.4 and Table 3.5. An examination of this table show that TGARCH model adequately capture the characteristics of return variances. For most portfolios, the GARCH coefficients are significantly different from zero at the 1% level, and at least one coefficient of ARCH and TARCH is significant. It has been argued that a negative shock to financial time series is likely to cause volatility to rise by more than a positive shock of the same magnitude; the coefficient a2 reflects this phenomenon.

3.4.3 Illustrating time-varying financial integration:

T he framework of combining Kalman filter and the TGARCH model

In the previous sub-section, we assumed the financial integration level is constant over the whole sample. However, one serious problem is that financial integration may exhibit strong variations over time. Thus, we employ the techniques of combining Kalman filter and the TGARCH model to capture this variation.

At the aggregate national market level:

Figure 3.1 provides the evolution in integration of different market indices with the world market.

1. The financial integration level is indeed volatile over time.

2. Another striking feature is that the integration levels of emerging markets (Singapore, Brazil and Mexico) are much more volatile than those of developed markets (the UK and Japan).

3. The inte gration levels i n the Japan, Brazil, and Mexico markets exhibit the tendency to increase over time.

4. Integration among international markets increases dramatically during the period of crisis. We find that the 1987 crisis in the US affects all markets within our sample; the 1997 crisis in Asia affects the Asian markets including Japan, Hong Kong, and Singapore; and the Aug. 1998 crisis in Russia affects Brazil and Mexico.

UK

The fluctuation of integration of UK becomes smaller and smaller from Jul. 1975 to Sep. 1987 with a decreasing trend, during which the highest value is 1.455 in Jul. 1975 and the lowest value is 0.560 in Feb. 1984. The integration level jumps from 0.651 in Sep. 1987 to 0.829 in Oct. 1987, which is largely caused by the 1987 crisis in the US. Then the integration remains at a relatively stable level around 0.8 until Jun. 1996, and replaced by a relatively observable drop to 0.525 in Aug. 1997. After that, the level maintains a gradually increasing trend until Jul. 2006 with value

0.813.

Japan

Among six markets within our sample, the integration level of Japan is the most stable. A slow increase from 0.077 in Jul. 1987 to 0.604 in Jul. 2001 is replaced by a relatively stable transition until Jun. 2006. The 1987 US crisis makes the integration of Japan jump from 0.140 to 0.239 during Sep. and Oct. of 1987.

Hong Kong

Among six markets within our sample, the integration level of Hong Kong is the most volatile in a large range from 0.237 (Apr. 1993) to 1.734 (Oct. 1997). Two dramatic increases appear in 1997, when the level jumps from 1.077 in Jul. to 1.274 in Aug. 1997, and then jumps from 1.285 to 1.734 during Sep. and Oct. 1997. These jumps are largely caused by the 1997 Asia Crisis. The 1987 US crisis makes the integration of Hong Kong jump from 0.167 to 1.460 during Sep. and Oct. 1987.

Singapore

The integration level of Singapore market also exhibits strong volatility. The integration drops from 1.701 in Oct. 1987 to 0.473 in Jul. 1997, and is then replaced by a jump from 0.473 to 0.602 during Jul. and Aug. 1997 (largely due to the 1997 Asia crisis). After that, it exhibits relatively stable transition with a range from 0.602 to 0.997 until Jun. 2006. The 1987 US crisis make the integration of Singapore jump from 0.487 to 1.701 during Sep. and Oct. 1987.

Brazil

The integration level of Brazil exhibits increasing trend over our sample with relatively large volatility with the minimum value 0.653 in Dec. 1996 and the maximum value 2.297 in May 2006. The Aug. 1998 Russian crisis makes the integration of Brazil jump from 1.331 to 1.915 during Jul. and Aug. 1998.

Mexico

The integration level of Mexico market increases dramatically from 0.706 in Jul. 1992 to 1.387 of Oct. 1998, and followed by a relatively gradual decrease to 1.228 of Jun. 2006. The Aug. 1998 Russian crisis makes the integration of Mexico jump from 1.118 to 1.374 during Jul. and Aug. 1998.

At the portfolio level:

Our main objective is to investigate whether big (growth) portfolios are more integrated with the world market than others, and which markets dominant the specific portfolio, the world market or the national market; and whether this phenomenon is persistent or significant over time.

Figure 3.2 and 3.3 illustrate these issues, and show that:

1. Significant discrepancies between small (high) and big (low) portfolios do exist for most cases with the exception of low and high portfolios in the Brazil and Mexico markets.

2. The general trend of the integration evolution for big (low) and small (high) portfolios are similar over time for most cases.

3. When comparing the relative importance of the world market and the national market, we find, in the developed markets, that the corresponding national markets are always the dominant forces for all portfolios. In contrast, in the emerging markets, the world market dominates most portfolios compared with the national market.

To confirm these discrepancies of the integration level between small (high) and big (low) portfolios, we introduce the T statistics. Table 3.6 presents the average value of

integration level for different portfolios based on the technique of combining Kalman filter and TGARCH model, and discrepancies between portfolios and the corresponding T statistics value are also included. The average discrepancies of integration level between big and small portfolios and the T statistics are: 0.279 [40.988] in the UK, 0.069 [36.129] in Japan, 0.502 [78.013] in Hong Kong, 0.240 [13.861] in Singapore, 0.739 [25.349] in Brazil, and 0.854 [38.318] in Mexico. The average discrepancies of integration levels between low and high portfolios and the T values are: 0.035 [5.471] in the UK, 0.052 [13.637] in Japan, 0.084 [16.264] in Hong Kong, 0.176 [9.603] in Singapore, 0.0012 [0.043] in Brazil, and -0.082 [-1.782] in Mexico. Therefore, these results show that the discrepancies of the integration level of small (high), and big (low) portfolios are indeed persistent or significant for most cases with the exception of low and high portfolios in the Brazil and Mexico markets. These discrepancies about integration level provide more opportunities for portfolio managers and investors, who can benefit from new insight into the co-movements among different portfolios in different international markets, for instance, the small and growth portfolios should be more attractive than other portfolios to international investors for the benefit of diversifying risks according to our empirical result.

Parameters estimates of variance equation of TGARCH model from the time varying equation are presented in Table 3.6a. This table shows that TGARCH model adequately capture the characteristics of return variances.

Based on the technique of combining Kalman filter and TGARCH model, Table 3.8 describes the relative importance of the world and national market through estimating the average discrepancies in the integration level of a specific portfolio with the world and national market, and the corresponding T statistics value are also included. The results of Table 3.8 provide strong evidence again that external shocks are far more important in developing markets (Singapore, Brazil, and Mexico) than in developed countries (the UK and Japan). We also examine the proportions of

variance accounted for by the world and corresponding national markets shocks. Figure 3.4 presents these variance ratios. We find, for all cases, that the volatility of the specific portfolio is largely explained by the corresponding national market compared to the world market. When looking into the detail of the equation of variance ratio, we find that these discrepancies are largely caused by the much higher volatility of the national market compared with the world market.

Some studies showed that there are some relationships between realized average returns on common stocks and some firm characteristics, such as firm size and book-to-market ratio. Especially, Fama and French (1993, 1996) propose some factors related to size (market capitalization) and BE/ME ratios, and state that size and BE/ME effects can be captured by these factors (SMB and HML). Thus, we add the factors related to firm size and book-to-market ratio into our model. Table 3.7 presents the result from our three factor model based on the technique of combining Kalman filter and TGARCH model, the discrepancies between portfolios and the corresponding T statistics value are also included. The average discrepancies of integration level between big and small portfolios and the T statistics are: 0.010 [10.674] in the UK, 0.082 [6.488] in Japan, 0.101 [30.446] in Hong Kong, 0.079 [12.047] in Singapore, 0.278 [24.396] in Brazil and -0.0018 [-0.182] in Mexico. The average discrepancies of integration level between low and high portfolios and the T values are: 0.012 [6.609] in the UK, 0.050 [5.385] in Japan, 0.060 [3.753] in Hong Kong, -0.0037 [-0.384] in Singapore, -0.033 [-4.781] in Brazil, and -0.106 [-6.093] in Mexico.

Comparing the results of our three factor model with those of the one factor model, we find, as we expected, that the discrepancies of integration levels between small (high) and big (low) portfolios tend to disappear for most cases. Especially in the Singapore and Mexico markets, the discrepancies between big and small portfolios in the Singapore market, low and high portfolios in the Mexico market are not significant any more. Although discrepancies remain significant in other cases, these

discrepancies between small (high) and big (low) portfolios become much smaller compared to the result estimated by our original model. And these remained discrepancies imply that other unobservable factors may influence our results. But, we only focus on the effect of these two factors (SMB and HML) in this study. And our results imply that the factors related to size and BE/ME ratios (SMB and HML) are able to largely capture the average returns on portfolios formed on size and BE/ME within our sample.

3.4.4 An analysis of alternative modeling techniques

Table 3.9 presents the log likelihood value for these two models (Kalman filter and GARCH-filter) respectively, and the likelihood ratio test statistics and the corresponding P value are provided. Table 3.9 shows, for all cases, that the LR statistics are statistically significant (p value < 0.005), which implies that our GARCH-filter model does fit the data of our sample more significantly than the Kalman filter techniques.

3.5 Conclusion

This study investigates the integration process among international equity returns at the market level as well as the portfolio level. The main objective is to examine:

1. whether big (growth) portfolios are more integrated with the world market than others,

2. how much of the shock of a specific portfolio is driven by a world factor, and how much is left to be explained by the corresponding national market factor, and the relative importance of the world market to that of the national market,

3. whether this phenomenon is persistent or significant.

For capturing the time variation of financial integration, we model the integration level within the Kalman filter framework extended to allow for GARCH effects in the innovations. Furthermore, we proposed a new estimation method to combine the Kalman filter system and the TGARCH model.

Our results are as follows:

1. The financial integration levels of countries that we test are indeed volatile over time.

2. The integration levels of emerging markets (Singapore, Brazil and Mexico) are much more volatile than those of developed markets (the UK and Japan).

3. There is no significant trend for the integration level over time in Japan, Hong Kong, Singapore and Mexico.

4. As expected, growth (large) portfolios are indeed more integrated with the world than others for most cases. Furthermore, these discrepancies are significant and persistent over time in our sample.

5. When risk factors SMB and HML are added to our model, we find that the discrepancies of integration levels between small (high) and big (low) portfolios tend to disappear for most cases. These results imply that the factors related to size and BE/ME ratios (SMB and HML) are able to capture most of average returns on portfolios formed on size and BE/ME within our sample.

6. When comparing the relative importance of the world market and the national market, we find, in the developed markets, that the corresponding national markets are the dominant forces for different portfolios. In contrast, in the emerging markets, the world market dominates most portfolios compared with

the national market. These results are consistent with much empirical evidence that external shocks are far more important in developing economies than in developed countries.

Our study provides more opportunities for portfolio managers and investors, who can benefit from new insight into the co-movements among different portfolios in different international markets. The empirical results show that the small and value portfolio should be more attractive than other portfolios to international investors for the benefit of diversifying risks.

Chapter 4

Evolution of International Stock and Bond Market Integration: Do Maturities of Government Bonds Matter?

4.1 Introduction

International financial market integration has dramatically increased during the last two decades. A growing body of literature describes international stock market integration; however, the attention paid to the government bond market is very limited. Study of international bond market integration is valuable in the literature; for instance, further integration in the government bond market helps governments service their debts at lower cost. In a further integration area, investors can decrease their exposure to the local shocks through diversification, which reduces the requirement of investors for the bond yield, and, in turn, reduces the interest payments by the government. Barr and Priestley (2004) examine five major international bond markets integration through testing how much of the local expected bond return is explained by world risk factors. Based on the monthly data from 1986 to 1996 for the US, UK, Japan, Germany, and Canada market, they conclude that the average contribution of world factors to domestic returns across these five markets is only 70%, which implies that the world government bond markets are not completely integrated within their sample. However, they reject the hypothesis that the extent of the major bond markets integration changed during their

sample period, and do not provide more description about evolution of bond market integration. Baele et al. (2004) employ two methods to investigate the integration evolution of the European government bond markets over the period 1993 – 2003. Firstly, they use the spread between 10-year local benchmark government bond yields and the corresponding German yield to measure integration. They argue that bond yield differences should reduce with further integration, and these differences should be zero when markets are completely integrated. Secondly, Baele et al. (2004) use the correlation of the yield change in 10-year local government bond and the corresponding German yield change to proxy integration. For obtaining dynamic integration level, they employ rolling estimation with an 18-month regression window. However, the well-known overlapping data problem make rolling estimation very limited. Therefore, the literature focus on time-varying bond market integration with more promising approach is expected all the time.

On the other hand, amongst the limited literature on bond market integration, they only focus on researching the integration of the national bond market (represented by the national bond market index or the local 10-year bond market index) with the world market. It is widely accepted that long-term bonds are more sensitive to changes in inflation and interest rates.[7] Changes in expectations of inflation and interest rates stem from a set of information. In other words, changes in these expectations can be considered as manifestations of changes in a set of information. With the deepening of globalization and monetary convergence, changes in expectations of inflation and interest rate are not only from national information, but more from global information. Therefore, long-term bonds are expected to be more sensitive to global information, and more integrated with the world. If bond portfolios with different maturities indeed exhibit systematically significant discrepancies in integration levels with the world market, it will provide more opportunities for international investors to diversify international portfolios.

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[7] e.g. Campbell and Ammer (1993), Bodie, Kane, and Marcus (2002)

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In this study we seek to contribute to the existing literature in four ways. The first contribution is our dynamic model; we model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations.

The second contribution is the focus on bond returns at the portfolio level (formed according to different maturities), in addition to those at the aggregate national market level (represented by the national bond market index or 10-year bond market index). This analysis enables us to investigate whether bond portfolios with longer maturities are more integrated with the world bond, stock and corresponding national stock markets than others. In this study we expect the results to show that bond portfolios with longer maturities are preferred by international investors. Given the international investment cost, international investors are more likely to adopt a passive investment strategy due to relatively asymmetric information. Compared with investing long-term bonds, investors have to spend more time and cost in obtaining limited information to research the next investment when shorter bond portfolios mature. This preference of international investors will be more obvious in relatively segmented capital markets as investment costs caused by asymmetric information will be relatively high for international investors. In fully or highly integrated markets, local and international investors share similar information and investment costs; the preference to long-term bond portfolios will be correspondingly reduced. Therefore, we expect the results to show that discrepancies in integration levels of bond portfolios with different maturities are smaller in highly integrated capital markets than those in segmented markets.

Our third contribution is the examination of bond markets integration across different maturities. Fama (1970) states that price should always fully reflect the available information relevant to the valuation of securities, and when markets are strong efficient private and public information is fully reflected in prices. Therefore,

in this research we assume that the price movements of a benchmark asset are a good reflection of all relevant common news. Given that the world market is strongly efficient, we assume the price movement of the world bond portfolio represents the world common news. In this part, we do not examine and compare integration levels of bond portfolios with different maturities with the world bond market. Instead, we divided the world bond benchmark into three parts: the world bond (1-3Y), the world bond (5-7Y), and the world bond (10+Y) markets, then estimate and compare integration levels of the national bond portfolio, say Japan 1-3Y bond portfolio, with these three benchmarks. If long-term bonds are indeed more sensitive to global information, one unit change of information should cause more price changes of long-term bonds. Inversely, one unit change in shocks of long-term bonds is due to relatively less change in global information. When focusing on the integration level of the national bond portfolio with these three world benchmark portfolios, one unit change in shocks of the world bond (1-3Y) market will result in more change in shocks of the national bond portfolio than those of the world bond (5-7Y), in turn more than those of the world bond (10+Y). Therefore, we expect, for all cases, that the national bond portfolio should be more integrated with the world bond (1-3Y) portfolio than the world bond (5-7Y), in turn more than the world bond (10+Y) portfolio. However, in segmented capital markets, free flow of information is restricted due to legal and economic barriers. Therefore, our expectation will be valid in highly integrated capital markets.

And these characteristics are expected to be more significant across bond portfolios (with different maturities) within a national market since information can freely flow across different portfolios within a country. Similarly, we expect that the US 1-3Y bond portfolio is more integrated with the US 5-7Y bond portfolio than the US 10+Y bond portfolio, and the US 5-7Y bond is more integrated with the US 1-3Y bond than the US 10+Y bond, and the US 10+Y bond is more integrated with the US 1-3Y bond than the US 5-7Y bond. The expectation is similar for other countries.

The fourth contribution is to investigate potential macro economic factors that may drive time variation in bond market integration. Most previous research focuses on studying the impact of variables on the integration of stock markets. Very few studies examine theses influences on the integration of bonds markets. To fill in this gap, this part will examine some potential macro economic variables that may have explanatory power for the volatility in the integration of bonds markets.

Therefore, key questions in this study are as follows:

1. Is long-term bond portfolio more integrated with the world bond, stock and national stock markets than others?

2. Is the national bond portfolio more integrated with the world short-term bond portfolio than the world long-term bond portfolio?

3. Is the bond portfolio more integrated with the short-term bond portfolio than others within the national market?

4. Is our GARCH-filter model more efficient than the traditional Kalman filter system based on Likelihood Ratio test?

5. Do any potential macro economic variables ha ve explanatory power for the volatility in the integration of bonds markets?

If there indeed exist systematic discrepancies in integration between long-term and short-term bond portfolios, our examination regarding the first three questions will provide more opportunities for international and national investors to diversify their investment portfolios. Investigating potential factors that may influence the financial integration level could provide some evidence to the local authorities for implementing effective policies to promote the co-movement of the local financial market with the world.

The following table describes the progress of this chapter.

Key question	Models	results
Is long-term bond portfolio more integrated with the world bond, stock and national stock markets than others?	models (4. 1) - (4. 13)	Section 4. 4. 1. 1
Is a national bond portfolio more integrated with the world short-term bond portfolio than the world long-term bond portfolio?	models (4. 1) - (4. 13), and models (4. 1), (4. 4), and (4. 9) are changes as described in Section 4. 3. 1. 2	Section 4. 4. 1. 2
Is a bond portfolio more integrated with the short-term bond portfolio than others within the national market?	models (4. 15) - (4. 21)	Section 4. 4. 1. 3
Do any potential macro economic variables have explanatory power for the volatility in the integration of bonds markets?	1st approach: model (4. 30) 2nd approach: model (4. 31) - (4. 34)	section 4. 5

The remainder of this study is organized as follows: Section 2 describes the data used for investigating and explaining time-varying bond market integration. Section 3 develops the empirical model to test for bond market integration. Empirical results about time variation in integration are presented in Section 4. Based on different approaches, Section 5 examines some potential macro economic variables that drive time variation in bond market integration. Finally, Section 6 concludes this study.

4.2 Data

4.2.1 Data description

Our sample consists of data from the US, UK, Japan, Australia, Canada, and Germany. We employ Morgan Stanley Capital International (MSCI) Government Bonds Return Indices to proxy different bond portfolios, and MSCI has provided

bond return indices for all traded government bonds according to their maturities. For each market, we choose the following government bond return indices to proxy our bond portfolios:

The government bond index with 1-3Y.

The government bond index with 3-5Y.

The government bond index with 5-7Y.

The government bond index with 7-10Y.

The government bond index over 10Y

For the world and national market, Morgan Stanley Capital International (MSCI) world sovereign all traded government bonds index is chosen as the world bond market portfolio. MSCI world stock index is chosen as the world stock market. The national stock markets indices of different countries are also from MSCI.

All return indices are in terms of US dollars with monthly frequency. Total return indices are chosen to calculate returns for each index according to $R_{it} = \ln(P_t / P_{t-1})$. Thus, there are 5 bonds portfolios for each market, the world bond market index, the world stock market index, and the corresponding national stock market index. Our sample is from January 1994 to April 2007. Excess returns are calculated relative to the US risk-free rate, and the US three-month Treasury bill rate is selected to be the risk-free rate.

4.2.2 The summary statistics of Data

Table 4.1 reports summary statistics for excess returns of all bond portfolios over the period January 1994 to April 2007. We find, with the exception of the Japan market, that mean excess returns of most portfolios are positive. For each market, the excess return of the bond portfolio increases as the extension of the bond maturity, and

coincides with the increase in the standard deviation. These are consistent with our expectation since investors bear more maturity risk caused by the extension of maturities, they will require a higher maturity premium. Take the US bond market as an example, excess returns of five bond portfolios (ranked by maturities) are 0.056%, 0.110%, 0.143%, 0.159%, and 0.244% respectively, and the corresponding standard deviations are 0.446%, 1.030%, 1.345%, 1.734%, and 2.457% respectively. Among these six bond markets, the Canada bond market (represented by the 10+Y bond market index) exhibits the highest return, 0.490%, followed by the UK (0.407%), Australia (0.379%), Germany (0.373), the US (0.244%), and Japan (0.037%).

Jarque-Bera (JB) test is a normality test based on the joint hypothesis that both skewness and excess Kurtosis (Exc) are zero. The null hypothesis that excess returns are normally distributed is rejected for all bond portfolios in the Japan market. Looking more into the detail, we find that this is largely due to relative leptokurtic with respect to the normal distribution, which means that large returns are more frequent than small returns. Excess returns of most bond portfolios in other markets exhibit normal distribution.

The last column of Table 4.1 describes the first-order correlation of excess returns, and it shows that excess returns of all bond portfolios in the Germany market are significantly auto-correlated.

Table 4.2 shows the unconditional correlation of all bond portfolios with the world bond market. The Germany bond market (represented by the 10+Y bond index) exhibits the highest correlation coefficient, 0.854, followed by Japan (0.716), the UK (0.702), Australia (0.531), the US (0.500) and Canada (0.427). The correlation of the US and world market is much lower than our expectation since it may be large enough to be immune to world influences. For instance, the US may matter for the world market, but the world market may not matter as much for the US. This is consistent with the findings of Barr and Priestley (2004) and Campbell and Hamao

(1992).

4.2.3 Information variables

Following Barr and Priestley (2004), the following information variables are employed to form conditional expected returns of the world bond market: a constant, the first lag of the world government bond market excess return (WB), the first lag of the world stock market excess return (WS), the spread between the yield on long-term government bonds and the one month euro-dollar rate (WBSP), the yield on long-term government bonds minus yield on the equity market (WGEYR). For the local bond market: a constant, the first lag of the local government bond market return (LB), the first lag of the local stock market return (LS), the spread between the yield on long-term government bonds and the one month euro-dollar rate (LBSP), the yield on long-term government bonds minus yield on the equity market (LGEYR).

Summary statistics for instruments of the world and national bond markets are presented in Table 4.3. As expected, for all cases the stock market excess return exceeds that of the bond market, and excess returns of stock and bond markets for different countries are: 0.425% and 0.134% for the world market, 0.540% and 0.136% for the US, 0.492% and 0.360% for the UK, -0.162% and -0.166% for Japan, 0.719% and 0.306% for Australia, 0.759% and 0.334% for Canada, and 0.549% and 0.222% for Germany. A similar discrepancy appears in standard deviations between stock and bond markets for all countries. For all cases, the value of the yield on long-term government bond in excess of the 1 month euro-dollar rate is positive, as is the bond-equity yield spread. The first-order correlation coefficient for bond or stock excess returns is not significant for most cases, with the exception of the world bond market (0.179), the Germany bond market (0.178), and the Canada stock market (0.133). For all cases, WBSP, WGEYR, LBSP, and LGEYR exhibit highly significant first-order correlation, and this value ranges from 0.95 to 1.00. We cannot

reject the null hypothesis that WBSP, WGEYR, LBSP, and LGEYR follow normal distribution for all cases.

4.3 Methodology

In this study, we investigate and compare integration levels of bond markets in three cases:

1. Integration of different bond portfolios (formed according to maturities) with the world bond, stock, and national stock market.
2. Integration of the national bond portfolio with different bond portfolios of the world market.
3. Integration of the bond portfolio with other bond portfolios within the national market.

Since our aim is to compare integration levels of different bond portfolios, we first introduce a Bivariate or Trivariate model to obtain the idiosyncratic shock of the world or corresponding market required to be estimated, and these shocks are orthogonalized to eliminate the potential effect caused by common news. Then the estimated innovations for the world and corresponding market are used as inputs for the univariate spillover model to obtain the integration of a specific bond portfolio with other markets.

4.3.1 Models

4.3.1.1 Integration of different bond portfolios with the world and corresponding national bond market.

Trivariate model

The joint process for the world bond, stock and corresponding national stock market returns is governed by the following trivariate GARCH(1,1) model:

$$
\begin{bmatrix} R_{sx,t} \\ R_{sw,t} \\ R_{bw,t} \end{bmatrix} = \begin{bmatrix} \alpha_{sx,0} \\ \alpha_{sw,0} \\ \alpha_{bw,0} \end{bmatrix} + \begin{bmatrix} \alpha_{sx,1} & \alpha_{sx,2} & a_{sx,3} \\ \alpha_{sw,1} & \alpha_{sw,2} & a_{sw,3} \\ a_{bw,1} & a_{bw,2} & \alpha_{bw,3} \end{bmatrix} \begin{bmatrix} X_{sx,t-1} \\ X_{sw,t-1} \\ X_{bw,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{sx,t} \\ \varepsilon_{sw,t} \\ \varepsilon_{bw,t} \end{bmatrix} \tag{4.1}
$$

$$
\varepsilon_t \big| \Omega_{t-1} \rightarrow N(0, H_t) \tag{4.2}
$$

where $R_{sx,t}$ is the excess return on the national equity index of country i with the US dollar. $R_{sw,t}$ is the excess return of the world stock market index. $R_{bw,t}$ is the excess return of the world bond market index. X represents information variables for the national stock market, the world stock market, and the world bond market respectively. $\varepsilon_t = \begin{bmatrix} \varepsilon_{sx,t} & \varepsilon_{sw,t} & \varepsilon_{bw,t} \end{bmatrix}$ is a vector of innovations, and H_t is the conditional variance of vector ε_t.

We limit the evolution of the conditional second moments of excess return to the asymmetric version of BEKK model of Engle and Kroner (1995), which is expressed as:

$$
\begin{bmatrix} h_{11t} & h_{12t} & h_{13t} \\ h_{21t} & h_{22t} & h_{23t} \\ h_{31t} & h_{32t} & h_{33t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 & u_{1t-1}u_{2t-1} & u_{1t-1}u_{3t-1} \\ u_{1t-1}u_{2t-1} & u_{2t-1}^2 & u_{2t-1}u_{3t-1} \\ u_{1t-1}u_{3t-1} & u_{2t-1}u_{3t-1} & u_{3t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}
$$

$$
+ \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} h_{11t-1} & h_{12t-1} & h_{13t-1} \\ h_{21t-1} & h_{22t-1} & h_{23t-1} \\ h_{31t-1} & h_{32t-1} & h_{33t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}
$$

$$
+ \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \begin{bmatrix} \eta_{1t-1}^2 & \eta_{1t-1}\eta_{2t-1} & \eta_{1t-1}\eta_{3t-1} \\ \eta_{2t-1}\eta_{1t-1} & \eta_{2t-1}^2 & \eta_{2t-1}\eta_{3t-1} \\ \eta_{3t-1}\eta_{1t-1} & \eta_{3t-1}\eta_{2t-1} & \eta_{3t-1}^2 \end{bmatrix} \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix}
$$

$$
\tag{4.3}
$$

where η represents the vector of negative return shocks with $\eta_{i,t} = \min\{0, \varepsilon_{i,t}\}$.

Since, there may be some common news that drives all of these three markets, the innovations from the world and national market are orthogonalized by assuming that the national stock return shock is driven by a purely idiosyncratic shock and by the world stock and bond return shocks. The orthogonalized world and national innovations are represented by $e_{bw,t}$ $e_{sw,t}$ and $e_{sx,t}$, and are expressed as:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{sx,t} \\ \varepsilon_{sw,t} \\ \varepsilon_{bw,t} \end{bmatrix} = \begin{bmatrix} 1 & k_{12t-1} & k_{13t-1} \\ 0 & 1 & k_{23t-1} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_{sx,t} \\ e_{sw,t} \\ e_{bw,t} \end{bmatrix} = K_{t-1} e_t \tag{4.4}$$

$$\varepsilon_t | \Omega_{t-1} \to N(0, H_t) \tag{4.5}$$

$$e_t | \Omega_{t-1} \to N(0, \textstyle\sum t) \tag{4.6}$$

$$\sum t = \begin{bmatrix} \sigma_{sx,t}^2 & 0 & 0 \\ 0 & \sigma_{sw,t}^2 & 0 \\ 0 & 0 & \sigma_{bw,t}^2 \end{bmatrix} \tag{4.7}$$

where $k_{t-1}, \sigma_{sx,t}^2, \sigma_{sw,t}^2$ and $\sigma_{bw,t}^2$ are computed such that $H_t = K_{t-1} \sum t K_{t-1}'$. According to this calculation, k_{t-1} can be expressed as the covariance divided by the variance:

$$k_{12t-1} = \frac{H_{sx,sw,t}}{H_{sw,t}} = \frac{Cov_{t-1}(\varepsilon_{sx,t}, \varepsilon_{sw,t})}{Var_{t-1}(\varepsilon_{sw,t})}$$

$$k_{13t-1} = \frac{H_{sx,bw,t}}{H_{bw,t}} = \frac{Cov_{t-1}(\varepsilon_{sx,t}, \varepsilon_{bw,t})}{Var_{t-1}(\varepsilon_{bw,t})}$$

$$k_{23t-1} = \frac{H_{sw,bw,t}}{H_{bw,t}} = \frac{Cov_{t-1}(\varepsilon_{sw,t}, \varepsilon_{bw,t})}{Var_{t-1}(\varepsilon_{bw,t})}$$

Univariate spillover model

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{4.8}$$

$$\varepsilon_{i,t} = \gamma_{bw,t-1} e_{bw,t} + \gamma_{sw,t-1} e_{sw,t} + \gamma_{sx,t-1} e_{sx,t} + e_{i,t} \tag{4.9}$$

$$h_{i,t} = \text{var}(e_{i,t} | \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1} e_{i,t-1}^2 + \alpha_{i2} h_{t-1} + \alpha_{i3} \xi_{i,t-1}^2 \qquad (4.10)$$

$$\gamma_{bw,t} = \gamma_{bw,t-1} + \eta_{bw,t} \qquad (4.11)$$

$$\gamma_{sw,t} = \gamma_{sw,t-1} + \eta_{sw,t} \qquad (4.12)$$

$$\gamma_{sx,t} = \gamma_{sx,t-1} + \mu_{sx,t} \qquad (4.13)$$

where $r_{i,t}$ is the excess return of a specific bond portfolio in US dollars. $\mu_{i,t-1}$ is the conditional mean return, and the unexpected part of bond portfolio i is represented by $\varepsilon_{i,t}$. The unexpected return $\varepsilon_{i,t}$ is decomposed into a purely local shock $e_{i,t}$, and reactions to world bond and stock markets news, represented by the world bond shock $e_{bw,t}$, and the world stock shock $e_{sw,t}$, and the corresponding national stock market news, represented by the national stock shock $e_{sx,t}$. The dependence of a specific bond portfolio shock on the world bond market shock is determined by $\gamma_{bw,t-1}$, which is considered as the proxy of the integration of a specific bond portfolio with the world bond market. $\eta_{bw,t} \rightarrow i.i.d.(0, \sigma_{\eta,bw}^2), \eta_{sw,t} \rightarrow i.i.d.(0, \sigma_{\eta,sw}^2)$, and $\eta_{sx,t} \rightarrow i.i.d.(0, \sigma_{\eta,sx}^2)$. These transition equations imply that the time-varying coefficients follow a random walk process, hence the only source of variation in $\gamma_{i,t}$ is due to the variance of the error term $\eta_{i,t}$, $e_{i,t}$ of measurement equation and error terms of transition equations are assumed to be distributed normally and uncorrelated with each other and across all time periods.

4.3.1.2 Integration of the national bond portfolio with different bond portfolios of the world market.

When examining the integration level of a specific bond portfolio with different bond portfolios of the world market, some changes of Model (4.1) are described as follows:

$R_{sx,t}$ is replaced by $R_{w1,t}$, which represents the excess return of the world 1-3Y bond portfolio,

$R_{sw,t}$ is replaced by $R_{w2,t}$, which represents the excess return of the world 5-7Y bond portfolio,

$R_{bw,t}$ is replaced by $R_{w3,t}$, which represents the excess return of the world 10+Y bond portfolio.

$\varepsilon_{sx,t}$, $\varepsilon_{sw,t}$, and $\varepsilon_{bw,t}$ are replaced by $\varepsilon_{w1,t}$, $\varepsilon_{w2,t}$, and $\varepsilon_{w3,t}$ respectively, which represent unexpected parts of returns of the world 1-3Y, 5-7Y, and 10+Y bond portfolios respectively. Other corresponding changes are similar as described above.

And Model (4.4) is changed as:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{w1,t} \\ \varepsilon_{w2,t} \\ \varepsilon_{w3,t} \end{bmatrix} = \begin{bmatrix} 1 & k_{12t-1} & k_{13t-1} \\ k_{21t-1} & 1 & k_{23t-1} \\ k_{31t-1} & k_{32t-1} & 1 \end{bmatrix} \begin{bmatrix} e_{w1,t} \\ e_{w2,t} \\ e_{w3,t} \end{bmatrix} = K_{t-1}e_t \qquad (4.14)$$

where

$$k_{12t-1} = \frac{H_{w1,w2,t}}{H_{w2,t}} = \frac{Cov_{t-1}(\varepsilon_{w1,t}, \varepsilon_{w2,t})}{Var_{t-1}(\varepsilon_{w2,t})}$$

$$k_{13t-1} = \frac{H_{w1,w3,t}}{H_{w3,t}} = \frac{Cov_{t-1}(\varepsilon_{w1,t}, \varepsilon_{w3,t})}{Var_{t-1}(\varepsilon_{w3,t})}$$

$$k_{21t-1} = \frac{H_{w2,w1,t}}{H_{w1,t}} = \frac{Cov_{t-1}(\varepsilon_{w2,t}, \varepsilon_{w1,t})}{Var_{t-1}(\varepsilon_{w1,t})}$$

$$k_{23t-1} = \frac{H_{w2,w3,t}}{H_{w3,t}} = \frac{Cov_{t-1}(\varepsilon_{w2,t}, \varepsilon_{w3,t})}{Var_{t-1}(\varepsilon_{w3,t})}$$

$$k_{31t-1} = \frac{H_{w3,w1,t}}{H_{w1,t}} = \frac{Cov_{t-1}(\varepsilon_{w3,t}, \varepsilon_{w1,t})}{Var_{t-1}(\varepsilon_{w1,t})}$$

$$k_{32t-1} = \frac{H_{w3,w2,t}}{H_{w2,t}} = \frac{Cov_{t-1}(\varepsilon_{w3,t}, \varepsilon_{w2,t})}{Var_{t-1}(\varepsilon_{w2,t})}$$

Some changes of Model (4.9) are:

$e_{bw,t}$, $e_{bw,t}$, and $e_{bw,t}$ are replaced by $e_{w1,t}$, $e_{w2,t}$, and $e_{w3,t}$, which represent innovations of the world 1-3Y, 5-7Y, and 10+Y bond portfolios after orthogonalization.

And the corresponding changes of other models are similar as described above.

4.3.1.3 Integration of the bond portfolio with other bond portfolios within the national market.

When examining integration of a specific bond portfolio with other bond portfolios within the national market, we take the US 1-3Y bond portfolio as an example, examine and compare the integration level of the US 1-3Y bond with the US 5-7Y and 10+Y bond portfolios.

The joint process for excess returns of the US 5-7Y and 10+Y bond portfolios is governed by the following bivariate GARCH(1,1) model:

$$\begin{bmatrix} R_{x1,t} \\ R_{x2,t} \end{bmatrix} = \begin{bmatrix} \alpha_{x1,0} \\ \alpha_{x2,0} \end{bmatrix} + \begin{bmatrix} \alpha_{x1,1} & \alpha_{x1,2} \\ \alpha_{x2,1} & \alpha_{x2,2} \end{bmatrix} \begin{bmatrix} X_{x1,t-1} \\ X_{x2,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{x1,t} \\ \varepsilon_{x2,t} \end{bmatrix} \tag{4.15}$$

$$\varepsilon_t | \Omega_{t-1} \rightarrow N(0, H_t) \tag{4.16}$$

where, $R_{x1,t}$ and $R_{x2,t}$ are excess returns of the US 5-7Y and 10+Y bond portfolios respectively. $X_{x,t-1}$ represents the information set, $\varepsilon_t = \begin{bmatrix} \varepsilon_{x1,t} & \varepsilon_{w2,t} \end{bmatrix}$ is a vector of innovations.

Similarly, we limit the evolution of the conditional second moments of excess return to the asymmetric version of BEKK model of Engle and Kroner (1995). We adopt a similar approach as described above to eliminate the potential effect caused by common news between $\varepsilon_{x1,t}$ and $\varepsilon_{x2,t}$. As innovations after orthogonalization,

$e_{x1,t}$ and $e_{x2,t}$ are us ed as inputs for the following univariate spillover model:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{4.17}$$

$$\varepsilon_{i,t} = \gamma_{x1,t-1}e_{x1,t} + \gamma_{x2,t-1}e_{x2,t} + e_{i,t} \tag{4.18}$$

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{4.19}$$

$$\gamma_{x1,t} = \gamma_{x1,t-1} + \eta_{x1,t} \tag{4.20}$$

$$\gamma_{x2,t} = \gamma_{x2,t-1} + \eta_{x2,t} \tag{4.21}$$

where $r_{i,t}$ is the excess return of the US 1-3Y bond portfolio in US dollars. $\mu_{i,t-1}$ is the conditional mean return, and the unexpected part of bond portfolio i is represented by $\varepsilon_{i,t}$. The unexpected return $\varepsilon_{i,t}$ is decomposed into a purely local shock $e_{i,t}$, and reactions to the US 5-7Y bond market news, represented by the US 5-7Y bond shock $e_{x1,t}$, and the US 10+Y bond market news, represented by the US 10+Y bond shock $e_{x2,t}$.

4.3.2 Assumption and some implications:

To complete model (4.8)-(4.13) and (4.17)-(4.19), we follow the method of Bekaert and Harvey (1997), and assume that the idiosyncratic shocks of a specific bond portfolio and other markets are uncorrelated.

$$E[e_{i,t}e_{j,t}|\Omega_{t-1}] = 0, \tag{4.22}$$

where i represents a specific bond portfolio, j represents the world bond, stock, or national stock markets. Since return shocks of the world bond, stock, and national stock markets have been orthogonalized, innovations of these markets are uncorrelated.

$$E[e_{j,t}\varepsilon_{k,t}|\Omega_{t-1}] = 0 \quad j,k = WB, WS, NS \quad j \neq k \tag{4.23}$$

where WB represents the world bond market, WS represents the world stock market,

and NS represents the corresponding national stock market.

As a result, the model implies the following variance and covariance expressions:

$$E[\varepsilon_{i,t}^2 | \Omega_{t-1}] = h_{i,t} = \gamma_{bw,t}^2 \sigma_{bw,t}^2 + \gamma_{sw,t}^2 \sigma_{sw,t}^2 + \gamma_{sx,t}^2 \sigma_{sx,t}^2 + \sigma_{i,t}^2 \qquad (4.24)$$

$$E[\varepsilon_{i,t} e_{bw,t} | \Omega_{t-1}] = \gamma_{bw,t} \sigma_{bw,t}^2 \qquad (4.25)$$

$$E[\varepsilon_{i,t} e_{sw,t} | \Omega_{t-1}] = \gamma_{sw,t} \sigma_{sw,t}^2 \qquad (4.26)$$

$$E[\varepsilon_{i,t} e_{sx,t} | \Omega_{t-1}] = \gamma_{sx,t} \sigma_{sx,t}^2 \qquad (4.27)$$

The conditional covariance equation (4.25) implies that, first, a specific bond portfolio's covariance with the world bond market return is positively related to the dependence of local shocks on world shocks, $\gamma_{bw,t}$. Second, higher volatility in the world bond market can result in higher covariance between the world market and a specific bond portfolio with the assumption that $\gamma_{i,t}$ is positive. Equations (4.26) and (4.27) imply the similar relationship between a specific bond portfolio with the world stock market, and the corresponding national stock market respectively.

In order to examine the proportion of the variance of a portfolio return explained by world shocks and national market shocks, the following variance ratios are computed:

$$VR_{bw,t} = \frac{\gamma_{bw,t}^2 \sigma_{bw,t}^2}{h_{i,t}} \qquad (4.28)$$

4.3.3 An analysis of alternative modeling techniques: GARCH-filter vs. Kalman filter

One contribution of this study is our dynamic model. Through examining the time varying betas of the market model, Faff, et al. (2000) test and compare some of the most popular models, which include GARCH type, the Schwert and Seguin extended

market model, and Kalman filter. They find that betas estimated using the Kalman filter algorithm are consistently most efficient among the methods examined. At the same time, they point out that a combined method that incorporates the information contained in the volatility of asset returns into the Kalman filter system is expected to be more powerful than any one estimation method in isolation, and they state that this is an area worthy of further investigation. Thus, in this study, we model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. In order to examine the ability of our GARCH-filter model, we focus on comparing the conventional Kalman filter system and the GARCH-filter model. Review model (4.9) – (4.13),

$$\varepsilon_{i,t} = \gamma_{bw,t-1} e_{bw,t} + \gamma_{sw,t-1} e_{sw,t} + \gamma_{sx,t-1} e_{sx,t} + e_{i,t} \tag{4.9}$$

$$\gamma_{bw,t} = \gamma_{bw,t-1} + \eta_{bw,t} \tag{4.11}$$

$$\gamma_{sw,t} = \gamma_{sw,t-1} + \eta_{sw,t} \tag{4.12}$$

$$\gamma_{sx,t} = \gamma_{sx,t-1} + \mu_{sx,t} \tag{4.13}$$

$$e_{i,t} \rightarrow i.i.d.(0,\sigma_e^2) \tag{4.29}$$

where $\eta_{bw,t} \rightarrow i.i.d.(0,\sigma_{\eta,bw}^2), \eta_{sw,t} \rightarrow i.i.d.(0,\sigma_{\eta,sw}^2)$, and $\eta_{sx,t} \rightarrow i.i.d.(0,\sigma_{\eta,sx}^2)$. In the system of Kalman filter, (4.9) is measurement equation, and (4.11) – (4.13) are transition equations, which imply that the time-varying coefficients follow a random walk process. The key point of the Kalman filter system is to assume that the variance of error term of measurement equation is constant, $e_{i,t} \rightarrow i.i.d.(0,\sigma_e^2)$. Thus, models (4.9), (4.11), (4.12), (4.13), and (4.29) constitute the Kalman filter system.

In our GARCH-filter model, we relax the assumption mentioned above, and limit the evolution of the conditional variance of error in measurement equation to the TGARCH(1,1) model, which is expressed as follows:

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{4.10}$$

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Thus, models (4.9), (4.10), (4.11), (4.12), and (4.13) constitute our GARCH-filter model.

To compare these two techniques, we adopt the likelihood ratio tests (LRT), and the equation of the LRT can be expressed as:

$$LR = 2 * (\ln(L1) - \ln(L2))$$

where $L1$ and $L2$ are the likelihood value of alternative models respectively, and LRT statistics are assumed to follow a chi-square distribution.

4.4 Time-varying financial integration

In this section, we show the evolution of different bond portfolios integration with the world market over the sample period. In order to compare the overall integration level of different portfolios, we first examine the average level of integration over the sample period, and then illustrate the integration evolution.

4.4.1 The average level of integration

Models (4.8) - (4.13), and (4.17) – (4.21) allow the integration to be time-varying, and we calculate the average level of integration over our sample according to the following equation:

$$\bar{\gamma}_i = \frac{1}{N} \sum_{i=1}^{N} \gamma_{i,t}$$

where $\gamma_{i,t}$ is the factor loadings (the integration level) of a national specific bond portfolio i with the world or national market at time t as described in our models. $\bar{\gamma}_i$ represents a shock of 1% in the world (or other assets) market leads on average to a change in returns of $\bar{\gamma}_i$% in the bond portfolio.

4.4.1.1 Integration with the world bond, stock, and corresponding national stock market.

Average integration levels, $\bar{\gamma}_i$, with the world and national market are reported in Table 4.4. The third column of Table 4.4 presents integration with the world total bond market index, and last two columns of Table 4.4 present integration with the world and national stock market respectively. There are some striking results as follows:

1. The integration levels with the world bond market, take the 10+Y bond portfolio as an example, in our sample range from 0.624 in Canada to 1.429 in Japan, and Japan is followed by 1.381 in Germany, 1.044 in the UK, 0.751 in Australia, 0.632 in the US, and 0.624 in Canada. The integration levels with the corresponding national stock market exhibit positive value for all cases in our sample, and they are ranked as follows: 0.561 in the US, 0.395 in Canada, 0.315 in Australia, 0.300 in the UK, 0.089 in Germany, and 0.083 in Japan. An interesting finding is that two groups of ranks regarding integration with the world bond and national stock market are almost reversed, the market with higher bond integration (with the world bond market) has lower stock integration level (with the corresponding national stock market). It is consistent with our expectation. When investigating financial integration in the framework of news-based measures, we assume that the price movements of a benchmark asset are a good reflection of all relevant common news, thus, shocks of the world bond and corresponding national stock market returns represent the world common news and relevant national news regarding the stock market respectively. Thus, if a market is fully integrated, the local news, including local stock market news, should not play any role, and if it is completely segmented, the influence of the world news should be ignored entirely. Therefore, between these two extremes regarding integration, since the Japan bond market shows the highest integration level with the world market, it is expected to exhibit the

lowest or a relatively low integration level with the Japan stock market, and it does so in our sample. As a market that shows the lowest integration level with the world market, Canada exhibits a relatively high integration level with the national stock market in our sample. Other cases are similar in our sample.

2. Comparing the integration levels of different bond portfolios with the world bond market, we find, as expected, that bond portfolios with longer maturities are indeed more integrated with the world bond market than others for all cases. Furthermore, this discrepancy between any two adjacent maturities is significant. The integration level of different bond portfolios are: 0.147 (1-3Y), 0.327 (3-5Y), 0.416 (5-7Y), 0.524 (7-10Y), and 0.632 (10+Y) in the US; 0.691, 0.767, 0.853, 0.940, and 1.044 in the UK; 1.217, 1.231, 1.275, 1.340, and 1.429 in Japan; 0.456, 0.537, 0.599, 0.690, and 0.751 in Australia; 0.310, 0.382, 0.468, 0.527, and 0.624 in Canada; 1.166, 1.282, 1.265, 1.317, and 1.381 in Germany.

3. When comparing the integration with the world bond market, we find that discrepancies among different bond portfolios are much smaller if this national market is highly integrated with the world market, and these discrepancies become bigger and bigger as the integration level of the corresponding national market decrease. Here, the range of discrepancy of each market is computed by $diff = \bar{\gamma}_{10+,i} - \bar{\gamma}_{13,i}$, where $\bar{\gamma}_{10+,i}$ represents the average integration level of the bond portfolio with more than 10 years maturity, and $\bar{\gamma}_{13,i}$ represents the average integration level of the bond portfolio with 1-3 year maturity. The range of discrepancy for each market (ranked by the integration level with the world bond market) is: 0.314 in Canada (the lowest integration level with the world market in sample), 0.485 in the US, 0.296 in Australia, 0.354 in the UK, 0.214 in Germany, and 0.213 in Japan. This result is consistent with our expectation. In this study we assume that long-term bond portfolios are preferred by international investors. Long-term bonds make investors avoid reinvestment risk

due to relatively asymmetric information. This preference will be more obvious in relatively segmented capital markets as investment costs caused by asymmetric information will be relatively high for international investors. In fully or highly integrated markets, local and international investors share similar information and investment costs, so the preference to long-term bond portfolios will be correspondingly reduced. Therefore, discrepancies in integration levels of bond portfolios with different maturities are smaller in highly integrated capital markets than those in relatively segmented markets.

4. When comparing the relative importance of the corresponding national stock market with that of the world, we find, for most cases, that the national stock market is the dominant market all the time, especially for the UK and the Germany market, and integration levels with the world stock market exhibit negative value for most bond portfolios. And this negative integration levels mean that a shock in the world stock market will cause the change in bond returns in the UK and Germany markets to move towards the opposite direction. When looking into the detail of these two markets, we find that these negative values in integration are not significant, which means that no shocks across these markets. Conversely, compared to the national stock market, the world stock market is the dominant factor in Australia.

4.4.1.2 Integration with the world bond portfolios.

Table 4.5 presents the average integration level of national bond portfolios with world bond portfolios. In this sub-section, we focus on comparing a national specific bond portfolio with different world bond portfolios (each row in Table 4.5). We find, for most cases, that the integration level of a national bond portfolio with the world 1-3Y bond portfolio is higher than that of the world 5-7Y bond, which in turn is higher than that of the world 10+Y bond. These results are consistent with our hypothesis. It is widely accepted that long-term bonds are more sensitive to changes

in inflation and interest rates, and changes in expectation of inflation and interest rates stem from a set of information. In other words, changes in these expectations can be considered as manifestations of changes in a set of information. Thus, long-term world bonds are expected to be more sensitive to global information. If so, one unit change of information should cause more price changes of long-term bonds. Inversely, one unit change in shocks of long-term bonds is due to relatively less change of global information. In short, one unit change in shocks of long-term bonds contains less information change compared with short-term bonds. However, in segmented capital markets, free flow of information is restricted due to legal and economic barriers. Therefore, our assumption will be more significant in highly integrated capital markets, such as the Japan and German market in our sample.

4.4.1.3 Integration across different bond portfolios within the national market.

Table 4.6 presents the average integration level across different bond portfolios. We find, as expected, that the US 1-3Y bond portfolio is more integrated with the US 5-7Y bond portfolio than the US 10+Y bond portfolio (0.275 and 0.129 respectively), and the US 5-7Y bond is more integrated with the US 1-3Y bond than the US 10+Y bond (2.284 and 0.394 respectively), and the US 10+Y bond is more integrated with the US 1-3Y bond than the US 5-7Y bond (4.519 and 1.583 respectively). Similar results are found in other markets.

A question may arise: why are the matrices regarding integration levels of Table 4.6 not symmetric? As described above, long-term bonds are more sensitive to local and global information. Inversely, compared with the short-term bond, one unit change in shocks of long-term bonds is due to relatively less change of information. We assume that the price movements of a benchmark asset are a good reflection of all relevant common news. Thus:

1. One unit shock of the 1-3Y bond portfolio represents more change in local and global information.

2. One unit shock of the 10+ Y bond portfolio represents relatively less change in local and global information

Again, long-term bonds are more sensitive to local and global information. Thus:

1. One unit change of information will cause relatively more shocks of the 10+ Y bond portfolio.

2. One unit change of information will cause relatively less shocks of the 1-3Y bond portfolio.

Therefore, in our sample, the integration level of 10+ Y bond with 1-3Y bond should be highest, and the integration level of 1-3Y bond with 10+ Y bond should be lowest; and they are different from each other. Other cases are similar.

4.4.2 Illustrating time-varying financial integration

Figure 4.1 describes the evolution of integration of different bond portfolios with the world and national market, and it yields a number of important results:

1. Financial integration levels of different bond portfolios with the world and national market are indeed volatile for all markets over time. Among three cases (integration with the world bond and stock market, and the corresponding national stock market), integration levels with the world stock market are most volatile.

2. Although integration levels with the world bond market are volatile, integration levels of long-term bond portfolios are always higher than those of bonds with shorter maturities. These discrepancies are significant between any two adjacent maturities for all cases.

3. When examining integration with the world bond market, we find an increasing

trend in integration levels in the UK market starting from 2001, and the US, Australia, and Canada markets over the whole period we tested, and there is no significant trend for the integration level over time in the Japan, and Germany markets.

4. In three cases (integration with the world bond and stock market, and the corresponding national stock market), integration levels of five bond portfolios in each market exhibit the similar trend over time, and the evolution of five portfolios almost keep synchronization. Despite synchronous changes in evolution of integration, one important finding is that bond portfolios with longer maturities are much more volatile than short-term bonds. This is consistent with our assumption since long-term bonds are more sensitive to the global and national information.

Figure 4.2 describes the evolution of variance ratio of a specific bond portfolio with the world bond market, and this ratio shows how much volatility of a specific bond portfolio is explained by the world bond market over time. Figure 2 shows, in each market, that variance ratios of bond portfolios with different maturities exhibit a similar trend over time. Departing from integration levels, we do not find any systematic discrepancies in variance ratios between bond portfolios with different maturities. This result is reasonable, review equation (4.28).

$$VR_{bw,t} = \frac{\gamma_{bw,t}^2 \sigma_{bw,t}^2}{h_{i,t}}$$

$\gamma_{bw,t}$ represents the integration level, $\sigma_{bw,t}^2$ represents the conditional variance of the world bond market, and $h_{i,t}$ represents the conditional variance of a specific bond portfolio's unexpected return. Although the numerator $\gamma_{bw,t}$ is significantly bigger for long-term bond portfolio, the denominator $h_{i,t}$ also exhibits similar characteristics, bigger value for long-term bond. Therefore, the significant

discrepancy is counteracted by the numerator and denominator.

4.4.3 An analysis of alternative modeling techniques

In our case, the framework of Kalman filter assumes that the variance of the error process is constant, and the GARCH-filter model limits the evolution of the error term to a TGARCH(1,1) process through adding 3 additional parameters, which is the relatively more complex model. Thus we set the degree of freedom to equal 3 when comparing Kalman filter and GARCH-filter models. Under this condition of degree of freedom, LRT critical value (P=0.10)=6.2514. If our computed LR value is more than this value, we can infer that the GARCH-filter model is significant better than the one without the TGARCH errors with 90% probability.

Table 4.7 presents the log likelihood value for these two models (Kalman filter and GARCH-filter) respectively, and then the likelihood ratio test statistics and the corresponding P value are provided. Table 4.7 shows, for most cases (23 out of 30 cases), that the LR statistics are statistically significant (p value < 0.10), which implies that the GARCH-filter model does fit the data of our sample significantly better than the Kalman filter techniques. In other cases, although most LRT values are positive, they are not significant. This may be down to two reasons: first, the GARCH effect is not significant in these cases. Second, parts of parameters in variance equation are not significant.

4.4.4 Parameters estimates of variance equation from GARCH-filter model

Parameters estimates of variance equation of TGARCH model from the time varying equation are presented in Table 4.4a. For most cases, the GARCH coefficients are significantly different from zero at the 1% level, and at least one coefficient of ARCH and TGARCH is significant. It has been argued that a negative shock to financial time series is likely to cause volatility to rise by more than a positive shock

of the same magnitude. The significant level of a2 in Table 4.4a reflects this phenomenon. However, we find that a2 exhibits significant and negative value for all cases in the US, UK, and Japan markets, and some cases in Australia and Canada. These significantly negative values imply that positive shocks have more effects compared with negative shocks. This table shows that TGARCH model adequately captures the characteristics of return variances.

4.5 Explaining time-varying bond integration

Why does the level of financial integration change over time, and which factors could explain the volatility in the degree of this integration? This issue is as important as the co-movement among international financial markets. Investigating potential factors that may influence the financial integration level could provide some evidence to the local authorities for implementing effective policies to promote the co-movement of the local financial market with the world. When examining this issue, most former research focus on the integration among stock markets, or the integration of stock and bond markets. Very few studies investigate the influence of macro economic variables on the integration of bond markets. To fill this gap, this part will examine some potential macro economic variables that have explanatory power for the volatility in the integration of bond markets.

In this section, we first describe some potential macro-economic variables for explaining bond market integration. Second, we examine causality relationships between bond market integration and these explanatory variables respectively. Lastly, results based on two approaches will be discussed.

4.5.1 Potential variables for explaining bond market integration

Many studies have shown that factors that drive time variation in financial market

integration may not be the local own fundamentals but also the real and financial convergence with the world (Fratzscher, 2002; Kim, et al. 2005, etc.). However, the problem is that there is a high degree of correlation among these variables because real and monetary convergences do not occur in isolation. One way of minimizing this problem of multi-collinearity is to adopt principle component analysis. In order to interpret coefficients of the convergence variables in a meaningful way, we employ only one variable for each category (real and monetary convergence), which, furthermore, avoids the serious problem of high correlations among many independent variables. Thus, we employ the correlation of output growth (COUT) to proxy the real convergence variable, and the correlation of inflation rate (CINF) to proxy the monetary variable.

Correlation of output growth

This variable is the correlation in monthly growth rates of seasonally adjusted industrial production with the world estimated by Kalman filter. Because the world data is not available in Datastream, we construct the world industrial production through all available data of industrial production weighted by local annual GDP of each country. These countries used to form the world industrial production include: Euro 12 countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain), the US, Japan, and the UK (Datastream only provides data of these countries, and it is really hard to obtain the world data directly from Datastream or other systems). The more the output growths that are linked, the more they will be exposed to common shocks, and the more integrated markets are with each other. Therefore, the coefficient for this variable is expected to be positive.

Correlation of inflation rate

This variable is formed by the correlation of inflation rate of the national market with those of the world estimated through Kalman filter. Since financial markets are very sensitive to changes in monetary policies, a high degree of financial integration

may be explained by the convergence of monetary policies. As the proxy of monetary convergence, the increase in correlation of inflation rates implies monetary convergence tends to deepen. Thus, the more the inflation rates are correlated, the more integrated markets are expected. Therefore, the coefficient for this variable is expected to be positive.

Trade open

This variable is the ratio of total exports plus imports to annual GDP. Bekaert and Harvey (1995) found that countries with open economies are more integrated with world markets. Chen and Zhang (1997) also found that countries with heavier bilateral trade with a region tend to have higher return correlations with that region. Therefore, the coefficient for this variable is expected to be positive.

Exchange rate volatility

This variable is obtained by a GARCH(1,1) model for monthly local currency to the US exchange returns, and use the estimated conditional variance as an explanatory variable for integration levels. High currency volatility could cause international investors to encounter additional currency risk relative to local investors. Therefore, the increase in volatility of exchange rates will result in more cost hedging against such uncertainty, which will lead to a lower degree of integration levels. Thus, a negative coefficient is expected. However, on the other hand, if the increased currency volatility is caused by increasing flows of foreign portfolio investments, this could reduce currency risk price differentials, as investors could regard this inflow as providing support for their currency. Given these two conditions, the coefficient for exchange rate volatility could be positive or negative.

4.5.2 Granger causality test

In this sub-section, we examine causality relationships between bond market integration and these explanatory variables respectively. This analysis enables us to

examine whether real convergence, monetary convergence, trade open, and exchange rate volatility drive bond market integration, or whether bond market integration accelerates these convergences and volatility, or both.

Granger causality relationship is expressed as follows:

$$x_t = c_1 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{j=1}^{p} \beta_j y_{t-i} + u_{1t}$$

$$y_t = c_2 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{j=1}^{p} \beta_j y_{t-i} + u_{2t}$$

$$x_t = c_3 + \sum_{i=1}^{p} \gamma_i x_{t-i} + e_{1t}$$

$$y_t = c_4 + \sum_{j=1}^{p} \delta_j y_{t-i} + e_{2t}$$

According to Granger's definition of causal relationships:

Y does not cause X if $\beta_1 = \beta_2 = ... = \beta_p$

X does not cause Y if $\alpha_1 = \alpha_2 = ... = \alpha_p$

To examine whether these conditions hold, the following F-statistics are computed:

$$F = \frac{(RSS_{UR} - RSS_R)/p}{RSS_{UR}/(T - 2p - 1)} \rightarrow F_{p, T-2p-1}$$

Where:

$$RSS_{UR} = \sum_{t=1}^{T} \hat{u}_t^2, \quad RSS_R = \sum_{t=1}^{T} \hat{e}_t^2$$

T = the number of observations

P = the number of lagged periods.

If the F value is greater than the specific critical value, then we reject the null hypothesis that Y does not cause X, or X does not cause Y.

In our case, the Granger causality test is conducted between the time varying

integration estimated by our GARCH-filter model and a macro-economic variable described in Section 5.1. We use 2 lags structures for each case. As seen in Table 4.8, gamma represents the integration level of a national bond portfolio with the world bond market estimated by our GARCH-filter model. COUT represents the correlation of output growth. CINF represents the correlation of inflation rates. TOPEN represents trade open. EX_vol represents exchange rate volatility. From the point of view of monetary convergence, there exists a unidirectional causality relationship from the CINF to the bond market integration in the US, Canada, and Germany markets, and bilateral causality between the CINF and integration in the UK and Japan markets. From the point of view of real convergence, there exists a unidirectional causality relationship from COUT to integration in the US market, from integration to COUT in the Japan market, and bilateral causality between the COUT and integration in the Germany market. We find bilateral causality relationship between TOPEN and integration in the Japan and Germany markets, and unidirectional causality from TOPEN to integration in Canada. Results about exchange rate volatility show that there exists unidirectional causality from EX_vol to integration in Canada, and from integration to EX_vol in the UK and Germany, and bilateral causality between EX_vol and integration in Japan.

These results show that most variables described above have Granger-caused financial integration of the national bond portfolio with the world market. Furthermore, they are helpful for finding a suitable model specification to determine which factors are driving the evolution of integration.

4.5.3 Explaining bond market integration

In this sub-section, we employ two approaches to examine the impact of some macro-economic variables on bond market integration. The first approach is based on our GARCH-filter model, and regresses the time-varying gamma on these variables by OLS; second, we express the time-varying integration as a function of

these variables, and then re-estimate our theoretical GACH model.

Firstly, we express our model as follows:

$$\gamma_{i,t} = \alpha_{0,i} + \alpha_{1,i}COUT_{i,t-1} + \alpha_{2,i}CINF_{i,t-1} + \alpha_{3,i}TOPEN_{i,t-1}$$
$$\ldots\ldots\ldots + \alpha_{4,i}Evol_{i,t-1} + \alpha_{5,i}JAN\_dum_{i,t} + \alpha_{6,i}\gamma_{i,t-1}(+\alpha_{7,i}\gamma_{i,t-1}) + u_{i,t}$$

(4.30)

where $\gamma_{i,t}$ represents the integration level of a specific bond portfolio with the world

bond market estimated by our GARCH-filter. $COUT_{i,t-1}$ represents the correlation of

output growth. $CINF_{i,t-1}$ represents the correlation of inflation rates.

$TOPEN_{i,t-1}$ represents trade open. $JAN\_dum_{i,t}$ represents January Dummy variables.

In order to reduce serial correlation of residuals, we add the first or second lag of

integration levels in our model. This model is estimated by OLS.

The results are presented in Table 4.9 Coefficient of 'trade open' exhibits

significantly positive value for most cases in the UK, Australia and Canada markets.

Although 'trade open' variables are negative for some cases in the US, Japan, and

Germany markets, almost all of these negative coefficients are not significant. These

results imply that heavier bilateral trade is able to impel the evolution of bond

market integration, and supports the view of Bekaert and Harvey (1995), Chen and

Zhang (1997) based on bond markets.

In six markets of our sample, Datastream only provide data of industrial production

for four markets. Results show that variables of 'correlation of output growth' are

significantly positive for all cases (different bond portfolios) in the Japan and

Germany market, and one-fifth of cases in the US market. These results show, as

expected, that the real convergence has great explanatory power for the volatility in

the integration of these bond markets. Our results are very similar with those of Kim

et al. (2005), who examined the EMU influence on international stock-bond market

integration. They found that coefficients of the real convergence are significant and

positive for the US and Japan markets, and nearly significant for the Germany market ('p value' = 0.1426), but not significant for the UK market ('p value' = 0.8493).

'Correlation of inflation rates' enters significantly positive value for most cases in the UK market, which implies that monetary convergence indeed plays a significant role in driving time variation in integration of the UK bond market. However, results about this variable are not significant for the US, Japan, Canada and Germany markets. Our results are partly consistent with Kim et al. (2005), who also found non-significant coefficient about monetary convergence for the US, Japan, and Germany markets.

Coefficients of 'exchange rate volatility' are significant for most cases in the Japan, Australia, Canada and Germany markets. When looking in more detail, we find that all of these significant coefficients show positive sign, which implies that the increased currency volatility might be caused by increasing flows of foreign capital or investment. These results show that exchange rate volatility indeed has a lot of power in explaining the time variation of bond market integration within our sample. Among five markets, only the UK market exhibits non-significant coefficient about this variable. Baele (2003) examined the macro economic variables' influence on European equity markets, and found that 'exchange rate volatility' enters significantly positive sign in Germany, but not significant in the UK. In these two markets, we obtain similar results with those based on bond market integration.

Lastly, we find no evidence of seasonality in bond market integration dynamics since all January dummy variables are not significant in our sample. These results are consistent with Kim et al. (2005).

Secondly, reviewing model (4.8) – (4.13), the time-varying gamma is achieved by the Kalman filter system. We achieve the time-varying gamma through expressing

gamma as a function of macro-economic variables instead of Kalman filter. Models are as follows:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{4.31}$$

$$\varepsilon_{i,t} = \gamma_{i,t} e_{bw,t} + e_{i,t} \tag{4.32}$$

$$h_{i,t} = \text{var}(e_{i,t} | \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1} e_{i,t-1}^2 + \alpha_{i2} h_{t-1} + \alpha_{i3} \xi_{i,t-1}^2 \tag{4.33}$$

$$\gamma_{i,t} = \alpha_{0,i} + \alpha_{1,i} COUT_{i,t-1} + \alpha_{2,i} CINF_{i,t-1} + \alpha_{3,i} TOPEN_{i,t-1} + \alpha_{4,i} Evol_{i,t-1} + \alpha_{5,i} JAN\_dum_{i,t}$$

$$\tag{4.34}$$

Where $r_{i,t}$ is the excess return of a specific bond portfolio in US dollars. $\mu_{i,t-1}$ is the conditional mean return, and the unexpected part of bond portfolio i is represented by $\varepsilon_{i,t}$. The unexpected return $\varepsilon_{i,t}$ is decomposed into a purely local shock $e_{i,t}$, and reactions to world bond market news, represented by the world bond shock $e_{bw,t}$, notes: we only focus on the impact of variables on bond market integration, so we do not include the unexpected return of the world and corresponding national stock markets.

The results are presented in Table 4.10. Broadly speaking, estimated parameters are not as significant as those in Table 4.9.

Results show that variables of 'correlation of output growth' are significantly positive for all cases (different bond portfolios) in the Japan market, and for some cases in the US and UK markets. These results show, as expected, that the real convergence has great explanatory power for the volatility in the integration of these bond markets.

Variable of 'correlation of inflation rates' is significantly positive for some cases in the UK market, which is consistent with our expectation. However, significantly negative values appear for all cases in Japan. Variable of 'exchange rate volatility'

exhibits significantly positive value for all cases in the Japan and Australia markets. We find some seasonal evidence for some cases in the Australia market.

4.6 Conclusion

This study examines and compares the evolution of integration of international bond markets at the portfolio level (formed according to maturities). The main objective is to investigate:

1. whether the long-term bond portfolio is more integrated with other assets' markets than the short-term bond, and whether this phenomenon is significant;

2. whether the national bond portfolio is more integrated with the short-term bond portfolio than the long-term bond;

3. whether there is any potential macro economic variables that drive the time variation in bond market integration.

For capturing the time variability of financial integration, we model the integration level within the Kalman filter framework extended to allow for GARCH effects in the innovations. The Likelihood Ratio test shows that our GARCH-filter model is indeed more efficient than the traditional Kalman filter system.

Our main results are as follows:

1. Integration levels of different bond portfolios with the world and national market are indeed volatile for all markets over time. Five bond portfolios in each market exhibit the similar trend in integration over time, and the evolution of five portfolios almost keep synchronization. Despite synchronous changes in evolution of integration, bond portfolios with longer maturities are much more volatile than short-term bonds. This is consistent with our assumption since

long-term bonds are more sensitive to global and national information.

2. Integration levels of long-term bond portfolios are always more integrated with the world bond market than short term bonds. These discrepancies are significant between any two adjacent maturities for all cases.

3. The national bond portfolio is more integrated with the short-term bond than the long-term bond.

4. We find that real convergence (proxied by the correlation of output growth), monetary convergence (proxied by the correlation of inflation rate), trade openness, and exchange rate volatility significantly explain the changes in the levels of integration for most cases in our sample.

Chapter 5

Time-varying Financial Contagion

5.1 Introduction

Since the 1980s, and especially in the 1990s, some medical histories have appeared frequently in international financial markets. Several major financial crises include: the Mexican debt crisis in 1982, the European Exchange Rate Mechanism (ERM) crisis in 1992, the Tequila Effect of Mexican in 1994, the Asia Flu in 1997, the Russian Cold in 1998, the Brazilian Sneeze in 1999, and the Nasdaq Rash of 2000. These crises were usually initiated by a local turmoil, but ultimately spilled over to other markets, which may have direct or indirect, even little economic linkages to the local market. In other words, for some crises, the channel through the transmission of shocks could be explained by theory. For example, a mass of national fiscal deficits of the Latin American countries are financed by external borrowing, which results in the debt crisis in the 1980s. The overvaluation of the peso and the critical decrease in Mexico's international reserves make Mexico's central bank suffer the difficulty of solvency when facing any kinds of liquidity shocks. In most countries affected by the crisis in 1994 it was for the same reason as in Mexico. On the contrary, some transmissions of shocks are very difficult to explain theoretically. For example, the Asia Crisis in 1997 is international in scope and their spread surprises many economists. After Thailand's devaluation, many countries in Southeast Asia are attacked seriously, but the United States does not avoid the attack of the Asia Flu in 1997. According to Rigobon (2002), some Latin American stock markets, for

example Argentina, Brazil, Mexico and Venezuela, fell between 10 percent and 30 percent during the period of Asia Crisis. Surprisingly, these countries had almost no direct trading relationships with Southeast Asian countries. The Russian Cold in 1998 is another international crisis in scope, although the Russian stock market is very small compared with the total capitalization of the world market, almost all markets of the world are affected after the Russian default. Thus, one interesting question arises: why did these crises, that began from a specific country, quickly affect other countries around the globe, regardless of economic or financial links among these countries. Most people describe these phenomena as 'contagion'.

However, financial contagion is still an open question in the academic literature: there is no consensus on exactly what constitutes contagion and how to measure it, in particular the definition of the term contagion varies widely across the literature. Among all the extant descriptions about contagion, two definitions are widely accepted. The first is proposed by King and Wadhwani (1990), who define contagion as the shift in the strength of the propagation of shocks during the period of crisis. According to this definition, contagion is tested through the correlation coefficient of international markets' co-movement, and the change in the estimated correlations implies contagion. The second is proposed by Eichengreen and Rose (1995) and Eichengreen, Rose and Wyplosz (1996), who consider contagion as the correlation of excess returns of two markets after controlling for the effects of fundamentals. The main advantage of the first definition is that it is easier to test compared with the second, and the fundamental channels need not be considered. However, a serious problem is that the empirical test proposed by the first definition will be difficult to detect when the source of contagion is always present, the first definition requires correlations to be higher during the crisis period, and a significant increase in correlations from tranquil to crisis period are essential. If contagion is always present over the test sample, correlations would keep at a relatively high level, but a significant increase is not necessary. Thus, the first definition will fail to detect contagion without this significant increase. On the other hand, the high degree of

correlation cannot be considered as enough proof of contagion. If markets are highly cross-correlated, then a sharp change caused by a crisis in one market will result in a corresponding change in other markets. If the significant increase in correlations during the crisis does not exist, then these international markets only react to each other, which is usually considered as interdependence between markets, other than the contagion we addressed in this study. Furthermore, even though the increase in correlations was significant, it did not constitute proof of contagion because correlations are usually higher during periods of high volatility. Fortunately, the second definition effectively avoids the problems mentioned above. Therefore, in this study we define contagion as:

Correlation between markets in excess of that implied by economic fundamentals

This definition about contagion is consistent with that of Bekaert, Harvey, and Ng (2005).

At present, much attention has been paid to financial contagion. However, most previous studies focus on international stock markets; research examining contagion of bond markets and inter-stock-bond market is very limited. Because bond markets are sensitive to changes in inflation and interest rates, and most crises mentioned above are caused by, or associated with currency crises, the examination of co-movements of bond markets during the period of turmoil will be valuable in the academic literature.

On the other hand, the identification of crisis periods has been a difficult problem in the research of financial contagion. Ideally, most researchers wish to clearly distinguish between the period of turmoil, during which the local financial market is in crisis, and the tranquil period. For instance, Bekaert, Harvey, and Ng (2005) set the dummy variable according to the crisis period, say, the Mexico crisis period is from Nov. 1994 to Dec. 1995, and the Asia crisis period is from Apr. 1997 to Oct.

1998. However, two serious problems arise: first, this method may mask other periods when markets exhibit high volatilities; furthermore, even during the period of crisis, temporary smooth markets may exist. Take the Mexico stock market as an example, Figure 1 describes the conditional variance (estimated by TGARCH(1,1) model) of the Mexico stock market; indeed, the conditional variance is very high during the period Nov. 1994 and Dec. 1995, which has been captured by Bekaert, Harvey, and Ng (2005). However, the conditional variance is also high from Oct. 1998 to May 1999, which is neglected by Bekaert, et al. (2005). Second, results of the contagion test may be seriously affected by the size of the 'crisis' and 'non-crisis' periods because the observations of the 'crisis' period usually contains very few or relatively few observations, which may greatly affect the power of the test. Through examining the US stock market crash, Dungey and Zhumabekova (2001) find that statistically significant evidence of contagion would appear if the crisis sample period is extended, and this significance would disappear with the shorter crisis period. Therefore, the method of identifying the 'crisis' period needs to be improved.

Thirdly, as mentioned above, we define contagion as the co-movement of excess returns of two markets after controlling for the effects of specified fundamentals. According to this definition, contagion is treated as the correlation of the model's residual (idiosyncratic shocks) in most empirical work, and the residual is the part not explained by the model with the specified fundamental channels. Therefore, identifying the market fundamental variables is the key when investigating contagion, otherwise the conclusion will be biased. In the academic research, three approaches to defining the market fundamentals are adopted. The first is to assume that the market fundamentals are known. The second approach assumes that the fundamentals cannot be observed and need to be proxied by some observable variables. For instance, Gerlach and Smets (1995) examine contagion through the current and capital accounts of two countries and Miller, Thampanishvong and Zhang (2003) employ the US interest rate as the control variable. The third approach is the latent factor model, which is achieved through the dynamic relationships

between variables being studied. This latent factor model is promoted by recent empirical studies, such as Dungey, Gonzalez-Hermisillo, and Martin (2003), Bekaert, Harvey, and Ng (2005), because this approach does not require the specification of the fundamental relationships. To examine contagion, Bekaert, Harvey, and Ng (2005) define a dynamics model through the time-varying risk factors, which is achieved by some instrumental variables. More specifically, they express the risk factors as a function of some market instrumental variables to capture the time variation in integration. However, a common problem of approaches depending on several fundamental variables is that they only focus on a very small set of variables, which may partly explain the time variation in risk factors, furthermore, the included variables may pick up effects of other excluded variables. Therefore, the literature, with a more promising approach, focusing on time-varying risk factors, is expected all the same.

Therefore, we seek to contribute to the existing literature in three ways:

The first contribution is the examination of contagion at bond and inter-stock-bond markets, in addition to that at international stock markets. It has been argued that bond markets are more sensitive to changes in expectation of inflation and interest rates, therefore, bond markets may be infected to a greater extent during the currency crises. This analysis enables us to investigate whether the excess correlations of bond markets and stock-bond markets, respectively, are statistically significant during financial crises.

The second contribution to the literature is about the identification of crisis periods. Given the drawbacks of sample split mentioned above, we seek another method to identify the crisis period. Most studies have agreed on the fact that periods of financial crisis usually coincide with high volatility of assets prices and high covariance of returns across markets. The conditional variance of assets returns is a good proxy for volatility of assets markets. These characteristics inspire us to

distinguish between tranquil and turmoil periods according to the magnitude of the conditional variance of assets returns. On the other hand, many studies find that correlation between international markets returns usually increase during the period of crisis. However, correlations usually appear higher during periods of high volatility, which are often caused by business cycle troughs, rather than structural change of the financial system. To solve this problem, we employ the increased level in integration as a measurement instrument to distinguish between tranquil and crisis periods. Our hypothesis is that the integration level will increase during the crisis period. Thus, we would introduce two variables into the model for contagion test: the conditional variance of the local assets returns, and the increased level of the integration level of the national market with the world (regional) market. Two ways are used: firstly, we will set dummy variables according to the magnitude of the conditional variance and the increase level of integration levels; secondly, we will express the coefficient of contagion as a function of the conditional variance and the increased level of integration, by which we can obtain the time-varying level about contagion. This method of identifying crisis periods is expected to provide a consistent platform for the contagion test. Thus, departing from former studies, which only focus on the period of turmoil or crisis to examine contagion, our central hypothesis is that contagion may exist at any time over the sample.

The third contribution to the literature is our dynamic model, which is the key when examining contagion because unexpected shocks of models will change as the volatility of the factors changes, which is determined by the factor sensitivities. The popular approach is to express the factor loadings as a function of some fundamental variables to capture this time variation (Bekaert and Harvey, 1997; Bekaert, Harvey, and Ng, 2005). Given the problems mentioned above, we model this time variation within the Kalman filter framework extended to allow for GARCH effects in the innovations. The problem is that the procedure of Kalman filter assumes the variance of the error process to be constant. However, the error process of financial models may not satisfy a full set of NIID properties. Including the autoregressive dynamics

into the factor structure will form a more general modeling framework, and the natural way to capture it is the GARCH model. Thus, the framework of combining Kalman filter and GARCH models is expected to be a more ideal model for capturing time variation of factors. Furthermore, we proposed a new method to combine the system of Kalman filter and GARCH models through the iteration between prediction errors from the Kalman filter and conditional variances from GARCH models.

The rest of this chapter is as follows: the next section describes the data we use in this study. Section 3 develops models for integration and contagion. Section 4 analyzes two variables for identifying the crisis period and studies the result of time-varying contagion. Section 5 briefly concludes this chapter.

5.2 Data

5.2.1 Data description

This study includes stock and bond markets. For the stock market, we employ the national total market return share indices from Morgan Stanley Capital International (MSCI). Our empirical analysis is conducted for a sample set of countries that are grouped into four geographical regions: (1) North American – the US and Canada, (2) Latin American – Brazil and Mexico, (3) European – UK and Germany, (4) the Pacific – Japan, Australia, and Hong Kong. For the bond market we use J.P. Morgan Government Bond Return Indices, and we focus on several major international bond markets, which include the US, the UK, Japan, Australia, Canada, and Germany markets. The indices including stock and bond markets are all in terms of US dollars with monthly frequency. Based on the availability o f data from MSC I and J.P. Morgan, the sample ends on Sep. 2007, and most stock market indices are from Jan. 1975, while Brazil and Mexico stock markets are from Jan. 1988. All bond market

indices are from Jan. 1986.

The continuous markets returns examined in this study are measured as the natural logarithms of the ratios of the return index at time t and the next one such that $r_{i,t} = \ln(R_t / R_{t-1})$ for market i on month t. All returns are expressed in terms of excess returns relative to the US risk-free rate, and the US three-month Treasury bill rate is selected to be the risk-free rate.

5.2.2 The summary statistics of data

To provide some perspective on the data, the summary statistics are presented in Table 5.1 for the total available data for stock and bond markets. The statistics presented in Table 5.1 include observations (sample size), the average monthly return, standard deviation, the value of skewness, extra Kurtosis, JB (Jarque-Bera) test for the normality test, and the test for first-order autocorrelation.

The sample mean of the stock monthly return are 0.479 percent for the world market, 0.502 percent for the US, 0.399 percent for the UK, 0.304 percent for Japan, 0.602 percent for Australia, 0.456 percent for Canada, 0.485 percent for Germany, and 0.868 percent for Hong Kong. The developing countries have relatively higher return than those of developed countries within our sample, for instance, Brazil with 1.212 percent, and Mexico with 1.136 percent. The higher return is accompanied by higher volatility in developing countries. It can be seen from Table 5.1.1 that the standard deviation of monthly returns of these developing countries is much higher, 14.509 and 9.407 percent for Brazil and Mexico respectively. Among the developed countries, the asset return of the Hong Kong market has higher standard deviation, 9.018 percent, followed by Australia (6.833 percent), Japan (6.258 percent), Germany (6.161 percent), the UK (6.061 percent), Canada (5.574 percent), and the world and US markets with relatively low standard deviations, 4.054 and 4.270

percent respectively. JB test is a normality test for time series, which based on values of skewness and kurtosis. Table 5.1 shows that p values of JB test for all markets including the world market are significant, thus, we have to reject the null hypothesis that asset returns are normally distributed for all markets. Looking more into detail, values of skewness for all markets are significantly positive, which means that positive shocks are more frequent than negative shocks. For most markets, with the exception of Japan, the values of kurtosis are significant. The column of first-order correlation shows that the correlation coefficient of one developing market, Brazil (-14.19%), is significant, and this significance implies that asset return is predictable based on past return.

The third column of Table 5.1.2 shows the average return of bond markets: Australia has the highest average return, 0.511 percent, and the US market shows the lowest return, 0.192 percent. At the same time, the US bond market shows lowest standard deviation, 1.356 percent, and the highest, from Japan, is 3.716 percent. The JB test about normal distribution in the Japan, Australia and Canada markets is rejected with 1 percent level of significance. The first-order correlation shows that the world and UK markets are auto-correlated, 15.704% and 11.728% respectively.

Table 5.2 presents unconditional correlations of stock and bond markets with the world market respectively. Table 5.2.1 shows that the US market has the highest correlations with the world and regional markets over our sample, 0.851 and 0.996 respectively. When examining the difference of correlations between the world and regional market, we find, for most cases in our sample, that correlations with the corresponding regional markets are higher than those of the world market. Two exceptions are the Australia and Hong Kong markets: differences of correlations between the world and Pacific region are 0.138 and 0.096 respectively.

Table 5.2.2 describes correlation levels of bond markets. Within our sample, the Germany bond market has the highest correlation with the world (0.855), followed

by UK (0.731), Japan (0.720), the US (0.662), Canada (0.484), and Australia (0.301).

5.2.3 Information variables

The following information variables are employed to form conditional expected returns of the local stock market: a constant, a dummy variable for the month of January, the lagged excess returns on the local stock market index, the local stock market index dividend yield in excess of the 30-day Eurodollar rate, the change in the term structure spread (long-term bond yield of the local market minus three months Treasury Bill yield), All of these information variables are lagged. Information variables used here are consistent with Bekaert and Harvey (1997), and Fratzsher (2001).

For the bond market, information variables include: a constant, the first lag of the local government bond market return, the first lag of the local stock market return, the spread between the yield on long-term government bonds and the one month euro-dollar rate and the yield on long-term government bonds minus yield on the equity market. These information variables are consistent with Barr and Priestley (2004).

Summary statistics for instruments of the world stock and government bond markets are presented in Table 5.3. Instruments of the world stock market are: a constant, a dummy variable for the month of January, the lagged excess returns on the world stock market index (WS), the world stock market index dividend yield in excess of the 30-day Eurodollar rate (WDY), the change in the term structure spread (US ten years bond yield minus three months Treasury Bill yield) (WCTS), the change in the 30-day Eurodollar rate (WCIR), and the default spread (Moody's Baa yield minus Aaa bond yield) (WDFS). Instruments of the world bond market are: a constant, the first lag of the world government bond market return, the first lag of the world stock market return, the spread between the yield on long-term government bonds and the

one month euro-dollar rate, the yield on long-term government bonds minus yield on the equity market. Table 5.3.1 shows statistics for the world stock market. We find that not all information variables follow normal distribution, and change of dividend yield, change of term structure, and default spread appear first-order correlated. Table 5.3.2 shows the world market, as expected, the stock market excess return exceeds that of the bond market, 0.482 percent and 0.232 percent respectively, with a similar discrepancy appearing in standard deviations between stock (4.183 percent) and bond (1.847 percent) markets. The value of the yield on long-term government bond in excess of the 1 month euro-dollar rate is positive, as is the bond-equity yield spread. The world bond excess return is first-order correlated, which is not in the world stock excess return. We cannot reject the null hypothesis that the world bond excess return follows normal distribution.

5.3 Methodology

In this study, we define contagion as the correlation of excess returns of two markets after controlling for the effects of fundamentals. Consistent with most empirical work, contagion is treated as the correlation of residuals of regressions in this study, such as the transmission of unexpected local shocks to another market. This part provides the details of the structure for testing contagion. This section starts from a model of examining integration, in which co-movements of assets returns are determined by the dependence of local shocks on another market's shocks. Then, as the unanticipated shocks, the residuals generated from the regression are employed to investigate the contagious linkages between asset markets.

5.3.1 Models of integration

To examine co-movements of assets returns, we follow the basic models of Bekaert and Harvey (1997) as our starting point, and extend their models in two ways.

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Firstly, to capture the time-varying integration, Bekaert and Harvey (1997) express the spillover weight parameters as a function of some local and world information variables. However, this approach may not always be ideal. For instance, these variables of their model only include market capitalization to GDP, and exports plus imports divided by GDP, which may pick up effects of other excluded variables. On the other hand, even though we could obtain all possible variables that affect co-movements of asset returns, there may be a high degree of correlation among many macro or micro variables, which may directly result in multicollinearity and generate spurious results. Thus, we introduce the framework of Kalman filter into our model. The outstanding merit of Kalman filter is that it provides a convenient platform for inferring time-varying parameters and latent factors through the data itself. The problem is that the procedure of Kalman filter assumes the variance of the error process to be constant (homoscedasticity). However, the error process of financial models may not satisfy a full set of NIID properties. The natural way to capture it is the GARCH model. Thus, the framework of combining Kalman filter and GARCH models is expected to be a more efficient model for capturing time variation of factors. Furthermore, we propose a new method to combine the system of Kalman filter and GARCH models through the iteration between time-varying betas from Kalman filter and conditional variances from GARCH models.

Secondly, since Morgan Stanley Capital International (MSCI) provides the regional data for the stock market, when examining co-movements of stock markets, we extend the model of Bekaert and Harvey (1997) to a two-factor model because we distinguish between two sources of shocks (the regional market shock and the world shock respectively) instead of only one.

Thus, our models for different markets are as follows:

Bond markets:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{5.1}$$

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t} \tag{5.2}$$

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{5.3}$$

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t} \tag{5.4}$$

$$r_{w,t} = \mu_{w,t-1} + \varepsilon_{w,t} \tag{5.5}$$

$$h_{i,t} = \text{var}(\varepsilon_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{5.6}$$

where $r_{i,t}$ is the excess return on the national bond market index of country i in US dollars. $\mu_{i,t-1}$ is the conditional mean return for country i, and the unexpected part of country i's return is represented by $\varepsilon_{i,t}$. The unexpected return $\varepsilon_{i,t}$ is decomposed into a purely local shock $e_{i,t}$, and a reaction to world news represented by the world shocks $\varepsilon_{w,t}$. $r_{w,t}$ is the excess return of the world bond market index, which is the difference between the real return and the US three months Treasury Bill rate. $\varepsilon_{w,t}$ represents the unexpected return of the world bond market. These models are estimated in our GARCH-filter framework with measurement equation (model 5.2) and transition equation (model 5.4), and $\eta_{iw,t} \rightarrow i.i.d.(0,\sigma_{\eta,iw}^2)$. This transition equation implies that the time-varying coefficient follows a random walk process, hence the only source of variation in $\gamma_{iw,t}$ is due to the variance of the error term, $\eta_{iw,t}$. Error terms of measurement and transition equations are assumed to be distributed normally, to be uncorrelated with each other and across all time periods.

The conditional mean return of country i is expressed as:

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_w X_{w,t-1}$$

X represents a set of information variables, $X_{w,t-1}$ includes a constant, the first lag of the world government bond market return, the first lag of the world stock market return, the spread between the yield on long-term government bonds and the one month euro-dollar rate, the yield on long-term government bonds minus yield on the equity market. $X_{i,t-1}$ includes variables of the local market i.

Following Bekaert and Harvey (1997), the dependence of local shocks on world shocks is determined by $\gamma_{i,t-1}$ of model 5.2, which is considered as the proxy of the stock markets' integration. $e_{i,t}$ of mode 5.2 represents the unanticipated local shock of market i, which is extracted for testing contagion in next sub-section.

Bond and Stock markets

Models of inter-bond-stock markets are very similar to those of bond markets, and are specified as follows:

$$r_{is,t} = \mu_{is,t-1} + \varepsilon_{is,t} \tag{5.7}$$

$$\varepsilon_{is,t} = \gamma_{i,t-1}\varepsilon_{ib,t} + e_{is,t} \tag{5.8}$$

$$h_{is,t} = \text{var}(e_{is,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{5.9}$$

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t} \tag{5.10}$$

$$r_{ib,t} = \mu_{ib,t-1} + \varepsilon_{ib,t} \tag{5.11}$$

$$h_{ib,t} = \text{var}(e_{ib,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{5.12}$$

where $r_{is,t}$ ($r_{ib,t}$) is the excess return on the national stock (bond) market index of country i in US dollars, and the corresponding national stock (bond) market shock is represented by $\varepsilon_{is,t}$ ($\varepsilon_{ib,t}$). One point that should be noticed here is that these models are only used to estimate the integration level of the national inter-bond-stock market,

$e_{is,t}$ of model (5.8) does not represent the unexpected shock of the national stock market, and will not be extracted to test contagion of inter-bond-stock market.

Stock markets

Since MSCI provides the regional data for stock markets, we extend the model of Bekaert and Harvey (1997) to a two-factor model, and synchronously estimate the effect of the world and regional shocks on the local stock market, for which I first describe a bivariate model for the world and regional stock markets returns, and then the estimated innovations for the world and the regional market are used as inputs for the univariate model.

The joint process for the world and regional market returns is governed by the following bivariate GARCH(1,1) model:

$$\begin{bmatrix} R_{x,t} \\ R_{w,t} \end{bmatrix} = \begin{bmatrix} \alpha_{x,0} \\ \alpha_{w,0} \end{bmatrix} + \begin{bmatrix} \alpha_{x,1} & \alpha_{x,2} \\ \alpha_{w,1} & \alpha_{w,2} \end{bmatrix} \begin{bmatrix} X_{x,t-1} \\ X_{w,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{x,t} \\ \varepsilon_{w,t} \end{bmatrix} \qquad (5.13)$$

$$\varepsilon_t | \Omega_{t-1} \rightarrow N(0, H_t) \qquad (5.14)$$

where $R_{x,t}$ is the excess return on the equity index of a region x, $R_{w,t}$ is the excess return of the world stock market index. $X_{x,t-1}$ represents the information set of region x, $X_{w,t-1}$ represents the information set of the world market. $\varepsilon_t = \begin{bmatrix} \varepsilon_{x,t} & \varepsilon_{w,t} \end{bmatrix}$ is a vector of innovations.

We limit the evolution of the conditional second moments of excess return to the asymmetric version of BEKK model of Engle and Kroner (1995), which is expressed as:

$$\begin{bmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} u_{1t-1}^2 & u_{1t-1}u_{2t-1} \\ u_{1t-1}u_{2t-1} & u_{2t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

$$+\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} h_{11t-1} & h_{12t-1} \\ h_{12t-1} & h_{22t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

$$+\begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix} \begin{bmatrix} \eta_{1t-1}^2 & \eta_{2t-1}\eta_{1t-1} \\ \eta_{1t-1}\eta_{2t-1} & \eta_{2t-1}^2 \end{bmatrix} \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix}$$

where η represents the vector of negative return shocks with $\eta_{i,t} = \min\{0, u_{i,t}\}$

The innovations from the world and regional market are orthogonalized by assuming that the regional stock return shock is driven by a purely idiosyncratic shock and by the world stock return shocks. The orthogonalized world and regional innovations are represented by $e_{w,t}$ and $e_{x,t}$, and are expressed as:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{x,t} \\ \varepsilon_{w,t} \end{bmatrix} = \begin{bmatrix} 1 & k_{1t-1} \\ 1 & 1 \end{bmatrix} \begin{bmatrix} e_{x,t} \\ e_{w,t} \end{bmatrix} = K_{t-1}e_t \tag{5.15}$$

$$\varepsilon_t | \Omega_{t-1} \rightarrow N(0, H_t) \tag{5.16}$$

$$e_t | \Omega_{t-1} \rightarrow N(0, \sum t) \tag{5.17}$$

$$\sum t = \begin{bmatrix} \sigma_{x,t}^2 & 0 \\ 0 & \sigma_{w,t}^2 \end{bmatrix} \tag{5.18}$$

where $k_{t-1}, \sigma_{sx,t}^2, \sigma_{sw,t}^2$ and $\sigma_{bw,t}^2$ are computed such that $H_t = K_{t-1} \sum t K_{t-1}'$. According to this calculation, k_{t-1} can be expressed as the covariance divided by the variance:

$$k_{1t-1} = \frac{H_{x,w,t}}{H_{w,t}} = \frac{Cov_{t-1}(\varepsilon_{x,t}, \varepsilon_{w,t})}{Var_{t-1}(\varepsilon_{w,t})}$$

Thus, $e_{x,t}$ and $e_{w,t}$ of model (5.15) are estimated by models described above, and used as inputs for the following model to examine co-movement of stock returns.

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \tag{5.19}$$

$$\varepsilon_{i,t} = \gamma_{iw,t-1}e_{w,t} + \gamma_{ix,t-1}e_{x,t} + e_{i,t} \tag{5.20}$$

$$h_{i,t} = \text{var}(e_{i,t} | \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{5.21}$$

$$\gamma_{iw,t} = \gamma_{iw,t-1} + \eta_{iw,t} \tag{5.22}$$

$$\gamma_{ix,t} = \gamma_{ix,t-1} + \eta_{ix,t} \qquad\qquad (5.23)$$

where $r_{i,t}$ is the excess return on the national stock market index of country i in US dollars. $\mu_{i,t-1}$ is the conditional mean return for country i, and the unexpected part of country i's return is represented by $\varepsilon_{i,t}$. $e_{w,t}$ and $e_{x,t}$ are the unexpected return of the world and regional market after orthogonalization with each other.

The conditional mean return of country i is expressed as:

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_x X_{x,t-1} + \delta_w X_{w,t-1}$$

X represents a set of information variables, $X_{w,t-1}$ ($X_{i,t-1}$) represents the information set of the world (local) market, and $X_{x,t-1}$ includes a constant, the lagged excess returns on the regional stock market index.

5.3.2 Identifying crisis periods

The choice of sample period is an important step of testing contagion. At present, the popular approach of most studies is still to distinguish between the turmoil and tranquil periods according to the prior-determined date, therefore the length of crisis period is determined differently from paper to paper. For instance, Bekaert, Harvey, and Ng (2005) define the Asia crisis period from Apr. 1997 to Oct. 1998, Dungey, Fry, and Martin (2001) define the same crisis from Oct. 1997 to Dec. 2001. Which approach would be more accurate? Dungey and Zhumabekova (2001) show that the results of contagion will be largely determined by the definition of crisis periods, and they find that statistically significant evidence of contagion would appear if the crisis sample period is were to be extended, and that this significance would disappear with the shorter crisis period.

Given the problems mentioned above, we try to use the data itself to identify the

crisis periods. Under this method, our central hypothesis is that contagion may exist at any time over our sample, rather than existing only in the artificial crisis date. Thus, the key question arises: which variables could be employed to identify the crisis periods? Former studies have agreed on the fact that periods of financial crisis usually coincide with high volatility of assets returns. In the empirical work, the conditional variance of assets returns is usually selected as a good proxy for volatility of assets markets. These characteristics inspire us to distinguish between tranquil and turmoil periods according to the magnitude of the conditional variance of assets returns. The Mexico stock market gives us a good example, Figure 1 describes the conditional variance of the Mexico stock market, and this conditional variance is estimated by the following TGARCH (1,1) model,

$$r_{i,t} = c + e_{i,t} \tag{5.24}$$

$$h_{i,t} = \text{var}(e_{i,t} | \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1} e_{i,t-1}^2 + \alpha_{i2} h_{t-1} + \alpha_{i3} \xi_{i,t-1}^2 \tag{5.25}$$

where $r_{i,t}$ is the excess return of the Mexico stock market index, c is a constant, and $e_{i,t}$ represents the residual. The value of the conditional variance $h_{i,t}$ is described in Figure 1. Figure 1 shows that the conditional variance exhibits very high value during three periods: from Jan. 1988 to Aug. 1988, from Nov. 1994 to Dec. 1995, and from Oct. 1998 to May 1999. However, in the work of Bekaert, Harvey, and Ng (2005), only the period between Nov. 1994 and Dec. 1995 is captured, which is according to the artificial date of the Tequila Effect of Mexican.

On the other hand, many studies show that correlations between assets market returns usually increase during crisis periods. However, correlations usually exhibit higher levels during periods of high volatility, which are often accompanied by business cycle troughs. To reflect the structure change of the financial system, we employ the integration estimated by models described in Section 4.1 to replace correlations of assets returns. We directly use the change in integration as a measurement instrument to distinguish between tranquil and crisis periods. We let K

represent the increased level of integration, and K is expressed as:

$$K_{i,t} = \ln(\gamma_{iw,t}) - \ln(\gamma_{iw,t-1}) \qquad (5.26)$$

where $\gamma_{i,t}$ represents the integration level estimated by models described in Section 5.3.1.

Thus, two variables are selected to be expected to identify crisis periods: the conditional variance of assets returns and the increased integration level. To test abilities of these two variables for identifying crisis periods, we introduce some dummy variables to examine statistics of assets returns when the conditional variance exhibits a relatively high value, or the integration level increases respectively.

Firstly, the conditional variance of asset returns.

Let $r_{i,t}$ represents the excess return on the national equity (bond) index of country i in US dollars.

$r_{i,t}^{h} = r_{i,t} * D_{i,t}$ set $D_{i,t} = 1$ if $h_{i,t} > \overline{H}$, otherwise, we set $D_{i,t} = 0$.

$r_{i,t}^{l} = r_{i,t} * D_{i,t}$ set $D_{i,t} = 1$ if $h_{i,t} < \overline{H}$, otherwise, we set $D_{i,t} = 0$

where $h_{i,t}$ is the conditional variance of asset market index of country i, and is estimated by model (24) and (25). $\overline{H}$ is the average value of this conditional variance $h_{i,t}$. Thus, $r_{i,t}^{h}$ represe nts the excess return when the conditional variance exhibits relatively high value, and $r_{i,t}^{l}$ represents the excess return when the conditional variance shows relatively low value.

Secondly, the increased level of integration.

$r_{i,t}^{in} = r_{i,t} * D_{i,t}$ set $D_{i,t} = 1$ if $K_{i,t} > 0$, otherwise, we set $D_{i,t} = 0$.

$r_{i,t}^{de} = r_{i,t} * D_{i,t}$ set $D_{i,t} = 1$ if $K_{i,t} < 0$, otherwise, we set $D_{i,t} = 0$.

where $r_{i,t}$ represents the excess return on the national equity (bond) index of country

i in US dollars. $K_{i,t}$ represents the increase rate of the integration level of country i

with the world (regional) market, and is estimated by model (5.26). Thus,

$r_{i,t}^{in}$ represents the excess return when the integration level increases, and

$r_{i,t}^{de}$ represents the excess return when the integration level decreases.

Compared with the tranquil period, assets returns during the crisis are negative or

much lower, at the same time, which is accompanied by much higher risk.

Covariance of the local market with the world (regional) market is also higher during

crisis. Our hypothesis is that statistics of assets returns should be consistent with

these characteristics when the conditional variance is higher or the integration level

increases; at the same time, the higher conditional variance should coincide with the

increase in integration.

Some summary statistics of excess returns in different conditions are presented in

Table 5.4 and Table 5.5. High and Low in Table 5.4 represent the condition when the

conditional variance of asset returns exhibit higher or lower levels respectively. IN

and DE represent the condition when the increased level of integration is above 0 or

below 0 respectively. For more clear, IN represents the condition when the

integration level increases; and DE represents the condition when the integration

level decreases. In Table 5.4.1, statistics of stock returns of some countries (Japan,

Australia, Hong Kong, Brazil and Mexico) exhibit features of crisis periods when the

conditional variance is relatively high, for instance, the average return of higher

conditional variance (thereafter represented by H) is much lower than those of lower

conditional variance (thereafter represented by L). Furthermore, the mean of change

in integration levels are positive or relatively higher when (H), which means that

higher conditional variance coincide with the increase in integration levels. A similar

condition can be found in the US, and the UK bond markets, which are presented in

Table 5.4.2. For the US, the UK, Japan and Australia bond markets, means of changes in integration levels are positive or relatively higher when (H). For most cases of bond and stock markets, the standard deviations are relatively high when (H). All of this evidence shows that the conditional variance could be considered as a good instrumental variable for identifying the crisis period.

Table 5.5 shows statistics of excess returns according to the increased integration levels. When the integration levels increase (thereafter represented by IN), we find, for most stock markets with the exception of the Japan and Germany markets, that average returns are lower, the standard deviations appear much higher value, and the covariance with the world or regional stock markets are dramatically high. In the theory of finance, higher assets returns should be accompanied by higher risk, which is proxied by the standard deviations or conditional variance. However, this feature is just converse in our cases, but this converse feature is reasonable during the crisis periods. When examining bond markets, we find, for most cases with the exception of Germany, that the feature of crisis identified by integration levels is more outstanding. The average return when (IN) is less than one half of that when (DE). On the contrary, the standard deviation when (IN) is more than twice that when (DE). This evidence shows that the increase level of integration is an excellent instrumental variable for identifying the crisis period.

5.3.3 Models of contagion

Bekaert, Harvey, and Ng (2005) examine contagion through investigating correlations of the model's idiosyncratic shocks or unanticipated returns. Their models are as follows:

$$e_{i,t} = w_i + v_{i,t} e_{g,t} + u_{i,t} \tag{5.27}$$

$$v_{i,t} = v_0 + v_1 D_{i,t} \tag{5.28}$$

where $e_{i,t}$ and $e_{g,t}$ are the estimated idiosyncratic shocks of market i and region g,

respectively. $v_{i,t}$ represents the additional correlation of $e_{i,t}$ and $e_{g,t}$, which is considered as the contagion of the local market i with the region g. They examine this correlation over the full example; in addition, they pay attention to the correlations during some particular crisis periods, which is determined by the dummy variable $D_{i,t}$.

Given the drawbacks of identifying the crisis period according to the artificial crisis date mentioned above, we introduce two variables described in Section 5.3.2 into these models in two ways.

Firstly, given that the high volatility of assets returns coincides with the increase of integration during the crisis period, we introduce a joint dummy variable according to the magnitude of the conditional variance of assets returns, and the increased integration level. Thus, model (5.28) is changed as follows:

$$v_{i,t} = v_0 + v_1 D_{i,t}^{joint}$$
(5.29)

where $D_{i,t}^{joint}$ is the joint dummy variable according to the magnitude of the conditional variance and the increased integration level. This joint dummy variable is set as follows:

Set $D_{i,t}^{joint} = 2$ if $h_{i,t} > \overline{H} + SD^h$ and $K_{i,t} > \overline{K}$,

or if $K_{i,t} > \overline{K} + SD^K$ and $h_{i,t} > \overline{H}$,

Set $D_{i,t}^{joint} = 1$ if $\overline{H} < h_{i,t} < \overline{H} + SD^h$ and $\overline{K} < K_{i,t} < \overline{K} + SD^K$,

Otherwise, set $D_{i,t}^{joint} = 0$.

And the aim that we set the dummy variable to equal 2 is to part the significantly increased integration from other no-significant increased integration. Similarly, part the effect of the highest volatility from the relatively high volatility.

The second serious problem is that the 'crisis' period identified by these two

variables usually contain very few or relatively few observations, which may largely affect the power of our test. To avoid this problem, we express the coefficient of contagion as the function of these two instrumental variables directly and therefore model (5.28) is changed as follows:

$$v_{i,t} = v_0 + v_1 H_{i,t} + v_2 K_{i,t} \tag{5.30}$$

where $v_{i,t}$ is the contagion coefficient, v_0 is a constant, $H_{i,t}$ represents the conditional variance of asset returns, and $K_{i,t}$ represents the increase rate of integration levels.

Furthermore, to avoid the problem caused by heteroskedastic, we limit the second conditional moment to the TGARCH(1,1) model. Thus, our models for testing contagion are expressed as follows:

$$\hat{e}_{i,t} = w_t + v_{i,t}\hat{e}_{g,t} + u_{i,t} \tag{5.31}$$

$$v_{i,t} = v_0 + v_1 D_{i,t}^{join int} \tag{5.32}$$

$$/ \quad v_{i,t} = v_0 + v_1 H_{i,t} + v_2 K_{i,t} \tag{5.33}$$

$$h_{i,t} = \operatorname{var}(u_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}u_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2 \tag{5.34}$$

For the stock market, two cases are considered: $\hat{e}_{g,t} = e_{w,t}$, $\hat{e}_{g,t} = e_{x,t}$, $e_{w,t}$ is the residual of the world stock market, $e_{x,t}$ is the residual of the regional stock market. $\hat{e}_{i,t}$ is the estimated idiosyncratic return shocks of stock market i.

For the bond market, $\hat{e}_{g,t}$ represents the residual of the world bond market, $\hat{e}_{i,t}$ is the estimated idiosyncratic shock of bond market i.

For the inter-bond-stock market, $\hat{e}_{g,t}$ represents the estimated idiosyncratic shock of

the national bond market, which is estimated by model (5.1) – (5.6). $\hat{e}_{i,t}$ represents the estimated idiosyncratic shock of the corresponding national stock market, which is estimated by model (5.19) – (5.23).

5.4 Results

Our approach decomposes co-movements of assets returns into two parts: the part explained by models provides evidence about integration proxied by the dependence of local shocks on the world or regional shocks. The second component is the part that our models fail to explain, which, as the unexpected shocks, generated from the regression are used to examine the contagious links between assets markets.

5.4.1 Dynamic factor loadings gamma (time-varying integration)

The dynamic factor loadings is the crucial stage when examining contagion, because as with the unanticipated shocks, residuals of our models will change as the volatility of the factors changes, which is determined by the factor sensitivities. As described in Section 4.1, our GARCH-filter model combining the framework of Kalman filter and the TGARCH(1,1) model is expected to be a more efficient estimation approach for capturing the time variation of factor sensitivities.

Model (5.1) - (5.4) for the bond market, Model (5.7) – (5.10) for the inter-bond-stock market, and Model (5.19) - (5.23) for the stock market allow the integration to be time-varying. Firstly, we calculate the average level of integration over our sample according to the following equation:

$$\bar{\gamma}_i = \frac{1}{N} \sum_{t=1}^{N} \gamma_{i,t}$$

where $\gamma_{i,t}$ represents the factor loadings (the integration level) of market i with the world (regional) market at time t as described in our models. Average levels are

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presented in Table 5.6. Table 5.6.1 is for the stock market: the Brazil stock market exhibits the highest integration levels with the world and regional markets, 2.116 and 1.506 respectively. The US market shows the lowest level with the world in our sample, 0.883. In addition, we are interested in comparing the relative importance of the world and regional market, more specifically, whether the difference created by $\gamma_{w,t} - \gamma_{re,t}$ is statistically different from zero. The following t-statistics are used:

$$T = \frac{\frac{1}{N}\sum_{t=1}^{N}(\gamma_{w,t} - \gamma_{re,t})}{S_t / \sqrt{N}}$$

where $S_t = \sqrt{\dfrac{\sum_{t=1}^{N}(\gamma_{D,t}^{w,rel} - A\gamma_{D,t}^{w,re})^2}{(N-1)}}$,

where $\gamma_{D,t}^{w,re} = \gamma_{w,t} - \gamma_{re,t}$, $A\gamma_{D,t}^{w,re} = (\sum_{t=1}^{N}\gamma_{D,t}^{w,re})/N$,

N = sample size.

The null hypothesis is $H_0 : \gamma_{w,t} = \gamma_{re,t}$, and the alternative hypothesis is $H_1 : \gamma_{w,t} \neq \gamma_{rel,t}$. Thus, the null hypothesis $H_0 : \gamma_{w,t} = \gamma_{re,t}$ can be rejected with the 5% significance level if $|T| > 2.086$. Otherwise, we do not reject the null hypothesis, or the discrepancy between $\gamma_{w,t}$ and $\gamma_{re,t}$ is not significant.

The column of 'T value' Table 5.6.1 implies that the discrepancies of the relative importance between the world and regional markets are statistically significant for all cases in our sample. For most markets, the world market is the dominant factor comparing the regional market, especially for the Brazil (2.116 (world) vs. 1.506 (region)), Hong Kong (1.184 vs. 0.679), Australia (1.004 vs. 0.562), and Mexico (1.000 vs. 0.728). In the Japan and Canada markets, the world factor is relatively strong compared to the regional: Japan (1.095 vs. 1.042) and Canada (0.894 vs. 0.863). However, markets in the European area exhibit the contrary situation: the European market is relative stronger than the world: the UK (1.030 vs. 1.051) and

Germany (0.917 vs. 0.966). Our results for Europe are consistent with the work of Fratzscher (2002), who finds that the European market is the dominant factor in Europe.

Table 5.6.2 shows the bond market, integration levels with the world bond market in our sample range from 0.417 in the Australia market to 1.579 in Germany. Germany is followed by 1.491 in Japan, 1.393 in the UK, 0.697 in Canada, and 0.477 in the US.

Different from the former cases, the integration of the inter-bond-stock market is not statistically significant for most cases in our sample, the integration levels and the corresponding p values are presented in Table 5.6.3. Only the Japan and Australia markets display significant results: 0.451 and 0.833 respectively. The US market exhibits negative level, -0.154 with p value 0.536.

Next, we focus on the volatility of the integration level. Figure 5.2 describes the evolution of integration levels (gamma) for different assets markets, and it shows that those gammas vary dramatically indeed, with many peaks and troughs within our sample. Figure 5.2.1 is for the stock market, the regional gamma is relatively stable compared with the world gamma for most cases, especially for the US and Japan markets, the regional gamma vary within a range from 0.954 to 1.070, and from 0.971 to 1.294 respectively. The world gamma usually exhibit jumping increase in the Asian markets (Japan, Australia, and Hong Kong), for instance, some of the most dramatic jumps occur from Sep. to Oct. 1987, during which the world gamma in the Australia market jumps from 0.982 to 1.852, and jumps from 0.666 to 1.529 in the Hong Kong market. The evolution of gamma is relatively smooth for most cases in the bond market, which is described in Figure 5.2.2. The world gammas of the US and Canada bond markets exhibit smaller variation within our sample, and they change around 0.5 and 0.7 with small fluctuation respectively. The increased trend of gamma is only found in the Australia market. However, regardless of the trend in the

whole period, gammas in different markets usually appear to be increasing, even jumping state in several periods. Compared to the bond and stock markets, the gamma of the inter-bond-stock market is more unstable, and many peaks and troughs occur alternatively, which is described in Figure 5.2.3. Some outstanding findings are: the US and UK gammas arrive at the correspondingly lowest point synchronously within the sample in Dec. 2002, -1.474 and -0.948 respectively, and then followed by a dramatically synchronous increase. The inter-bond-stock gammas in the Japan and Australia markets start rapid growth in Jul. 1998, and synchronously arrive at the correspondingly highest point, 0.635 (Oct. 2000), and 1.072 (Jun. 2000), respectively. These shifts coincide with the crisis periods such as the Russian Cold (Aug. 1998) and the Nasdaq Rash (Apr. 2000). Overall, the phenomenon that increased gamma, especially jumping gamma during specific periods may suggest possible contagion effects.

5.4.2 The increased level of integration and conditional variance

Most studies find that periods of financial crisis usually coincide with high volatility of assets prices, and correlations between international markets returns also increase during this period. Figure 5.3 and 5.4 describe the evolution of the conditional variance and increase level of integration respectively. In Figure 5.3, h represents the conditional variance, AV h represents the average level of the conditional variance over the sample, and SD represents the sum of the standard deviations and the average conditional variance. In Figure 5.4, inin represents the increase level of integration, and SD represents the standard deviations of the integration increase level. From these figures, we find that the higher conditional variance usually coincides with the higher integration increase level, which is consistent with the state during the crisis period. Here, we describe some outstanding results:

In the US stock market, the conditional variance (represented by h) jumps from 0.0017 to the highest point 0.0097 within our sample during Oct. and Nov. 1987. An

interesting find is that, during this period, the integration increased level (represented by inin) also arrives at a very high level, 0.051 (the standard deviation of increased level over our sample is just 0.018), and both of these shifts about the conditional variance and integration increased level coincide with the 1987 US stock market crash.

In the Japan stock market, Apr. 1990 is a very specific period, during which h of the stock return arrives the highest level, 0.0140, over our sample, at the same time, inin with the world market also reached the highest point, 0.290 (the integration level jumps from 1.259 to 1.683 during Mar. and Apr. 1990).

In the Australia stock market, some jumping changes occur from Oct. to Dec. 1987. h dramatically falls to the lowest point, 0.0008 in Nov from 0.0078 in Oct., and then goes back to a relatively normal level, 0.0042 in Dec. inin of Australia stock market follows the similar evolution, and has a highest value, 0.635 in Oct., and markedly goes down to -0.031 in Nov. and then recovers a normal level, 0.0003. These shifts coincide with the 1987 US stock market crash. On the other hand, these shifts state, even during the crisis period, that temporary smooth of markets may exist, because h and inin do not sustain a high level all the time, instead by a dramatic fluctuation, although they reach a very high, even the highest level during this period.

During the period of the same crisis, the 1987 US stock market crash, h of the Hong Kong stock market arrives at the highest level, 0.0333 in Oct. 1987, during the same period, inin also reaches to the highest level, 0.831 (the integration level jumps from 0.666 in Sep. to 1.529 in Oct.).

In the Japan bond market, h reaches the dramatically highest level, 0.0217, in Apr. 1995, (the sum of average h and standard deviation is only 0.0035). An interesting find is that during this period, inin also arrives at its highest point, 0.598 (the standard deviation is only 0.067), in Mar. 1995, which means that the integration

level jumps from 0.999 in Feb. to 1.816 in Mar. 1995. These shifts coincide with the Mexico crisis, which start from the end of 1994.

In the Mexico stock market, h varies with the range of 0.0084 and 0.0378 from Nov. 1994 to Nov. 1995 (the sum of average h and standard deviation is 0.0136), during the same period, inin also exhibits several peaks, such as 0.085 in Dec. 1994, and 0.011 in Jul. 1995. The period from Nov. 1994 to Nov. 1995 is just the time of the Mexico crisis.

One point that should be noticed here is that we only report some outstanding results, which is used to describe the ability of h and inin to identify the crisis periods. These crisis periods in our study include the artificial period determined by the historical crisis date, as well as the crisis period determined by data itself (h and inin).

5.4.3 Contagion

Through model (5.31), (5.32) and (5.34) for the stock market, model (5.35), (5.36) and (5.38) for the bond market, and model (5.39), (5.40) and (5.42) for the inter-bond-stock market, we examine the overall contagion for the whole sample. In addition, we are interested in investigating contagion during several particular crisis periods, which are determined by our joint dummy variable.

Table 5.7.1 presents contagion results of the stock market based on our joint dummy variable. The v_1 coefficient measures the additional correlation in several particular periods. We find for most cases including the world and regional contagion that v_1 is highly significant, and the regional v_1 s of Australia and Mexico are significant at the 10% and 5% level respectively. All of these coefficients are positive, and suggest that the idiosyncratic residuals are better correlated during the particular periods. The additional correlations with the world market are significantly higher for the

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developing or less-developed markets: Hong Kong (0.543), Brazil (0.497), Australia (0.446), and Mexico (0.389), compared with Canada (0.148), UK (0.110), and Germany (0.110). The US exhibits lowest value in our sample, 0.019. The similar discrepancies also appear in the regional contagion: the v_1 coefficients are much higher for the developing markets – Hong Kong (0.353), Mexico (0.229), and Brazil (0.150), compared with developed markets (Canada (0.089), Germany (0.081), Australia (0.078), Japan (0.034), the US (0.014)). These findings are consistent with modern financial research: during the crisis period, developing markets are more sensitive to the world or regional risk, and exhibit more significant contagion phenomena. The coefficient $v_0 = v_1 = 0$ is a joint test for contagion within the overall sample, which is conducted by the Likelihood Ratio test. We reject the null hypothesis of no contagion for most markets with high significance, with the exception of Canada with the North America region, and Australia with the Pacific region. Looking into more detail, one can see that this is mainly due to the high significance of v_1.

Table 5.8.1 presents bond markets' contagion. All of v_1 are highly significant and positive, and we find that the additional correlation of bond markets with the world are much higher than those of the corresponding stock market. The estimated value is:

0.784 in Japan, 0.631 in Canada, 0.479 in Germany, 0.411 in Australia, 0.408 in the UK, and 0.270 in the US. Coefficients v_0 and v_1 are joi ntly significant for all cases.

Table 5.9.1 presents results about the inter-bond-stock market. Results show, for most cases with the exception of Japan and Germany, that overall contagion exists in the inter-bond-stock market (coefficients v_0 and v_1 ar e jointly significant). During the particular period, coefficients of joint dummy variables are significant in the Canada and Germany markets, 0.662 and 0.277 respectively.

One problem of our approach of introducing a joint dummy variable is that the identified 'crisis' period usually contain very few or relative few observations, which may greatly affect our results. Therefore, we express the contagion coefficient as the function of these two variables (the conditional variance and the increase rate of integration) directly. Furthermore, this approach allows us to obtain the time-varying contagion level, and this is the first study that investigates the time variation of contagion. Results are estimated by model (5.31), (5.33) and (5.34) for the stock market, model (5.35), (5.37) and (5.38) for the bond market, and model (5.39), (5.41) and (5.42) for the inter-bond-stock market.

Table 5.7.2, 5.8.2, and 5.9.2 presents results of the stock, bond, and inter-bond-stock markets respectively. Features of these results are reported as follows:

1. Coefficients of the increased integration level, v_2, are highly significant and positive for most cases, with the exception of the inter-bond-stock market in the US, Japan and Australia (presented in Table 5.9.2).

2. Coefficients of the conditional variance, v_1, are significant for some cases. However, these significant coefficients vary largely from market to market, including negative and positive values. These results are reasonable because discrepancies among conditional variances of different markets are remarkable.

3. The coefficient $v_0 = v_1 = v_2 = 0$ is a joint test for contagion within the overall sample, which is conducted by the Likelihood Ratio test. We reject the null hypothesis of no contagion for most markets with high significance, with the exception of the Mexico stock market with the world, and the Japan inter-bond-stock market. Looking more into detail, this is mainly due to the high significance of v_2.

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Figures 5.5, 5.6, and 5.7 describe the evolution of contagion for stock, bond, and inter-bond-stock markets respectively, and Table 5.10 presents the average contagion level over our sample and some relevant discrepancies. Some common characteristics of results are:

1. For all cases, contagion levels vary dramatically all the time over the sample, which is due to the notable volatility of the integration increase level and conditional variance, [see Figures 5.5, 5.6, 5.7]. In the stock market, we find, for most cases, that the contagion levels with the world market are much more volatile than those with the regional market [see Figure 5.5].

2. For most cases, contagion levels vary around zero value, which means that negative and positive contagion levels usually alternate over the sample [see Figures 5.5, 5.6, 5.7].

3. Table 5.10 presents the average contagion level over our sample, furthermore we are interested in whether the time-varying contagion is significantly different from zero over the sample. Thus, a t-statistics similar to that in Section 5.4.1 is used:

$$T = \frac{\frac{1}{N} \sum_{t=1}^{N} (v_{i,t} - o_t)}{S_t / \sqrt{N}}$$

where $S_t = \sqrt{\frac{\sum_{t=1}^{N} (v_{D,t} - Av_{D,t})^2}{(N-1)}}$,

where $v_{D,t} = v_{i,t} - o_t$, $Av_{D,t} = (\sum_{t=1}^{N} v_{D,t})/N$,

N = sample size. $v_{i,t}$ represents the contagion level with the world market, o_t represents a time series consisting of zero.

The null hypothesis is $H_0 : v_{D,t} = o_t$, and the alternative hypothesis is $H_1 : v_{D,t} \neq o_t$.

We find, for most markets, the time-varying contagion is significantly different from

zero in the entire sample. In the stock market (Table 5.10.1), the significant average contagion level with the world is: Mexico (0.022), Australia (0.019), Canada (0.018), Germany (0.010), the UK (-0.044), Brazil (-0.093), and Hong Kong (-0.10). contagion levels of the US and Germany markets are not significant from zero.

In the bond market (Table 5.10.2), the highest value of average contagion level appears in the Australia market, 0.149, followed by the US (-0.036), Germany (-0.046), and the UK (-0.062). The negative value of additional correlations implies that the direction of additional movement in the stock market with the corresponding national bond market is opposite after controlling for the fundamental. The Japan and Canada markets have non-significant values.

In the inter-bond-stock market (Table 5.10.3), all markets appear to have significant value: Canada (0.576), Australia (0.465), Germany (0.139), Japan (0.044), UK (0.035), only the US market appears to have negative value, -0.030.

4. For the stock market, Table 5.10.1 also presents discrepancies in contagion levels with the world and regional markets. The t-statistics is very similar with the former, the only difference is that $v_{i,t}$ is replaced by $v_{w,t}$ which represents the contagion level with the world market, and o_t is replaced by $v_{re,t}$,which represents the contagion level with the regional market. Table 5.10.1 shows, for most significant cases, that the regional market is the dominant factor compared with the world market: the discrepancy of Australia is -0.828 (0.0193 (world contagion) – 0.848 (regional contagion)), Brazil (-0.117), Hong Kong (-0.081), Japan (-0.017), the UK (-0.009). Among significant cases, only the Canada market appears to have positive value, 0.014, which shows that the world market is the dominant factor.

5.5 Conclusion

This is the first study to investigate the time-varying contagion across international assets markets. Our model of testing contagion is dynamic in two ways: first, through our GARCH-filter model, we obtain time-varying factor loadings gamma in our model, which is crucial because the volatility of factor loadings will directly determine the residual value in the model. As the unexpected shocks, this estimated residual will be extracted to test the additional correlation with the world (regional) market. Second, instead of using the artificial historical date, we construct two variables (the conditional variance and integration increase level) to identify the crisis period, furthermore, we introduce these two variables into our model, and express the coefficient of contagion as a function of them, by which we obtain the time-varying coefficients for contagion. Thus, our central hypothesis is that the 'crisis period' may exist at any potential time over the sample, other than several periods determined by the artificial historical date, such as the 1994 Mexico crisis, or the 1997 Asia crisis.

Our central results are as follows:

1. The increased level of integration and conditional variance of assets returns are excellent variables for identifying the crisis period (described in Section 5.4.2 and 5.4.3).

2. When a joint dummy variable constructed by these two variables is introduced into our model, the coefficient of contagion becomes significant for most cases, which is largely due to the high significance of the coefficient of this joint dummy variable.

3. When introducing these two variables into our model, we find that the coefficient of the integration increase level is significant and positive for most cases. The coefficient of the conditional variance is significant for several cases, but

coefficient values vary largely from market to market, which is mainly due to the remarkable discrepancies among the conditional variance of these markets. The joint coefficient of contagion is significant for most cases, which is mainly contributed by the high significance of the coefficient of the integration increase level.

4. For all cases, contagion levels vary dramatically all the time over the sample, which is due to the notable volatility of the integration increase level and conditional variance. Furthermore, the contagion levels of different asset markets with the world or regional market are significantly different from zero for most cases.

5. For most cases, with the exception of the US, contagion levels of the inter-bond-stock market are persistently above the zero value for most periods. The contagion level of the Australia stock market with the regional market exhibits persistently positive values over the whole period.

Chapter 6

Conclusion

The degree of financial integration has increased dramatically during the last two decades. Given that financial integration and contagion play an important role in the area of macroeconomics and international finance, including research and practice, more and more attention has been paid to integration and contagion.

6.1 Outline of the thesis

A. For research into integration, most previous studies only focus on the national market level. Although assets within one national market share a similar economic and financial environment, systematic discrepancies in characteristics of different assets may exist. For instance, the size effect of Banz (1981), BE/ME effect of Rosenberg, et al. (1985), and the long-term bond is more sensitive to changes in inflation and interest rates (Campbell and Ammer, 1993). This study focuses on integration at the portfolio level (constructed according to the market value, BE/ME, and the bond maturity). If these different characteristics of assets do result in systematic discrepancies in integration with the world market, this study will provide more investment opportunities to international investors for diversifying their international portfolios.

B. For research into contagion, all previous studies only investigate whether the contagion phenomena exist or not during a specific crisis period, and most

studies define the crisis period according to the historical crisis date. This study attempts to investigate whether there exists any financial variables that are competent for identifying the crisis period, and whether the contagion coefficient can be expressed as a function of these variables. If so, we will obtain the time-varying contagion level, and provide a consistent platform for measuring contagion.

Thus, this thesis focuses on the following three key research questions throughout three chapters:

A. Is the growth (large) portfolio more integrated with the world than the value (small) portfolio and is this phenomenon persistent or significant?

B. Is the long-term bond portfolio more integrated with the world market than others?

C. Is any financial variable competent for identifying the crisis period of testing contagion, and is the financial contagion level constant?

To answer these questions, we model the time variation of integration within the Kalman filter framework extended to allow for GARCH effects in the innovations. The sample of this study focuses on seven stock markets (the US, the UK, Japan, Hong Kong, Singapore, Brazil, and Mexico), and six bond markets (the US, the UK, Japan, Australia, Canada, and Germany).

6.2 Main findings of the thesis

The main results are summarized as follows:

1. We adopt the likelihood ratio (LR) tests to examine the efficiency of our GARCH-filter model (combining the Kalman filter and GARCH effects) and the traditional Kalman filter system. In these groups of tests, our GARCH-filter model is considered as the relatively more complex model since three additional variables (three variables of variance equation of the TGARCH(1,1) model) are added into the GARCH-filter model compared to the simpler model (the traditional Kalman filter system). The LR tests are significant for all cases (30 out of 30) in stock markets, and most cases (23 out of 30) in bond markets. LR tests in several cases are not significant, which may be down to two potential reasons: the GARCH effect of the time series itself is not significant, or parts of parameters in variance equation are not significant. Therefore, we conclude that our GARCH-filter model is more efficient than the traditional Kalman filter system.

2. As we expected, large portfolios are indeed more integrated with the world than small portfolios for all cases, and growth portfolios are more integrated with the world than value portfolios for most cases with the exception of the Brazil and Mexico markets. Furthermore, these discrepancies in integration are significant and persistent over time. Regarding the Brazil and Mexico markets, results from the TGARCH(1,1) are consistent with our expectation, growth portfolios are more integrated than value portfolios; however, results estimated by the GARCH-filter are not. When looking into the detail of results of GARCH-filter, we find that the integration level of the growth portfolio is significantly higher than the value portfolio in the Brazil market starting from Jan. 2000, and in the Mexico market starting from Aug. 1998. These states are converse before Jan. 2000 in Brazil, and before Aug. 1998 in Mexico. These problems may be largely caused by the poor initialization of the Kalman filter.

3. When risk factors of SMB and HML are added into our model, we find, as we expected, that the discrepancies of integration levels between small (high) and

big (low) portfolios tend to disappear for most cases. Especially in the Singapore and Mexico markets, the discrepancies between big and small portfolios in the Singapore market, and low and high portfolios in the Mexico market are no longer significant. Although discrepancies remain significant in other cases, these discrepancies between small (high) and big (low) portfolios become much smaller compared to results estimated by our original model. These results imply that the factors related to size and BE/ME ratios (SMB and HML) are able to largely capture the average returns on portfolios formed on size and BE/ME within our sample.

4. Integration levels of long-term bond portfolios are always more integrated with the world bond market than short-term bonds. These discrepancies are significant between any two adjacent maturities for all cases.

5. This study examines potential macro-economic variables that may drive the time variation in integration of bond markets, and finds that real convergence (proxied by the correlation of output growth), monetary convergence (proxied by the correlation of inflation rate), trade openness and exchange rate volatility significantly explain the changes in the levels of integration for most cases in our sample.

6. This study examines the evolution of the conditional variance of assets returns and increased level of integration with the world market respectively, and finds that these two variables are excellent for identifying the crisis period.

7. When a joint dummy variable constructed by these two variables is introduced into our model, the coefficient of contagion becomes significant for most cases. When introducing these two variables into our model directly, we find that the coefficient of the integration increase level is significant and positive for most cases. The coefficient of the conditional variance is significant for several cases,

but coefficient values vary largely from market to market, which is mainly due to the remarkable discrepancies among the conditional variance of these markets. The joint coefficient of contagion is significant for most cases, which is mainly contributed by the high significance of the coefficient of the integration increase level. For all cases, contagion levels vary dramatically all the time over the sample, which is due to the notable volatility of the integration increase level and conditional variance. Furthermore, the contagion levels of different asset markets with the world or regional market are significantly different from zero for most cases.

8. Fo r most cases, with the exception of the US, contagion levels of the inter-bond-stock market are persistently above the zero value for most periods. The contagion level of the Australia stock market with the regional market exhibits persistently positive values over the whole period.

6.3 The possible policy and business implications

For the international investment, portfolio diversification is usually achieved by two basic strategies: investing in different kinds of assets or similar assets in multiple markets. This study classifies the similar assets into several parts according to stocks' market value and BE/ME ratios, and the bond maturities respectively. And we find the differences in characteristics are conductive to the discrepancies in integration between these relevant portfolios, which implies that our results will provide more investment opportunities for international investors and portfolio managers. For instance, for diversifying their portfolios, investors will prefer small stocks, value stocks, and short-term bonds according to our findings. Secondly, this study finds that some macro-economic variables have significantly explanatory power to the time variation in integration of bond markets, and these variables are real convergence, monetary convergence, trade openness and exchange rate volatility.

Thus, our results provide some evidence to the local authorities to promote the co-movement of the local financial market with the world through these macro-economic variables. Thirdly, this is the first study to provide the concept of 'time-varying financial contagion' and estimate the magnitude or intensity of the contagion. According to our results, the policy maker knows that the financial contagion not only exist in a specific crisis period, but it may also occur at any possible time. Thus, the policy maker may implement effective policy to avoid international financial risk.

6.4 Areas for further research

This thesis measures and compares the integration level of assets with different characteristics. However, the characteristics of assets are not limited to the size effect, BE/ME effect, and bond maturities. Further research is expected to seek other characteristics of assets, by which more portfolios would be formed, then examine and compare whether these characteristics of assets are conductive to the systematic discrepancies in integration. If so, more investment opportunities will be provided to international investors and portfolio managers.

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Table 3.1: Summary Statistics for Monthly Equity Market Returns

Market index and Portfolios	Obs.	Mean	Std. Dev.	Skewness	Kurtosis (Exc)	JB test	First-order correlation
US SP 500	384	0.160	4.496	-0.665	2.786	152.501•••	-0.001
UK market	384	0.262	6.289	0.447	6.599	709.536•••	0.085•
UK small	384	0.642	5.836	-0.396	1.350	39.208•••	0.264•••
UK big	384	0.131	6.674	0.359	6.045	592.870•••	0.087•
UK low	384	-0.012	6.817	0.243	5.312	455.282•••	0.096•
UK high	384	0.706	6.561	0.311	6.588	700.681•••	0.1••
Japan market	252	0.072	6.796	0.066	0.225	0.710	0.108•
Japan small	252	0.370	8.357	-0.004	0.368	1.421	0.131••
Japan big	252	-0.065	6.661	-0.008	0.748	5.878•	0.055
Japan low	252	-0.421	7.809	-0.008	0.674	4.767•	0.068
Japan high	252	0.527	7.406	-0.019	0.479	2.425	0.112•
HK market	252	0.519	8.256	-1.486	9.968	1136.027•••	-0.005
HK small	252	-0.141	10.309	-1.432	9.961	1127.985•••	0.267•••
HK big	252	-0.428	9.517	-1.802	10.752	1350.141•••	0.079
HK low	252	-1.333	9.031	-1.821	10.440	1283.689•••	0.112•
HK high	252	0.654	10.393	-1.993	12.528	1814.697•••	0.134••
Singapore market	252	0.314	7.465	-1.748	11.186	1442.058•••	0.011
Singapore small	252	-0.312	10.289	1.130	4.203	239.116•••	0.197•••
Singapore big	252	-0.106	8.758	-0.964	7.817	680.714•••	0.101
Singapore low	252	-0.621	10.223	-1.012	7.243	593.904•••	0.09
Singapore high	252	0.407	9.905	0.213	7.336	566.969•••	0.113•
Brazil market	156	0.840	13.568	-0.734	1.787	34.760•••	0.019
Brazil small	156	-0.483	9.195	-1.299	9.322	608.698•••	0.149•
Brazil big	156	-0.855	11.749	-1.248	4.031	146.071•••	0.052
Brazil low	156	-1.963	11.162	-1.871	7.648	471.202•••	0.087
Brazil high	156	0.936	11.342	-0.138	4.153	112.614•••	0.241•••
Mexico market	192	0.729	10.235	-1.395	4.344	213.195•••	0.095
Mexico small	192	-0.202	6.257	-1.112	10.784	969.902•••	0.268•••
Mexico big	192	0.233	9.076	-1.195	4.636	217.622•••	0.128•
Mexico low	192	0.409	8.424	-0.707	6.200	323.556•••	0.099
Mexico high	192	-0.043	9.679	-0.938	4.739	207.787•••	0.222•••

Table 3.2: Correlations of Different Portfolios with the S&P 500 Index

Market index and portfolios	UK	Japan	Hong Kong	Singapore	Brazil	Mexico
market index	0.564	0.311	0.575	0.576	0.563	0.508
small portfolio	0.448	0.181	0.347	0.384	0.232	0.196
big portfolio	0.559	0.275	0.484	0.566	0.383	0.486
low portfolio	0.542	0.259	0.467	0.552	0.286	0.418
high portfolio	0.526	0.189	0.416	0.516	0.260	0.307

Table 3.3: Predicting Local Excess Returns Using Local and World Instruments

	Local instruments only		World instruments only		World and local instruments		Increase of R square (%)
	R square	LR statistics	R square	LR statistics	R square	LR statistics	
US	2.846	10.682*					
UK	1.656	3.618	2.937	8.639	3.875	12.355	133.925
big	2.597	6.930	3.235	9.446	4.209	13.324	62.106
small	8.482	30.146***	9.564	34.701***	12.623	47.879***	48.816
low	5.756	19.243***	5.265	17.252***	7.567	26.675***	31.465
high	3.409	10.561	5.236	17.875***	5.635	19.491*	65.307
Japan	1.297	-0.252	5.103	13.200**	5.923	11.796	356.603
big	1.780	0.942	4.825	12.462*	6.111	12.262	243.392
small	3.148	5.237	5.196	13.445**	6.469	13.994	105.499
low	1.883	1.537	4.091	10.526	5.127	9.975	172.231
high	2.125	2.884	5.413	14.023**	5.972	12.949	181.009
HK	1.023	-0.091	2.107	5.366	2.840	4.561	177.681
big	2.203	3.052	5.825	15.123**	6.178	13.467	180.403
small	7.555	17.009***	3.534	9.066	9.686	22.861**	28.203
low	1.905	2.107	5.045	13.045**	5.979	12.752	213.804
high	2.715	4.841	4.263	10.977*	5.749	12.795	111.777
Singapore	1.100	-0.413	2.733	6.983	3.270	5.154	197.209
big	2.299	2.855	3.331	8.538	6.190	13.056	169.225
small	7.377	16.617**	2.059	5.243	10.539	25.334***	42.859
low	2.581	3.863	3.485	8.938	6.656	14.587	157.877
high	2.324	3.486	3.032	7.759	5.822	12.638	150.478
Brazil	3.911	5.027	4.204	5.223	9.909	13.147	153.356
big	3.011	3.852	6.240	8.118	10.630	14.160	253.002
small	9.269	12.256**	9.294	12.291*	18.515	25.798***	99.739
low	2.915	3.728	8.306	10.925*	8.132	10.649	178.929
high	5.596	7.256	5.833	7.572	13.111	17.708	134.282
Mexico	2.803	3.582	2.376	3.030	7.154	9.353	155.243
big	2.854	3.649	2.450	3.126	9.462	12.524	231.497
small	5.857	7.605	7.055	9.219	10.219	13.582	74.468
low	2.628	3.355	2.297	2.928	7.939	10.422	202.135
high	1.509	1.916	2.976	3.806	6.656	8.679	341.071

Table 3.4: Integration of Different Portfolios with the World Market [TGARCH(1,1)]

The following models are estimated

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t} \quad \varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t} \quad h_{i,t} = \mathrm{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}\xi_{i,t-1}^2 + \alpha_{i3}h_{i,t}$$

	The integration level with the world market					
	Mean equation		Variance equation [TGARCH(1,1)]			
	Gamma	Std. error	a0	a1	a2	a3
UK market	0.712	-0.037	7.79E-06	0.012	0.047	0.950***
UK big	0.786	-0.044	9.52E-06	0.015	0.028	0.957***
UK small	0.585	-0.042	5.98E-05	0.02	0.094**	0.901***
UK low	0.753	-0.052	6.81E-05*	0.059*	0.085*	0.867***
UK high	0.689	-0.038	1.92E-05	0.028	0.012	0.947***
Japan market	0.455	-0.097	1.84E-04	0.026	0.067	0.891***
Japan big	0.349	-0.072	0.002***	0.088	0.418**	0.268
Japan small	0.306	-0.098	0.002*	0.058	0.302*	0.493**
Japan low	0.389	-0.088	0.001***	0.063	0.480***	0.382**
Japan high	0.288	-0.085	0.001**	0.065	0.313*	0.437**
HK market	0.969	-0.078	5.68E-04**	0.284***	-0.097	0.667***
HK big	0.892	-0.088	0.001***	0.446***	0.019	0.486***
HK small	0.323	-0.076	0.001***	0.861***	-0.593***	0.477***
HK low	0.752	-0.072	0.001***	0.455***	0.094	0.467***
HK high	0.692	-0.099	0.001***	0.475***	-0.241**	0.531***
Singapore market	0.963	-0.063	4.63E-05	0.057	0.04	0.898***
Singapore big	1.012	-0.058	0.0001	0.092	0.066	0.847***
Singapore small	0.699	-0.082	0.0005**	0.365***	-0.018	0.623***
Singapore low	1.183	-0.073	0.0003**	0.143**	-0.002	0.807***
Singapore high	0.936	-0.066	0.0001	0.143**	0.095	0.806***
Brazil market	1.619	-0.157	1.30E-03	0.069	0.218	0.718***
Brazil big	0.783	-0.129	0.001**	0.457**	0.158	0.466***
Brazil small	0.178	-0.104	0.001***	0.183	0.986***	0.449***
Brazil low	0.504	-0.11	0.001***	0.011**	0.203	0.55
Brazil high	0.42	-0.108	0.0005**	0.174*	0.439**	0.612***
Mexico market	1.25	-0.122	0.001	0.186	0.282	0.566***
Mexico big	1.31	-0.087	0.002***	1.043***	-0.612**	0.018
Mexico small	0.233	-0.055	2.74E-04***	1.089***	-1.061***	0.536***
Mexico low	0.761	-0.077	1.21E-05	-0.055***	0.046**	1.007***
Mexico high	0.487	-0.097	2.07E-05	0.262***	-0.166**	0.820***

Table 3.5: Integration of Different Portfolios with the World and Corresponding National Market [TGARCH(1,1)] Models (3.11) – (3,17) are estimated.

	The integration level with the world and national market							
	Mean equation				Variance equation [TGARCH(1,1)]			
	World market		National market					
	Gamma	Std. error	Gamma	Std. error	a0	a1	a2	a3
UK market	0.712	-0.038			7.79E-06	0.012	0.047	0.950***
UK big	0.713	-0.02	1.003	-0.024	6.77E-06**	-0.001	0.011	0.974***
UK small	0.511	-0.032	0.809	-0.032	0.0006**	0.036	0.198	0.16
UK low	0.694	-0.032	0.991	-0.032	1.54E-05**	0.024	0.033	0.933***
UK high	0.618	-0.019	0.873	-0.028	7.21E-06**	-0.028**	0.019	1.003***
Japan market	0.455	-0.097			1.84E-04	0.027	0.068	0.891***
Japan big	0.445	-0.016	0.882	-0.012	0.0001***	0.491***	0.117	0.327***
Japan small	0.317	-0.063	1.001	-0.044	0.0003*	0.051	0.1540*	0.753***
Japan low	0.466	-0.042	1.06	-0.032	0.0001*	0.103**	0.035	0.783***
Japan high	0.308	-0.05	0.927	-0.029	0.0001***	0.083	0.189**	0.748***
HK market	0.969	-0.079			5.68E-04**	0.284***	-0.097	0.667***
HK big	0.965	-0.06	0.749	-0.043	0.0002***	0.222***	-0.106	0.773***
HK small	0.512	-0.072	0.469	-0.045	0.0006***	0.910***	0.545***	0.405***
HK low	0.781	-0.059	0.576	-0.042	0.0002***	0.323***	-0.065	0.660***
HK high	0.83	-0.073	0.682	-0.05	0.0004***	0.509***	0.378***	0.645***
Singapore market	0.963	-0.063			4.63E-05	0.057	0.041	0.898***
Singapore big	0.998	-0.043	0.843	-0.037	0.0003***	0.442***	-0.164	0.547***
Singapore small	0.924	-0.034	0.741	-0.054	0.0009***	0.798***	-0.119	0.280***
Singapore low	1.115	-0.06	0.943	-0.047	0.0005***	0.599***	-0.310**	0.508***
Singapore high	1.039	-0.063	0.825	-0.053	0.0004***	0.432***	-0.123	0.568***
Brazil market	1.619	-0.158			1.30E-03	0.07	0.218	0.718***
Brazil big	0.969	-0.105	0.602	-0.058	0.0004*	0.429**	0.007	0.511***
Brazil small	0.499	-0.108	0.558	-0.031	0.0018**	0.132*	0.204***	0.509**
Brazil low	0.577	-0.076	0.68	-0.027	7.90E-06	0.162***	0.255***	0.945***
Brazil high	0.439	-0.084	0.374	-0.049	0.0003**	0.075	0.629***	0.662***
Mexico market	1.25	-0.123			0.0011	0.186	0.282	0.566***
Mexico big	1.077	-0.051	0.85	-0.029	0.0004***	0.153	0.274*	0.506***
Mexico small	0.266	-0.053	0.257	-0.032	0.0003***	0.440***	0.461***	0.620***
Mexico low	0.738	-0.034	0.617	-0.027	-6.04E-06	0.057***	0.090***	0.993***
Mexico high	0.595	-0.082	0.784	-0.037	1.64E-03**	0.029	0.493*	0.34

Table 3.6: The Average Level of Integration [GARCH-filter]

The following models are estimated:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t},$$

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_x X_{x,t-1} + \delta_w X_{w,t-1}$$

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t}$$

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t},$$

$$h_{i,t} = \mathrm{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}\xi_{i,t-1}^2 + \alpha_{i3}h_{i,t}$$

The Average Level of Integration with the World Market	UK	Japan	Hong Kong	Singapore	Brazil	Mexico
big portfolio	0.828	0.388	0.784	1.032	0.891	1.024
small portfolio	0.548	0.319	0.282	0.792	0.151	0.170
discrepancies between small and big	0.279	0.069	0.502	0.240	0.739	0.854
T value of discrepancies	40.988	36.129	78.013	13.861	25.349	38.318
low portfolio	0.800	0.382	0.650	1.156	0.546	0.831
high portfolio	0.765	0.330	0.566	0.979	0.544	0.913
discrepancies between low and high	0.035	0.052	0.084	0.176	0.001	-0.082
T value of discrepancies	5.471	17.637	16.264	9.603	0.043	-1.782

Table 3.7: The Average Level of Integration [GARCH-filter]

(SMB HML risk factors are added)

The following models are estimated:

$$r_{i,t} = \mu_{i,t-1} + s_{ix}SMB_{x,t} + h_{ix}HML_x + s_{iUS}SMB_{US,t} + h_{iUS}HML_{US,t} + \overset{\bullet}{\varepsilon}_{it}$$

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_x X_{x,t-1} + \delta_w X_{w,t-1}$$

$$\overset{\bullet}{\varepsilon}_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t}$$

$$\gamma_{i,t} = \gamma_{i,t-1} + \eta_{i,t},$$

$$h_{i,t} = \text{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}\xi_{i,t-1}^2 + \alpha_{i3}h_{i,t}$$

The Average Level of Integration with the World Market	UK	Japan	Hong Kong	Singapore	Brazil	Mexico
big portfolio	0.526	0.397	0.674	0.905	0.542	0.166
small portfolio	0.516	0.315	0.573	0.826	0.264	0.168
discrepancies between small and big	0.010	0.082	0.101	0.079	0.278	-0.002
T value of discrepancies	10.674	6.488	30.446	12.047	24.396	-0.182
low portfolio	0.636	0.369	0.655	0.929	0.354	0.196
high portfolio	0.624	0.319	0.595	0.932	0.386	0.302
discrepancies between low and high	0.012	0.050	0.060	-0.004	-0.033	-0.106
T value of discrepancies	6.609	5.385	3.753	-0.384	-4.871	-6.093

Table 3.6a: Estimates of TGARCH(1,1) process from GARCH-filter (one factor model)

a 0 is the constant of the variance equation

a1 is the coefficient of $e_{i,t-1}^2$, a2 is the coefficient of $\xi_{i,t-1}^2$, a3 is the coefficient of h_{t-1}

Market Index and Portfolios	a0	a1	a2	a3
UK market	6.30E-06	0.019	0.035	0.950***
UK big	8.60E-06	0.027	0.021	0.949***
UK small	6.00E-05	0.032	0.117	0.879***
UK low	6.54E-05	0.087**	0.090*	0.842***
UK high	1.49E-05	0.045*	0.012	0.934***
Japan market	4.06E-04*	0.032	0.129**	0.799***
Japan big	0.0015***	0.103	0.430**	0.266
Japan small	0.0015*	0.054	0.301*	0.536***
Japan low	0.0015***	0.056	0.480***	0.414***
Japan high	0.0015**	0.067	0.321*	0.456**
HK market	5.35E-04**	0.199***	0.003	0.674***
HK big	0.0008***	0.464***	0.02	0.473***
HK small	0.0005***	0.887***	-0.585***	0.478***
HK low	0.0006***	0.458***	0.077	0.481***
HK high	0.0012***	0.519***	-0.283***	0.517***
Singapore market	8.22E-05	0.094**	0.093	0.838***
Singapore big	0.0001	0.1051**	0.196**	0.78***
Singapore small	0.0006***	0.3619***	0.039	0.595***
Singapore low	0.0003**	0.168***	0.085	0.738***
Singapore high	0.0002**	0.226***	0.106	0.718***
Brazil market	1.36E-03	0.052	0.276*	0.703***
Brazil big	0.0005**	0.291**	0.222	0.568***
Brazil small	0.0005***	0.193	0.815***	0.526***
Brazil low	0.0020***	0.33	1.084***	0.115
Brazil high	0.0005***	0.125	0.639***	0.567***
Mexico market	1.26E-03	0.103	0.262	0.614***
Mexico big	0.0026***	0.915***	-0.519**	0.007
Mexico small	0.0002***	0.872***	-0.802***	0.589***
Mexico low	4.52E-06	-0.038***	0.018***	1.008***
Mexico high	3.96E-05	0.367***	-0.220***	0.759***

Table 3.8: Comparing the Average Integration Level with the World and Corresponding National Market [GARCH-filter]

The following model is estimated: $r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t}$, $\varepsilon_{i,t} = \gamma_{iw,t-1}e_{w,t} + \gamma_{ix,t-1}e_{x,t} + e_{i,t}$

$\gamma_{iw,t} = \gamma_{iw,t-1} + \eta_{iw,t}$, $\gamma_{ix,t} = \gamma_{ix,t-1} + \eta_{ix,t}$, $h_{i,t} = \mathrm{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2$

	The average integration with		Discrepancies between world and national	
	World market	National market	Discrepancies	T statistics
UK big	0.723	1.023	-0.300	-35.064
UK small	0.475	0.798	-0.322	-52.850
UK low	0.708	0.998	-0.290	-30.339
UK high	0.669	0.934	-0.266	-33.059
Japan big	0.390	0.889	-0.500	-57.317
Japan small	0.299	1.005	-0.706	-41.861
Japan low	0.411	1.031	-0.620	-49.569
Japan high	0.318	0.920	-0.601	-46.512
HK big	1.074	0.840	0.235	32.856
HK small	0.590	0.603	-0.014	-1.138
HK low	0.890	0.635	0.255	37.443
HK high	0.955	0.840	0.115	15.243
Singapore big	0.834	0.883	-0.049	-4.985
Singapore small	0.804	0.721	0.082	4.165
Singapore low	0.959	0.930	0.030	7.085
Singapore high	0.814	0.849	-0.035	-6.178
Brazil big	0.776	0.551	0.225	15.413
Brazil small	0.207	0.307	-0.100	-8.152
Brazil low	0.652	0.537	0.115	7.162
Brazil high	0.546	0.500	0.046	1.970
Mexico big	1.217	0.791	0.427	25.702
Mexico small	0.285	0.355	-0.070	-2.863
Mexico low	0.874	0.669	0.205	8.491
Mexico high	0.848	0.616	0.232	8.888

Table 3.9: Likelihood Ratio Test

	log likelihood value		Likelihood ratio test	
	Kalman filter	GARCH-filter	LR statistics	p-value
UK market	575.347	666.082	181.469•••	[0]
UK big	554.126	624.182	140.111•••	[0]
UK small	603.247	626.580	46.665•••	[0]
UK low	548.722	600.104	102.764•••	[0]
UK high	558.440	624.414	131.948•••	[0]
Japan market	329.603	338.599	17.990•••	[0]
Japan big	331.564	349.195	35.261•••	[0]
Japan small	269.853	285.239	30.772•••	[0]
Japan low	287.510	308.263	41.505•••	[0]
Japan high	300.244	315.908	31.327•••	[0]
HK market	316.108	322.009	11.801•••	[<0.01]
HK big	260.097	296.449	72.705•••	[0]
HK small	236.179	291.487	110.617•••	[0]
HK low	269.514	315.995	92.960•••	[0]
HK high	233.252	267.133	67.762•••	[0]
Singapore market	341.284	362.593	42.618•••	[0]
Singapore big	296.825	331.133	68.615•••	[0]
Singapore small	232.478	275.705	86.455•••	[0]
Singapore low	256.645	285.243	57.196•••	[0]
Singapore high	256.014	296.452	80.876•••	[0]
Brazil market	112.253	123.759	23.0128•••	[0]
Brazil big	119.299	151.877	65.156•••	[0]
Brazil small	152.516	181.718	58.403•••	[0]
Brazil low	119.083	165.147	92.126•••	[0]
Brazil high	122.817	163.407	81.180•••	[0]
Mexico market	189.030	203.009	27.958•••	[0]
Mexico big	214.467	238.816	48.698•••	[0]
Mexico small	273.970	295.924	43.907•••	[0]
Mexico low	218.676	253.495	69.639•••	[0]
Mexico high	190.047	236.901	93.707•••	[0]

Table 4.1: Summary statistics for monthly bond market returns

Bond portfolios	Obs.	Mean	Std. Dev.	Skewness	Kurtosis (Exc)	JB test	First-order correlation
US							
1-3 Y	160	0.056	0.447	0.184	0.219	1.220	0.207•••
3-5 Y	160	0.110	1.030	-0.070	0.266	0.603	0.125
5-7 Y	160	0.143	1.345	-0.154	0.295	1.216	0.108
7-10 Y	160	0.159	1.734	-0.279	0.635	4.761•	0.107
10+ Y	160	0.244	2.457	-0.494	0.996	13.108•••	0.076
UK							
1-3 Y	160	0.319	2.127	0.035	-0.216	0.344	-0.104
3-5 Y	160	0.330	2.204	0.121	-0.327	1.101	-0.071
5-7 Y	160	0.343	2.322	0.115	-0.349	1.165	-0.048
7-10 Y	160	0.349	2.496	0.071	-0.382	1.107	-0.026
10+ Y	160	0.407	2.939	0.010	-0.392	1.026	-0.005
Japan							
1-3 Y	160	-0.288	3.289	0.859	3.940	123.177•••	0.024
3-5 Y	160	-0.205	3.301	0.862	4.483	153.833•••	0.037
5-7 Y	160	-0.132	3.350	0.806	4.659	162.005•••	0.052
7-10 Y	160	-0.082	3.455	0.727	4.409	143.684•••	0.069
10+ Y	160	0.004	3.809	0.502	3.032	67.996•••	0.080
Australia							
1-3 Y	160	0.270	2.811	-0.134	-0.344	1.198	0.059
3-5 Y	160	0.316	2.931	-0.097	-0.254	0.680	0.018
5-7 Y	160	0.322	3.074	-0.133	-0.179	0.675	0.003
7-10 Y	160	0.344	3.311	-0.138	-0.170	0.703	-0.004
10+ Y	160	0.379	3.564	-0.174	-0.161	0.985	-0.012
Canada							
1-3 Y	160	0.207	1.924	-0.009	-0.176	0.210	0.106
3-5 Y	160	0.273	2.176	-0.090	0.368	1.119	0.108
5-7 Y	160	0.326	2.357	-0.106	0.523	2.127	0.103
7-10 Y	160	0.362	2.574	-0.117	0.644	3.129	0.083
10+ Y	160	0.490	3.092	-0.112	0.702	3.616	0.045
Germany							
1-3 Y	160	0.134	2.717	0.295	0.232	2.686	0.149•
3-5 Y	160	0.191	2.805	0.451	0.447	6.759••	0.165••
5-7 Y	160	0.249	2.870	0.498	0.398	7.683••	0.181••
7-10 Y	160	0.270	2.947	0.471	0.275	6.411••	0.189••
10+ Y	160	0.373	3.307	0.313	0.001	2.617	0.187••

Table 4.2: Correlations of Different Bond Portfolios with the World Bond Market

Bond portfolios	US	UK	Japan	Australia	Canada	Germany
1-3 Y	0.528	0.675	0.672	0.446	0.367	0.835
3-5 Y	0.576	0.724	0.693	0.488	0.434	0.877
5-7 Y	0.573	0.739	0.710	0.513	0.465	0.896
7-10 Y	0.565	0.738	0.724	0.528	0.472	0.903
10+ Y	0.500	0.702	0.716	0.531	0.427	0.854

Table 4.3: Summary Statistics for Information Variables of Bond Market

	WB	WS	WBSP	WGEYR
World				
Mean	0.1337	0.4249	0.0932	0.3057
S.D.	1.8559	3.8747	0.1434	0.1181
Max	5.4767	8.461	0.3258	0.5568
Min	-4.441	-14.713	-0.145	0.1157
1st-order correlation	0.179**	0.018	0.97***	0.983***
Normality	3.781	27.968	10.643	8.461
	[0.150]	[0]	[0.004]	[0.014]

	LB	LS	LBSP	LGEYR
US				
Mean	0.1362	0.5402	0.1411	0.3709
S.D.	1.2996	4.1329	0.1314	0.0805
Max	3.4634	9.0114	0.3761	0.512
Min	-4.642	-15.389	-0.09	0.2208
1st-order correlation	0.098	-0.013	0.963***	0.956***
Normality	7.304	20.530	10.968	12.077
	[0.025]	[0]	[0.004]	[0.002]
UK				
Mean	0.3601	0.4922	0.1277	0.2225
S.D.	2.5058	3.7856	0.1674	0.1236
Max	6.2486	9.8022	0.4272	0.4571
Min	-5.82	-11.057	-0.192	4.46E-03
1st-order correlation	-0.029	0.022	0.976***	0.982***
Normality	1.135	3.981	12.774	13.135
	[0.567]	[0.136]	[0.001]	[0.001]

Table 4.3: Summary Statistics for Information Variables of Bond Market [Continued]

	LB	LS	LBSP	LGEYR
Japan				
Mean	-0.162	-0.166	-0.165	0.1351
S.D.	3.3466	5.5794	0.1437	0.0922
Max	15.0485	15.1532	0.1315	0.372
Min	-12.221	-12.759	-0.421	-0.029
1st-order correlation	0.051	0.106	0.967***	0.966***
Normality	153.838	1.932	9.850	28.469
	[0]	[0.380]	[0.007]	[0]
Australia				
Mean	0.3062	0.7192	0.2094	0.2862
S.D.	3.0907	4.9455	0.1635	0.1343
Max	7.8352	13.1231	0.5495	0.6796
Min	-7.915	-14.887	-0.099	0.0962
1st-order correlation	0.006	-0.128	0.973***	0.972***
Normality	0.997	8.863	11.687	29.133
	[0.607]	[0.011]	[0.002]	[0]
Canada				
Mean	0.3341	0.7592	0.1621	0.3676
S.D.	2.368	5.4189	0.169	0.1275
Max	7.3993	13.1094	0.4752	0.648
Min	-7.401	-24.964	-0.119	0.1473
1st-order correlation	0.086	0.133*	0.973***	0.979***
Normality	2.410	87.123	12.347	5.014
	[0.299]	[0]	[0.002]	[0.081]
Germany				
Mean	0.2219	0.5486	0.1065	0.3207
S.D.	2.8235	6.1487	0.1515	0.12
Max	8.4065	21.1694	0.3374	0.5486
Min	-5.587	-28.037	-0.137	0.1114
1st-order correlation	0.178**	-0.034	0.975***	0.98***
Normality	6.577	102.979	12.181	7.820
	[0.037]	[0]	[0.002]	[0.020]

Table 4.4: The Average Level of Integration Estimated by the GARCH-filter model

Markets	Bond maturities	Integration of Different Bond Portfolios with the		
		World Bond Market	World Stock Market	National Stock Market
US	1-3 Y	0.147	0.004	0.108
	3-5 Y	0.327	0.007	0.243
	5-7 Y	0.416	0.000	0.306
	7-10 Y	0.524	-0.002	0.423
	10+ Y	0.632	0.003	0.561
UK	1-3 Y	0.691	-0.037	0.226
	3-5 Y	0.767	-0.037	0.247
	5-7 Y	0.853	-0.028	0.278
	7-10 Y	0.940	-0.007	0.311
	10+ Y	1.044	0.002	0.300
Japan	1-3 Y	1.217	0.033	0.174
	3-5 Y	1.231	0.013	0.120
	5-7 Y	1.275	0.008	0.080
	7-10 Y	1.340	0.003	0.064
	10+ Y	1.429	0.010	0.083
Australia	1-3 Y	0.456	0.307	0.317
	3-5 Y	0.537	0.321	0.310
	5-7 Y	0.599	0.353	0.271
	7-10 Y	0.690	0.355	0.299
	10+ Y	0.751	0.358	0.315
Canada	1-3 Y	0.310	0.156	0.259
	3-5 Y	0.382	0.186	0.295
	5-7 Y	0.468	0.203	0.315
	7-10 Y	0.527	0.225	0.333
	10+ Y	0.624	0.269	0.395
Germany	1-3 Y	1.166	-0.010	0.054
	3-5 Y	1.282	-0.036	0.060
	5-7 Y	1.265	-0.047	0.060
	7-10 Y	1.317	-0.046	0.054
	10+ Y	1.381	-0.021	0.089

Table 4.4a: Parameters Estimates of Variance Equation from the GARCH-filter Model

Markets	Bond Maturities	a0	a1	a2	a3
US	1-3 Y	6.45E-07***	0.158**	-0.223***	0.887***
	3-5 Y	1.23E-06***	0.087***	-0.242***	1.027***
	5-7 Y	3.66E-06***	0	-0.122***	1.035***
	7-10 Y	7.93E-06*	0.190*	-0.232*	0.882***
	10+ Y	1.80E-05*	0.045	-0.077	0.940***
UK	1-3 Y	2.48E-05	0.02	-0.089	0.903***
	3-5 Y	2.45E-05	0.042	-0.086	0.869***
	5-7 Y	6.20E-05**	0.09	-0.261***	0.708***
	7-10 Y	3.23E-05**	0.122	-0.208**	0.834***
	10+ Y	4.78E-05***	0.172*	-0.278***	0.847***
Japan	1-3 Y	5.35E-05**	0.062	-0.174**	0.903***
	3-5 Y	8.97E-05***	0.057***	-0.236**	0.876***
	5-7 Y	3.74E-05***	0.056***	-0.306***	0.978***
	7-10 Y	0.00011***	1.76***	-1.54***	0.241***
	10+ Y	7.08E-05**	0.83***	-0.730***	0.540***
	1-3 Y	0.0001**	0.242**	0.386	0.238
Australia	3-5 Y	0.0001***	0.197*	0.557**	0.191
	5-7 Y	0.0003***	0.482***	0.626***	-0.072***
	7-10 Y	0.0003***	0.296	-0.052	-0.076
	10+ Y	0.0005***	0.256**	-0.066	-0.554*
Canada	1-3 Y	9.98E-06***	-0.051	0.081	0.942***
	3-5 Y	1.55E-05**	0.016	-0.031	0.921***
	5-7 Y	1.99E-05*	0.043	-0.084	0.916***
	7-10 Y	2.45E-05*	0.107*	-0.182**	0.907***
	10+ Y	3.52E-05**	0.055	-0.136***	0.946***
Germany	1-3 Y	4.02E-05	-0.019	0.015	0.833***
	3-5 Y	2.22E-05***	-0.070***	-0.099***	1.028***
	5-7 Y	7.08E-06	0.024	-0.124***	1.015***
	7-10 Y	2.79E-06	0.569***	-0.129***	1.007***
	10+ Y	0.0002*	-0.07	0.456**	0.166

Table 4.5: The Average Level of Integration with the World Bond Portfolios

Markets	Bond Maturities	Integration of Different Bond Portfolios with the Word Bond Market		
		(1-3Y)	(5-7Y)	(10+Y)
US	All	0.194	0.171	0.400
	1-3 Y	0.101	0.072	0.126
	3-5 Y	0.175	0.146	0.279
	5-7 Y	0.211	0.185	0.363
	7-10 Y	0.261	0.233	0.527
	10+ Y	0.212	0.240	0.763
UK	All	0.832	0.596	0.740
	1-3 Y	0.703	0.470	0.444
	3-5 Y	0.726	0.509	0.540
	5-7 Y	0.717	0.517	0.618
	7-10 Y	0.832	0.604	0.755
	10+ Y	0.891	0.659	0.876
Japan	All	1.678	1.241	0.731
	1-3 Y	1.619	1.156	0.606
	3-5 Y	1.689	1.220	0.672
	5-7 Y	1.712	1.243	0.702
	7-10 Y	1.702	1.254	0.696
	10+ Y	1.740	1.309	0.804

Table 4.5: The Average Level of Integration with the World Bond Portfolios

[Continued]

Markets	Bond Maturities	Integration of Different Bond Portfolios with the Word Bond Market		
		(1-3Y)	(5-7Y)	(10+Y)
Australia	All	0.412	0.311	0.289
	1-3 Y	0.372	0.237	0.049
	3-5 Y	0.402	0.272	0.180
	5-7 Y	0.446	0.344	0.342
	7-10 Y	0.624	0.477	0.473
	10+ Y	0.676	0.533	0.576
Canada	All	0.084	0.094	0.320
	1-3 Y	0.131	0.095	0.195
	3-5 Y	0.148	0.122	0.279
	5-7 Y	0.142	0.140	0.372
	7-10 Y	0.120	0.141	0.454
	10+ Y	0.047	0.109	0.581
Germany	All	1.303	0.885	0.668
	1-3 Y	1.282	0.838	0.524
	3-5 Y	1.346	0.902	0.628
	5-7 Y	1.249	0.857	0.674
	7-10 Y	1.310	0.906	0.769
	10+ Y	1.282	0.919	1.010

Table 4.6: The Average Level of Integration Across Different Bond Portfolios within the National Market

markets	bond maturities	integration of different bond portfolios with		
		1-3Y bond	5-7Y bond	10+Y bond
US	1-3 Y	/	0.275	0.129
	5-7 Y	2.284	/	0.394
	10+ Y	4.519	1.583	/
UK	1-3 Y	/	0.754	0.517
	5-7 Y	0.866	/	0.614
	10+ Y	1.011	1.076	/
Japan	1-3 Y	/	0.807	0.656
	5-7 Y	0.948	/	0.770
	10+ Y	0.838	0.830	/
Australia	1-3 Y	/	0.746	0.592
	5-7 Y	0.971	/	0.784
	10+ Y	0.991	0.971	/
Canada	1-3 Y	/	0.619	0.395
	5-7 Y	1.032	/	0.626
	10+ Y	1.061	1.034	/
Germany	1-3 Y	/	0.819	0.562
	5-7 Y	0.923	/	0.661
	10+ Y	0.891	0.943	/

Table 4.7: Likelihood Ratio Test

	Log Likelihood Value		Likelihood Ratio Test	
	Kalman Filter	GARCH-filter	LR statistics	P-value
US				
1-3 Y	661.883	668.535	13.302•••	[<0.005]
3-5 Y	534.653	538.640	7.973••	[<0.05]
5-7 Y	489.534	490.877	2.686	[>0.25]
7-10 Y	446.765	447.379	1.230	[>0.5]
10+ Y	380.770	381.291	1.043	[>0.75]
UK				
1-3 Y	410.570	416.211	11.282••	[<0.025]
3-5 Y	418.760	426.642	15.764•••	[<0.005]
5-7 Y	410.702	418.800	16.196•••	[<0.005]
7-10 Y	395.899	402.887	13.975•••	[<0.005]
10+ Y	361.996	370.901	17.808•••	[<0.005]
Japan				
1-3 Y	332.492	339.202	13.419•••	[<0.005]
3-5 Y	325.203	341.975	33.543•••	[<0.005]
5-7 Y	324.310	338.883	29.146•••	[<0.005]
7-10 Y	323.611	343.208	39.195•••	[<0.005]
10+ Y	318.343	338.737	40.788•••	[<0.005]
Australia				
1-3 Y	358.709	364.447	11.476•••	[<0.01]
3-5 Y	378.629	382.818	8.378••	[<0.05]
5-7 Y	365.283	363.797	-2.972	[>0.25]
7-10 Y	355.596	360.413	9.633••	[<0.025]
10+ Y	338.693	344.294	11.201••	[<0.025]
Canada				
1-3 Y	431.852	431.043	-1.618	[>0.5]
3-5 Y	413.889	415.524	3.270	[>0.25]
5-7 Y	400.486	404.098	7.223•	[<0.1]
7-10 Y	384.409	388.859	8.898••	[<0.05]
10+ Y	346.813	352.087	10.548••	[<0.025]
Germany				
1-3 Y	394.697	392.647	-4.100	[>0.25]
3-5 Y	406.728	411.345	9.233••	[<0.05]
5-7 Y	405.655	410.607	9.904••	[<0.025]
7-10 Y	405.617	412.298	13.362•••	[<0.005]
10+ Y	378.711	387.612	17.801•••	[<0.005]

Table 4.8: Granger Causality Test

		1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
US market						
COUT --> gamma	F value	9.356***	5.410***	0.922	3.027*	2.261*
	p value	[0]	[0.005]	[0.400]	[0.051]	[0.108]
gamma --> COUT	F value	3.026*	1.244	0.231	0.229	0.647
	p value	[0.051]	[0.291]	[0.794]	[0.795]	[0.525]
CINF --> gamma	F value	3.754**	1.496	0.374	0.673	1.265
	p value	[0.025]	[0.227]	[0.688]	[0.511]	[0.285]
gamma --> CINF	F value	0.005	0.214	0.17	0.511	0.118
	p value	[0.995]	[0.807]	[0.844]	[0.600]	[0.888]
TOPEN --> gamma	F value	1.475	0.237	0.003	1.156	1.334
	p value	[0.232]	[0.789]	[0.996]	[0.317]	[0.266]
gamma --> TOPEN	F value	1.382	2.283	1.234	0.861	0.133
	p value	[0.254]	[0.105]	[0.294]	[0.424]	[0.875]
UK market						
COUT --> gamma	F value	0.115	1.01	0.903	0.3	0.936
	p value	[0.891]	[0.366]	[0.407]	[0.741]	[0.394]
gamma --> COUT	F value	0.954	0.795	0.803	0.824	1.628
	p value	[0.387]	[0.453]	[0.450]	[0.441]	[0.200]
CINF --> gamma	F value	2.560*	4.217**	3.991**	2.337*	2.335*
	p value	[0.08094]	[0.0167]	[0.02067]	[0.10036]	[0.1006]
gamma --> CINF	F value	1.474	2.982*	3.702**	2.949*	4.088**
	p value	[0.232]	[0.053]	[0.027]	[0.055]	[0.018]
TOPEN --> gamma	F value	1.98	0.225	0.097	0.004	0.08
	p value	[0.141]	[0.799]	[0.907]	[0.995]	[0.922]
gamma --> TOPEN	F value	4.046**	0.923	0.361	0.494	0.192
	p value	[0.019]	[0.399]	[0.697]	[0.611]	[0.82]
EX_vol --> gamma	F value	0.214	0.78	0.464	0.14	0.56
	p value	[0.807]	[0.460]	[0.629]	[0.869]	[0.572]
gamma -->Ex_vol	F value	16.461***	18.971***	12.902***	10.872***	5.252***
	p value	[0]	[0]	[0]	[0]	[0.006]

Table 4.8: Granger Causality Test [Continued]

		1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
Japan market						
COUT --> gamma	F value	0.076	0.016	0.043	0.02	0.25
	p value	[0.926]	[0.984]	[0.958]	[0.980]	[0.779]
gamma --> COUT	F value	5.089•••	6.872•••	8.462•••	8.579•••	7.038•••
	p value	[0.007]	[0.001]	[0]	[0]	[0.001]
CINF --> gamma	F value	3.579••	3.440••	8.490•••	8.993•••	10.898•••
	p value	[0.030]	[0.034]	[0]	[0]	[0]
gamma --> CINF	F value	4.431••	4.233••	4.440••	4.177••	3.409••
	p value	[0.013]	[0.016]	[0.013]	[0.017]	[0.035]
TOPEN --> gamma	F value	1.179	2.946•	4.080••	4.597••	7.277•••
	p value	[0.310]	[0.055]	[0.019]	[0.011]	[0]
gamma --> TOPEN	F value	3.237••	2.869•	2.776•	2.609•	3.158••
	p value	[0.042]	[0.060]	[0.065]	[0.077]	[0.045]
EX_vol --> gamma	F value	6.104•••	7.897•••	9.677•••	10.014•••	7.145•••
	p value	[0]	[0]	[0]	[0]	[0.001]
gamma -->Ex_vol	F value	18.279•••	18.172•••	18.446•••	17.260•••	15.131•••
	p value	[0]	[0]	[0]	[0]	[0]
Australia market						
TOPEN --> gamma	F value	1.965	0.865	1.21	0.811	0.811
	p value	[0.144]	[0.423]	[0.301]	[0.446]	[0.446]
gamma --> TOPEN	F value	1.296	1.16	0.969	0.597	0.488
	p value	[0.276]	[0.316]	[0.382]	[0.551]	[0.615]
EX_vol --> gamma	F value	1.341	0.894	1.875	2.023	2.425•
	p value	[0.264]	[0.411]	[0.157]	[0.136]	[0.092]
gamma -->Ex_vol	F value	0.668	1.722	1.33	1.159	1.04
	p value	[0.514]	[0.182]	[0.267]	[0.316]	[0.356]

Table 4.8: Granger Causality Test [Continued]

		1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
Canada market						
TOPEN --> gamma	F value	2.357*	2.852*	3.079**	2.868*	2.148
	p value	[0.098]	[0.061]	[0.049]	[0.060]	[0.120]
gamma --> TOPEN	F value	3.103**	1.965	1.343	1.186	0.58
	p value	[0.048]	[0.144]	[0.264]	[0.308]	[0.561]
CINF --> gamma	F value	8.372***	6.142***	4.824***	3.265**	1.559
	p value	[0]	[0.002]	[0.009]	[0.041]	[0.214]
gamma --> CINF	F value	0.734	0.826	0.991	1.402	1.292
	p value	[0.481]	[0.439]	[0.373]	[0.249]	[0.278]
EX_vol --> gamma	F value	10.214***	7.823***	6.351***	4.177**	1.638
	p value	[0]	[0]	[0.002]	[0.017]	[0.198]
gamma -->Ex_vol	F value	2.784*	0.952	0.81	0.868	0.618
	p value	[0.065]	[0.388]	[0.446]	[0.421]	[0.540]
Germany market						
COUT --> gamma	F value	48.993***	46.519***	41.871***	37.793***	8.397***
	p value	[0]	[0]	[0]	[0]	[0]
gamma --> COUT	F value	20.822***	17.335***	20.889***	20.934***	21.669***
	p value	[0]	[0]	[0]	[0]	[0]
CINF --> gamma	F value	14.498***	16.970***	16.544***	18.069***	15.775***
	p value	[0]	[0]	[0]	[0]	[0]
gamma --> CINF	F value	0.117	0.22	0.607	0.918	1.283
	p value	[0.889]	[0.802]	[0.546]	[0.401]	[0.280]
TOPEN --> gamma	F value	15.616***	14.122***	12.283***	11.079***	5.538***
	p value	[0]	[0]	[0]	[0]	[0.004]
gamma --> TOPEN	F value	5.793***	5.547***	4.824***	4.256**	1.676
	p value	[0.003]	[0.004]	[0.009]	[0.016]	[0.190]
EX_vol --> gamma	F value	1.054	1.321	1.049	0.977	0.101
	p value	[0.351]	[0.270]	[0.353]	[0.378]	[0.904]
gamma -->Ex_vol	F value	8.667***	9.347***	8.761***	8.874***	4.189**
	p value	[0]	[0]	[0]	[0]	[0.017]

Table 4.9: Explaining Time-varying Bond Integration

	All	1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
US market						
Constant	0.023	0.012	0.013	0.02	0.041	0.083*
	[0.383]	[0.348]	[0.546]	[0.451]	[0.260]	[0.073]
Trade open (t-1)	-1.6	0.325	-0.061	-0.593	-2.136	-3.557
	[0.276]	[0.615]	[0.96]	[0.688]	[0.297]	[0.179]
Output growth (t-1)	0.053	0.021*	0.031	0.016	0.039	0.009
	[0.142]	[0.096]	[0.248]	[0.642]	[0.428]	[0.890]
Inflation rate(t-1)	-0.003	-0.006	0.002	0.003	-0.006	0.051
	[0.874]	[0.552]	[0.911]	[0.875]	[0.831]	[0.197]
Jan_Dum	0.002	0.001	0.002	0.003	0.003	0.008
	[0.7284]	[0.717]	[0.616]	[0.624]	[0.693]	[0.412]
Integration (t-1)	0.938***	0.813***	0.908***	0.955***	0.957***	0.921***
	[0]	[0]	[0]	[0]	[0]	[0]
UK market						
Constant	-0.069	-0.097	-0.002	-0.164	-0.045	-0.072
	[0.405]	[0.176]	[0.981]	[0.051]	[0.555]	[0.492]
Trade open (t-1)	1.015	3.024***	2.597**	1.744	0.907	0.861
	[0.445]	[0.005]	[0.016]	[0.214]	[0.457]	[0.622]
Output growth (t-1)	0.002	-0.002	0.011	0.007	-0.008	0.02
	[0.980]	[0.980]	[0.862]	[0.931]	[0.912]	[0.843]
Inflation rate(t-1)	0.614**	0.501**	0.365*	0.853***	0.553**	0.524
	[0.020]	[0.017]	[0.103]	[0.002]	[0.024]	[0.120]
EX_VOL (t-1)	-10.061	-1.652	-39.328	-10.03	-18.405	4.803
	[0.803]	[0.959]	[0.265]	[0.827]	[0.635]	[0.920]
Jan_Dum	0.012	0.012	0.011	0.008	0.009	0.01
	[0.365]	[0.269]	[0.294]	[0.596]	[0.481]	[0.552]
Integration (t-1)	0.908***	0.841***	0.956***	0.924***	0.904***	0.935***
	[0]	[0]	[0]	[0]	[0]	[0]
Integration (t-2)			-0.147*			
			[0.069]			

Table 4.9: Explaining Time-varying Bond Integration [Continued]

	All	1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
Japan market						
Constant	-2.025	-1.508	-1.824	-1.822	-2.031	-1.791
	[0]	[0]	[0]	[0]	[0]	[0]
Trade open (t-1)	-4.527	-2.466	-4.737	-3.14	-4.228	-9.461**
	[0.323]	[0.504]	[0.28]	[0.460]	[0.340]	[0.015]
Output growth (t-1)	0.636***	0.472***	0.570***	0.585***	0.656***	0.655***
	[0]	[0]	[0]	[0]	[0]	[0]
Inflation rate(t-1)	-0.387	-0.078	-0.699	0.317	0.446	0.832
	[0.574]	[0.892]	[0.272]	[0.659]	[0.555]	[0.194]
EX_VOL (t-1)	121.39***	92.36***	120.91***	108.83***	114.14***	55.85**
	[0]	[0]	[0]	[0]	[0]	[0.0133]
Jan_Dum	-0.007	0.005	0.002	0	-0.004	-0.007
	[0.823]	[0.835]	[0.942]	[0.997]	[0.885]	[0.781]
integration (t-1)	0.815***	0.844***	0.834***	0.789***	0.782***	0.737***
	[0]	[0]	[0]	[0]	[0]	[0]
Australia market						
Constant	-0.058	-0.077	-0.034	-0.119	-0.051	-0.063
	[0.644]	[0.514]	[0.744]	[0.482]	[0.720]	[0.695]
Trade open (t-1)	3.337	3.602	2.105	4.975	2.606	2.877
	[0.478]	[0.418]	[0.592]	[0.432]	[0.628]	[0.633]
EX_VOL (t-1)	83.566	82.735	60.846	141.691*	126.114*	157.811**
	[0.132]	[0.112]	[0.200]	[0.066]	[0.056]	[0.033]
Jan_Dum	0.015	0.016	0.017	0.018	0.008	0.008
	[0.693]	[0.659]	[0.599]	[0.731]	[0.858]	[0.880]
Integration (t-1)	0.717***	0.693***	0.727***	0.679***	0.746***	0.734***
	[0]	[0]	[0]	[0]	[0]	[0]
Integration (t-2)	0.152*	0.162**	0.177**	0.163**	0.121	0.12
	[0.050]	[0.039]	[0.028]	[0.033]	[0.123]	[0.123]

Table 4.9: Explaining Time-varying Bond Integration [Continued]

	All	1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
Canada market						
Constant	-0.094	-0.07	-0.066	-0.092	-0.118	-0.165
	[0.035]	[0.09]	[0.101]	[0.039]	[0.018]	[0.016]
Trade open (t-1)	1.739**	0.964	1.288*	1.892**	2.281***	3.157***
	[0.019]	[0.159]	[0.054]	[0.011]	[0.007]	[0.005]
inflation rate (t-1)	0.068	0.073	0.045	0.052	0.073	0.098
	[0.262]	[0.195]	[0.412]	[0.392]	[0.282]	[0.260]
EX_VOL (t-1)	172.034*	91.23	141.955*	179.789*	207.140**	238.047*
	[0.066]	[0.279]	[0.089]	[0.051]	[0.045]	[0.065]
Jan_Dum	0.003	-0.002	0	0.003	0.006	0.013
	[0.793]	[0.867]	[0.987]	[0.833]	[0.677]	[0.5]
integration (t-1)	0.840***	0.901***	0.847***	0.830***	0.833***	0.833***
	[0]	[0]	[0]	[0]	[0]	[0]
Germany market						
Constant	0.252	-1.508	-1.824	-1.822	-2.031	-1.791
	[0]	[0]	[0]	[0]	[0]	[0]
Trade open (t-1)	-0.104	-2.466	-4.737	-3.14	-4.228	-9.461**
	[0.909]	[0.504]	[0.28]	[0.460]	[0.340]	[0.015]
Output growth (t-1)	0.343**	0.472***	0.570***	0.585***	0.656***	0.655***
	[0.01]	[0]	[0]	[0]	[0]	[0]
inflation rate (t-1)	-0.802	-0.078	-0.699	0.317	0.446	0.832
	[0.292]	[0.892]	[0.272]	[0.659]	[0.555]	[0.194]
EX_VOL (t-1)	34.954	92.365***	120.914***	108.835***	114.140***	55.853**
	[0.167]	[0]	[0]	[0]	[0]	[0.013]
Jan_Dum	0.006	0.005	0.002	0	-0.004	-0.007
	[0.640]	[0.835]	[0.942]	[0.997]	[0.885]	[0.781]
integration (t-1)	0.837***	0.844***	0.834***	0.789***	0.782***	0.737***
	[0]	[0]	[0]	[0]	[0]	[0]

Table 4.10: Explaining Time-varying Bond Integration (2nd approach)

	1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
US market					
Constant	0.059	0.46	0.641	0.642	2.185
	[0.812]	[0.362]	[0.394]	[0.548]	[0.172]
Trade open (t-1)	-3.185	-37.687	-49.832	-67.677	-180.355*
	[0.824]	[0.248]	[0.284]	[0.296]	[0.057]
Output growth (t-1)	0.423	1.204	1.593	2.820**	2.488
	[0.243]	[0.117]	[0.116]	[0.029]	[0.193]
Inflation rate (t-1)	-0.298	-0.525	-0.794	-1.437	-0.083
	[0.258]	[0.265]	[0.323]	[0.170]	[0.958]
Jan_Dum	0.024	-0.112	-0.22	-0.508	-0.748
	[0.834]	[0.647]	[0.514]	[0.324]	[0.262]
UK market					
Constant	-0.075	-0.657	-0.872	-0.294	2.56
	[0.963]	[0.650]	[0.574]	[0.830]	[0.069]
Trade open (t-1)	-8.59	-4.69	-4.247	-4.971	-34.547
	[0.802]	[0.885]	[0.896]	[0.849]	[0.302]
Output growth (t-1)	1.384	1.21	1.083	1.984	3.550*
	[0.432]	[0.473]	[0.571]	[0.312]	[0.072]
Inflation rate (t-1)	5.657	8.3941**	10.188**	7.761*	-0.117
	[0.232]	[0.036]	[0.024]	[0.061]	[0.978]
EX_VOL (t-1)	-354.6	-409.572	-577.436	-650.493	-923.005
	[0.666]	[0.584]	[0.466]	[0.417]	[0.293]
Jan_Dum	0.627	0.362	0.027	-0.003	0.457
	[0.139]	[0.404]	[0.954]	[0.995]	[0.207]

Table 4.10: Explaining Time-varying Bond Integration (2nd approach) [Continued]

	1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
Japan market					
Constant	-18.117**	-19.94***	-19.242***	-20.890**	-24.176***
	[0.047]	[0]	[0.003]	[0.023]	[0.001]
Trade open (t-1)	1.529	-35.849	-42.557	-47.929	-42.958
	[0.986]	[0.441]	[0.522]	[0.563]	[0.536]
Output growth (t-1)	5.101**	5.715***	5.562***	6.028**	7.029***
	[0.040]	[0]	[0.006]	[0.029]	[0.002]
Inflation rate (t-1)	-13.789	-22.490***	-21.978***	-24.215***	-23.657***
	[0.138]	[0.001]	[0.002]	[0.019]	[0.004]
EX_VOL (t-1)	1409.176***	1746.569***	1778.358***	1923.158***	1925.018***
	[0.001]	[0]	[0]	[0]	[0]
Jan_Dum	0.63	0.303	-0.32	-0.254	-0.695
	[0.655]	[0.472]	[0.877]	[0.913]	[0.603]
Australia market					
Constant	-1.637	-1.289	-0.49	-0.132	-1.381**
	[0.238]	[0.327]	[0.723]	[0.926]	[0.033]
Trade open (t-1)	24.252	20.272	11.838	-3.674	45.901
	[0.658]	[0.706]	[0.835]	[0.949]	[0.155]
EX_VOL (t-1)	1879.719***	1763.401***	1183.25***	1383.02***	1307.197***
	[0]	[0.001]	[0.043]	[0.014]	[0]
Jan_Dum	1.877461*	1.59441*	1.543639*	1.057	0.695
	[0.084]	[0.099]	[0.054]	[0.115]	[0.276]

Table 4.10: Explaining Time-varying Bond Integration (2nd approach)

[Continued]

	1-3Y	3-5Y	5-7Y	7-10Y	10+ Y
Canada market					
Constant	0.021	0.131	0.178	0.256	0.708
	[0.981]	[0.901]	[0.873]	[0.835]	[0.628]
Trade open (t-1)	-3.642	-3.097	-0.809	0.034	-3.036
	[0.772]	[0.835]	[0.960]	[0.998]	[0.891]
Inflation rate (t-1)	1.049	1.424	1.435	1.817	2.275
	[0.424]	[0.271]	[0.269]	[0.149]	[0.130]
EX_VOL (t-1)	737.911	353.964	94.216	-415.846	-1485.15
	[0.682]	[0.835]	[0.958]	[0.818]	[0.494]
Jan_Dum	-0.068	-0.308	-0.337	-0.441	-0.735
	[0.898]	[0.644]	[0.610]	[0.551]	[0.330]
Germany market					
Constant	3.085	3.557	4.521	4.928	6.116**
	[0.306]	[0.238]	[0.176]	[0.153]	[0.026]
Trade open (t-1)	-0.9	-1.227	0.204	-4.269	-15.457
	[0.958]	[0.944]	[0.989]	[0.800]	[0.368]
Output growth (t-1)	-0.256	-0.667	-0.994	-1.908	-3.133
	[0.918]	[0.780]	[0.661]	[0.342]	[0.331]
Inflation rate (t-1)	-14.734	-17.049	-21.811	-21.988	-23.591
	[0.438]	[0.387]	[0.302]	[0.325]	[0.117]
EX_VOL (t-1)	658.921	808.112	568.254	588.616	598.374
	[0.321]	[0.177]	[0.353]	[0.358]	[0.356]
Jan_Dum	0.622**	0.3	0.249	0.289	-0.273
	[0.032]	[0.342]	[0.436]	[0.250]	[0.452]

Table 5.1.1: Summary Statistics for Monthly Equity Market Returns

Market index	Obs.	Mean	Std. Dev.	Skewness	Kurtosis (Exc)	JB test	first-order correlation
world	393	0.479	4.054	-0.608•••	1.950•••	86.564•••	0.052
US	393	0.502	4.27	-0.711•••	3.044•••	184.896•••	0.01
UK	393	0.399	6.061	0.721•••	7.648•••	992.117•••	0.051
Japan	393	0.304	6.258	0.081	0.666•••	7.7051••	0.071
Australia	393	0.603	6.833	-1.940•••	15.020•••	3940.90•••	-0.018
Canada	393	0.456	5.574	-0.875•••	3.267•••	225.030•••	0.04
Germany	393	0.485	6.161	-0.577•••	2.150•••	97.562•••	-0.018
Hong Kong	393	0.868	9.018	-1.028•••	5.903•••	640.020•••	0.074
Brazil	237	1.212	14.509	-1.399•••	10.112•••	1802.71•••	-0.1418••
Mexico	237	1.136	9.407	-1.198•••	3.777•••	327.726•••	0.076

Table 5.1.2: Summary Statistics for Monthly Bond Market Returns

Market index	Obs.	Mean	Std. Dev.	Skewness	Kurtosis (Exc)	JB test	first-order correlation
world	261	0.232	1.847	0.193	0.001	1.623	0.157••
US	261	0.192	1.356	-0.23	0.434	4.339	0.082
UK	261	0.438	3.405	-0.012	0.486	2.575	0.117•
Japan	261	0.181	3.716	0.432	1.641	37.423•••	0.081
Australia	261	0.511	3.509	-0.933	3.08	141.045•••	0.003
Canada	261	0.426	2.471	-0.222	0.73	7.936••	0.026
Germany	261	0.318	3.334	0.048	0.419	2.009	0.078

Table 5.2.1: Stock Market Correlations (MSCI)

Market index	Sample		Correlation with the		Differences between the World and Region
	Start time	End time	World	Region	
US	Jan-75	Sep-07	0.851	0.996	-0.146
UK	Jan-75	Sep-07	0.710	0.862	-0.152
Japan	Jan-75	Sep-07	0.686	0.984	-0.298
Australia	Jan-75	Sep-07	0.579	0.441	0.138
Canada	Jan-75	Sep-07	0.732	0.761	-0.029
Germany	Jan-75	Sep-07	0.668	0.821	-0.152
Hong Kong	Jan-75	Sep-07	0.523	0.427	0.096
Brazil	Jan-88	Sep-07	0.409	0.876	-0.467
Mexico	Jan-88	Sep-07	0.470	0.687	-0.218

Table 5.2.2: bond market correlations (JP Morgan)

Market Index	Sample		Correlation with the World Bond Market
	Start time	End time	
US	Jan-86	Sep-07	0.662
UK	Jan-86	Sep-07	0.731
Japan	Jan-86	Sep-07	0.719
Australia	Jan-86	Sep-07	0.301
Canada	Jan-86	Sep-07	0.484
Germany	Jan-86	Sep-07	0.855

Table 5.3.1: Summary Statistics for Information Variables of World Stock Market (MSCI)

	WS	WDY	WCTS	WCIR	WDFS
Mean	0.479	0.235	0.000	0.001	0.111
S.D.	4.054	0.093	0.030	0.092	0.051
Max	13.225	0.460	0.159	0.627	0.320
Min	-19.052	0.105	-0.161	-0.829	0.053
1st-order correlation	0.063	0.996***	0.313***	0.040	0.991***
Normality	83.854	46.911	400.867	13789.930	245.948
	[0]	[0]	[0]	[0]	[0]

Table 5.3.2: Summary Statistics for Information Variables of World Bond Market (JP Morgan)

	WB	WS	WBSP	WGEYR
Mean	0.232	0.482	0.052	0.330
S.D.	1.847	4.183	0.148	0.167
Max	5.417	10.634	0.385	0.640
Min	-4.473	-19.052	-0.215	0.050
1st-order correlation	0.170***	0.050	0.982***	0.994***
Normality	1.623	73.739	10.358	16.804
	[0.444]	[0]	[0.005]	[0]

Table 5.4: Summary Statistics of Assets Returns According to the Conditional Variance

Table 5.4.1: Stock Market (MSCI stock)

	The Conditional Variance Level	Mean	SD	Mean of Change in Integration Level (World)	Mean of Change in Integration Level (Region)
US	High	1.080857	4.750711	-0.042%	-0.050%
	Low	0.185542	3.974539	0.018%	0.006%
Canada	High	0.49946	7.250689	0.385%	0.243%
	Low	0.432623	4.94852	0.579%	0.684%
Japan	High	-0.01955	7.382049	0.622%	-0.035%
	Low	0.461182	5.519355	-0.403%	-0.076%
Australia	High	0.477986	8.081133	1.952%	0.384%
	Low	0.555855	6.109304	-0.173%	0.162%
HK	High	0.599819	10.40097	0.888%	0.725%
	Low	0.78049	8.062286	-0.131%	-0.085%
UK	High	0.871553	6.951382	1.159%	0.570%
	Low	0.145342	5.168412	-0.144%	-0.201%
Germany	High	0.453741	7.358376	0.154%	-0.022%
	Low	0.444538	5.432425	0.037%	0.129%
Brazil	High	0.532726	24.46327	0.325%	0.894%
	Low	1.513234	11.16588	-0.208%	-0.515%
Mexico	High	0.419213	11.55789	0.015%	-0.375%
	Low	1.679739	8.479172	-3.526%	0.928%

Table 5.4.2: Bond Market (JP bond)

	The Conditional Variance Level	Mean	SD	Mean of Change in Integration Level
US	High	0.107	1.466	-0.177%
	Low	0.216	1.184	-0.132%
UK	High	-0.294	3.343	-0.025%
	Low	1.256	2.950	-0.162%
Japan	High	0.348	4.776	1.204%
	Low	-0.031	3.017	-0.728%
Australia	High	0.496	3.710	2.366%
	Low	0.452	2.836	1.843%
Canada	High	0.410	2.850	-0.001%
	Low	0.358	2.228	-0.041%
Germany	High	0.375	3.242	-0.196%
	Low	0.020	3.102	0.007%

Table 5.5: Summary Statistics of Assets Returns According to the Increase

Level of Integration

Table 5.5.1: Stock Market (MSCI stock)

	Change of Integration Level	Mean	SD	COV(world)	COV(region)
US	IN	0.436	4.344	0.149%	0.178%
	DE	0.469	4.146	0.138%	0.162%
Canada	IN	0.373	6.923	0.257%	0.308%
	DE	0.529	3.677	0.065%	0.053%
Japan	IN	0.476	6.096	0.162%	0.383%
	DE	0.119	6.429	0.178%	0.325%
Australia	IN	-0.125	8.417	0.257%	0.321%
	DE	1.209	4.553	0.052%	0.018%
HK	IN	0.372	11.143	0.343%	0.444%
	DE	1.038	6.288	0.028%	-0.016%
UK	IN	0.015	6.310	0.221%	0.287%
	DE	0.463	4.402	0.097%	0.150%
Germany	IN	0.538	6.859	0.256%	0.382%
	DE	0.334	5.136	0.046%	0.085%
Brazil	IN	0.919	19.493	0.508%	1.783%
	DE	1.463	13.163	0.084%	0.849%
Mexico	IN	0.918	10.064	0.261%	0.894%
	DE	2.056	7.954	0.060%	0.292%

Table 5.5.2: Bond Market (JP bond)

	Change of Integration Level	Mean	SD	COV
US	IN	-0.032	1.672	0.026%
	DE	0.337	0.883	0.006%
UK	IN	0.349	4.113	0.067%
	DE	0.511	2.124	0.019%
Japan	IN	-0.129	4.693	0.075%
	DE	0.305	2.231	0.018%
Australia	IN	0.170	3.540	0.038%
	DE	0.784	2.812	0.000%
Canada	IN	0.124	3.050	0.044%
	DE	0.630	1.571	-0.004%
Germany	IN	0.621	3.851	0.059%
	DE	-0.111	2.482	0.040%

Table 5.6: The Average Level of Integration (GARCH-filter model)

Table 5.6.1: Stock Market (MSCI stock)

Market index	Sample		Integration with the		Differences between the World and Region	
	Start time	End time	World	Region	Differences	T value
US	Jan-76	Sep-07	0.883	0.983	-0.099	-16.603
UK	Jan-76	Sep-07	1.030	1.051	-0.021	-3.929
Japan	Jan-76	Sep-07	1.095	1.042	0.053	5.451
Australia	Jan-76	Sep-07	1.004	0.562	0.443	26.104
Canada	Jan-76	Sep-07	0.894	0.863	0.031	8.906
Germany	Jan-76	Sep-07	0.917	0.966	-0.049	-5.615
Hong Kong	Jan-76	Sep-07	1.184	0.679	0.443	28.508
Brazil	Jan-89	Sep-07	2.116	1.506	0.610	12.345
Mexico	Jan-89	Sep-07	1.000	0.728	0.272	10.787

Table 5.6.2: Bond Market (JP bond)

Market index	Sample		Integration with the World Market
	Start time	End time	
US	Jan-87	Sep-07	0.477
UK	Jan-87	Sep-07	1.393
Japan	Jan-87	Sep-07	1.491
Australia	Jan-87	Sep-07	0.417
Canada	Jan-87	Sep-07	0.697
Germany	Jan-87	Sep-07	1.579

Table 5.6.3: Inter-bond-stock Market (MSCI stock and bond)

Market index	Sample		Integration of Stock-Bond	
	Start time	End time	Level	P value
US	Jan-95	Sep-07	-0.154	[0.536]
UK	Jan-95	Sep-07	0.298	[0.952]
Japan	Jan-95	Sep-07	0.451	[0.056]
Australia	Jan-95	Sep-07	0.833	[0.014]
Canada	Jan-95	Sep-07	0.950	[0.144]
Germany	Jan-95	Sep-07	0.154	[0.168]

Table 5.7: Contagion of Stock Market

Table 5.7.1: Joint Dummy Variable

	The World Return Residual			The Regional Return Residual		
			LR test			LR test
	v0	v1	v0=v1=0	v0	v1	v0=v1=0
				The north American market		
US	-0.0028	0.0191	107.8760	-0.0027	0.0144	19.5040
	[0.3435]	[0]	[0]	[0.2809]	[0]	[0]
Canada	-0.0178	0.1475	20.3638	-0.0071	0.0895	3.5210
	[0.3653]	[0]	[0]	[0.6847]	[0.0108]	[>0.1]
				The European market		
UK	0.0008	0.1098	6.9372	-0.0116	0.1442	6.8358
	[0.9482]	[0.0001]	[<0.05]	[0.2643]	[0]	[<0.05]
Germany	-0.0258	0.1099	30.2754	-0.0338	0.0806	16.2534
	[0.2715]	[0]	[0]	[0.0729]	[0.001]	[0]
				The Pacific market		
Japan	-0.0646	0.1292	51.4620	-0.0099	0.0341	7.9920
	[0]	[0]	[0]	[0.2346]	[0.0134]	[<0.025]
Australia	-0.0615	0.4459	22.5000	-0.0073	0.0776	2.7092
	[0.1074]	[0]	[0]	[0.7751]	[0.0761]	[>0.25]
HK	-0.1042	0.5426	30.6320	-0.0530	0.3531	24.8946
	[0.022]	[0]	[0]	[0.1191]	[0]	[0]
				The Latin American market		
Brazil	-0.1921	0.4967	8.8170	-0.0119	0.1499	12.4640
	[0.0138]	[0.0162]	[<0.025]	[0.7274]	[0]	[0]
Mexico	-0.0683	0.3886	8.0868	-0.0205	0.2286	7.5032
	[0.2637]	[0]	[<0.025]	[0.4551]	[0.0482]	[<0.025]

Table 5.7.2:

	The World Return Residual				The Regional Return Residual			
				LR test				LR test
	v0	v1	v2	v0=v1=v2=0	v0	v1	v2	v0=v1=v2=0
					The north American market			
US	0.007	-3.310	0.772	77.864	-0.005	2.674	4.302	29.738
	[0.386]	[0.402]	[0]	[0]	[0.274]	[0.108]	[0]	[0]
Canada	0.003	-0.649	6.284	106.400	-0.008	1.558	3.210	16.508
	[0.953]	[0.964]	[0]	[0]	[0.761]	[0.7483]	[0]	[0]
					The European market			
UK	0.019	-12.687	3.136	70.622	0.036	-14.107	3.689	76.972
	[0.348]	[0.088]	[0]	[0]	[0.025]	[0.0099]	[0]	[0]
Germany	-0.003	2.715	3.256	81.055	0.032	-4.537	2.295	57.559
	[0.949]	[0.733]	[0]	[0]	[0.406]	[0.478]	[0]	[0]
					The Pacific market			
Japan	-0.015	1.037	1.290	113.146	0.034	-6.328	7.029	48.384
	[0.565]	[0.856]	[0]	[0]	[0.006]	[0.001]	[0]	[0]
Australia	-0.992	138.887	1.467	59.215	0.850	-117.685	1.177	72.583
	[0]	[0.001]	[0]	[0]	[0.002]	[0.003]	[0]	[0]
HK	0.060	-17.183	1.215	38.139	-0.036	1.254	1.213	79.375
	[0.529]	[0.047]	[0]	[0]	[0.512]	[0.836]	[0]	[0]
					The Latin American market			
Brazil	0.034	-2.514	18.952	71.595	0.042	-0.366	2.091	55.307
	[0.789]	[0.397]	[0]	[0]	[0.309]	[0.754]	[0]	[0]
Mexico	0.218	-21.725	0.039	4.332	-0.016	2.031	0.103	14.666
	[0.124]	[0.089]	[0.07]	[>0.1]	[0.792]	[0.657]	[0]	[0]

Table 5.8: Contagion of Bond Market

Table 5.8.1: Joint Dummy Variable

| | The World Return Residual | | |
| | | | LR test |
	v0	v1	v0=v1=0
US	-0.1597	0.2696	43.7308
	[0.0001]	[0]	[0]
UK	-0.2270	0.4082	30.0040
	[0.0022]	[0]	[0]
Japan	-0.2413	0.7841	59.7854
	[0.0046]	[0]	[0]
Australia	0.0546	0.4107	5.5948
	[0.5882]	[0.0101]	[<0.10]
Canada	-0.2341	0.6310	19.0678
	[0.0007]	[0]	[0]
Germany	-0.2320	0.4794	26.2214
	[0.0001]	[0]	[0]

Table 5.8.2:

| | The World Return Residual | | | |
| | | | | LR test |
	v0	v1	v2	v0=v1=v2=0
US	-0.070	310.075	10.790	92.430
	[0.595]	[0.686]	[0]	[0]
UK	-0.156	104.621	7.718	77.740
	[0.193]	[0.393]	[0]	[0]
Japan	-0.109	67.073	4.873	86.924
	[0.493]	[0.737]	[0]	[0]
Australia	-0.164	279.386	0.959	38.483
	[0.514]	[0.187]	[0]	[0]
Canada	-0.034	18.692	28.503	122.781
	[0.891]	[0.961]	[0]	[0]
Germany	0.062	-100.308	9.606	45.105
	[0.898]	[0.835]	[0]	[0]

Table 5.9: Contagion of Inter-bond-stock Market

Table 5.9.1: Joint Dummy Variable

|	The Corresponding National Bond Return Residual		
	v0	v1	LR test v0=v1=0
US stock	-0.0341	0.0056	5.5768
	[0.0752]	[0.8663]	[<0.1]
UK stock	0.0829	0.0118	5.2936
	[0.0532]	[0.8306]	[<0.1]
Japan stock	0.0634	-0.0085	1.8884
	[0.1505]	[0.9148]	[>0.25]
Australia stock	0.4106	0.1256	31.4130
	[0.0002]	[0.2654]	[0]
Canada stock	0.5197	0.6618	40.4850
	[0]	[0.0005]	[0]
Germany stock	0.0212	0.2772	3.9898
	[0.8888]	[0.0463]	[>0.1]

Table 5.9.2:

	The Corresponding National Bond Return Residual			
	v0	v1	v2	LR test v0=v1=v2=0
US stock	0.025	-30.360	0.014	9.615
	[0.495]	[0.060]	[0.623]	[<0.025]
UK stock	0.325	-200.266	0.275	17.983
	[0.007]	[0.008]	[0.006]	[0]
Japan stock	0.032	3.668	0.482	3.026
	[0.859]	[0.932]	[0.334]	[>0.25]
Australia stock	0.504	-14.875	0.918	28.098
	[0.097]	[0.880]	[0.506]	[0]
Canada stock	0.560	6.082	1.535	47.200
	[0.001]	[0.841]	[0]	[0]
Germany stock	0.193	-11.983	1.109	6.723
	[0.452]	[0.793]	[0.001]	[<0.05]

Table 5.10: The Average Level of Contagion

Table 5.10.1: Stock Market (MSCI stock)

Market Index	The Average Level of Contagion with		The Average Level of Contagion with		Differences between the World and Region	
	The World	T Value	The Region	T Value	Differences	T Value
US	0.110%	1.499	-0.019%	-0.243	0.129%	1.314
Canada	1.817%	2.423	0.374%	1.012	1.443%	2.143
UK	-4.442%	-6.937	-3.511%	-5.552	-0.931%	-3.030
Germany	1.031%	1.117	1.606%	3.440	-0.575%	-0.699
Japan	-1.146%	-2.983	0.508%	2.088	-1.654%	-3.789
Australia	1.933%	2.115	84.754%	126.721	-82.821%	-76.347
Hong Kong	-10.232%	-13.634	-2.181%	-2.560	-8.051%	-7.282
Brazil	-9.279%	-2.563	2.393%	3.065	-11.672%	-3.385
Mexico	2.205%	2.919	0.380%	1.911	1.825%	1.808

Table 5.10.2: Bond Market (JP Morgan)

Market Index	The Average Level of Contagion	T Value
US	-3.641%	-2.886
UK	-6.246%	-3.016
Japan	-1.793%	-0.781
Australia	14.855%	5.396
Canada	-2.863%	-0.979
Germany	-4.613%	-2.760

Table 5.10.3 inter-bond-stock market (MSCI stock and bond)

Market Index	The Average Level of Contagion	T Value
US	-3.029%	-11.626
UK	3.456%	2.704
Japan	4.417%	16.165
Australia	46.518%	197.223
Canada	57.551%	33.538
Germany	13.907%	6.998

Figure 3.1: The Integration Level of National Market with the World

The following model is estimated

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t},$$

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_w X_{w,t-1}$$

$$\varepsilon_{i,t} = \gamma_{i,t-1}\varepsilon_{w,t} + e_{i,t}, \qquad \gamma_{iw,t} = \gamma_{iw,t-1} + \eta_{iw,t},\ ,$$

$$h_{i,t} = \mathrm{var}(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2$$

$\gamma_{iw,t}$ represent the integration level.

UK

Japan

Hong Kong

Singapore

Brazil

Mexico
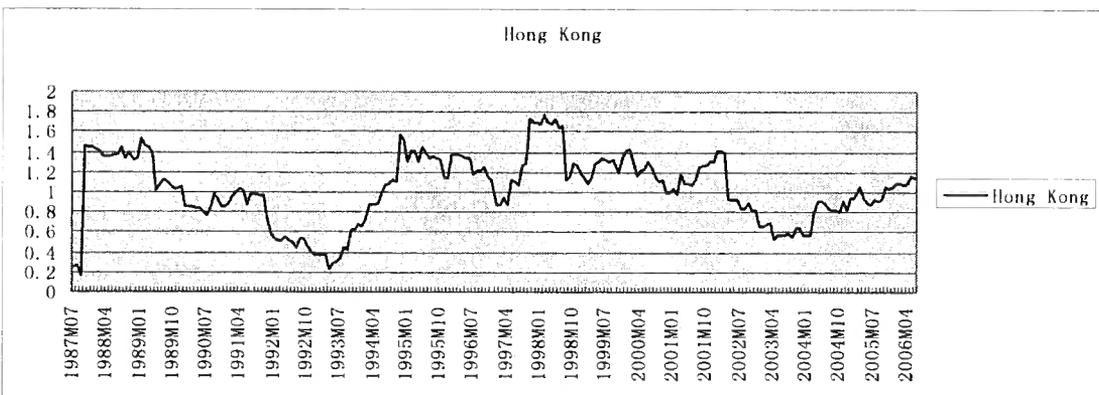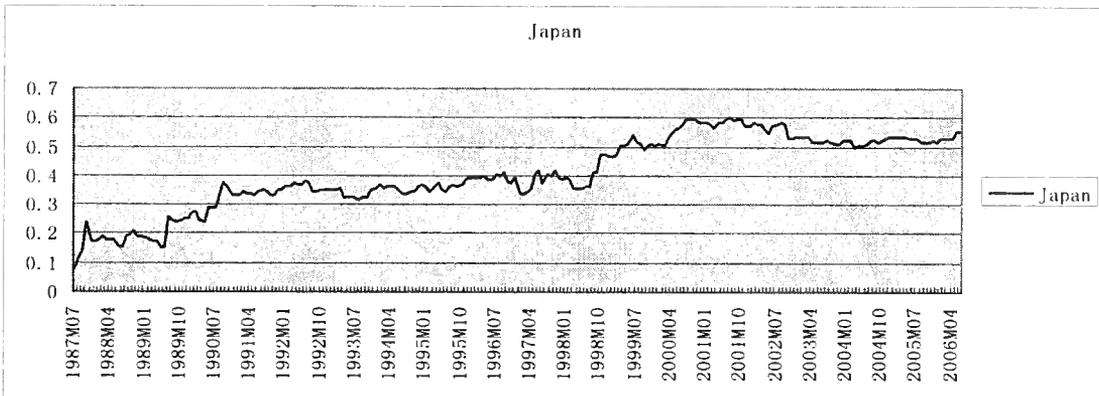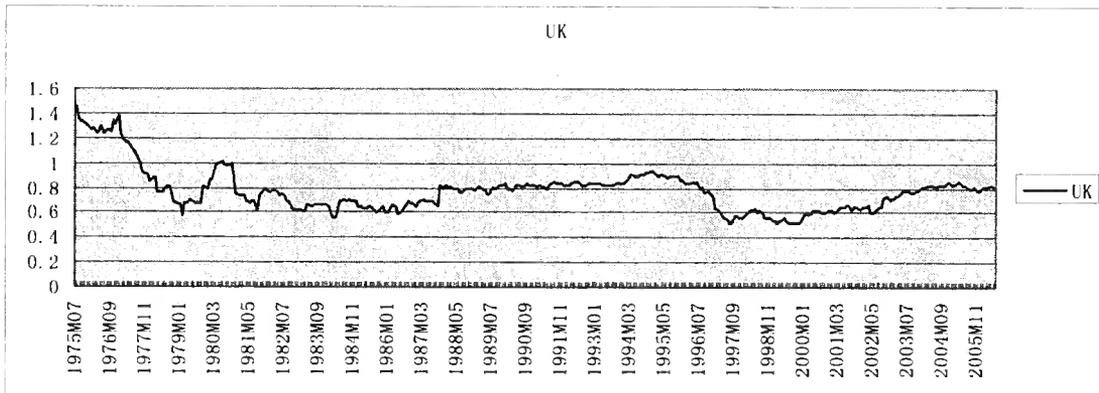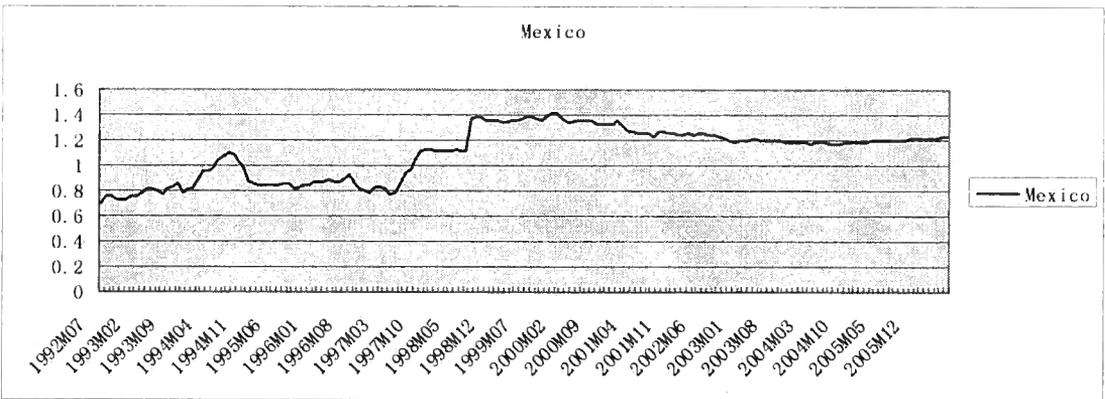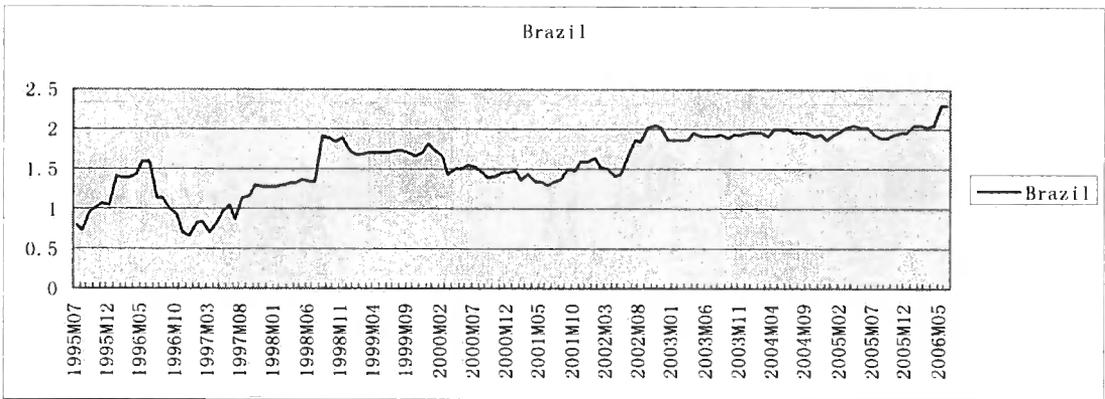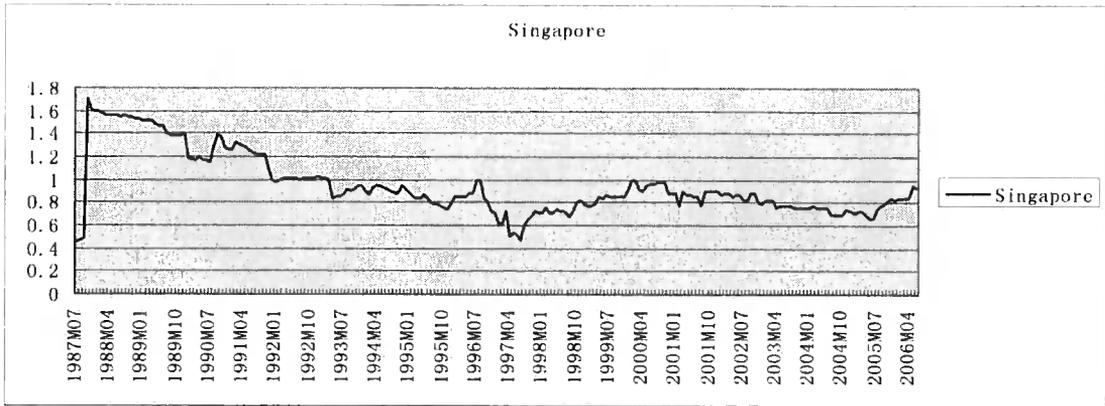
Figure 3.2: The Integration Level of Different Portfolios with the World

The following model is estimated:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t}, \quad \text{or}$$

$$r_{i,t} = \mu_{i,t-1} + s_{ix}SMB_{x,t} + h_{ix}HML_x + s_{iUS}SMB_{US,t} + h_{iUS}HML_{US,t} + \varepsilon_{it}^{\bullet}$$

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_x X_{x,t-1} + \delta_w X_{w,t-1}$$

$$\varepsilon_{i,t}(or\varepsilon_{i,t}^{\bullet}) = \gamma_{iw,t-1}e_{w,t} + e_{i,t} \qquad \gamma_{iw,t} = \gamma_{iw,t-1} + \eta_{iw,t},$$

$$h_{i,t} = var(e_{i,t}|\Omega_{t-1}) = \alpha_{i0} + \alpha_{i1}e_{i,t-1}^2 + \alpha_{i2}h_{t-1} + \alpha_{i3}\xi_{i,t-1}^2$$

$\gamma_{iw,t}$ represents the integration level with the world market.

UK

UK (SMB HML are added)

UK

UK (SMB HML are added)

223

Japan

Japan (SMB HML are added)

Japan

Japan (SMB HML are added)

224

Hong Kong

HK (SMB HML are added)

Hong Kong

HK (SMB HML are added)

225

Singapore

Singapore (SMB HML are added)

Singapore

Singapore (SMB HML are added)

226

Brazil

Brazil (SMB HML are added)

Brazil

Brazil (SMB HML are added)

227

Mexico

Mexico (SMB HML are added)

Mexico

Mexico (SMB HML are added)

228
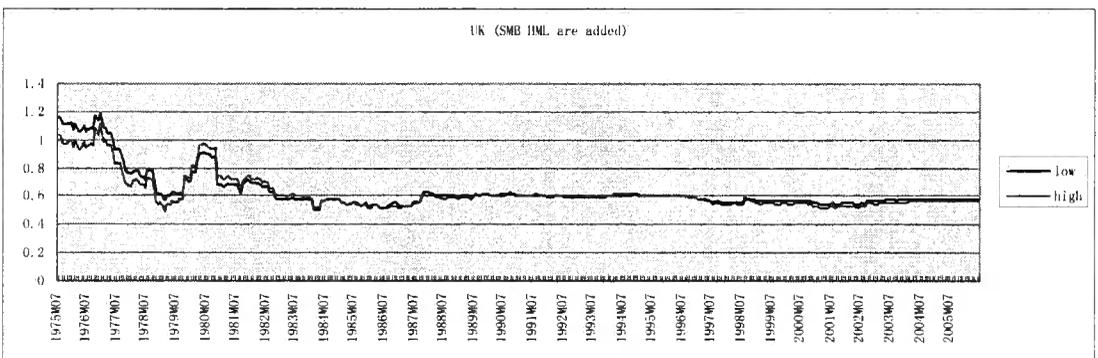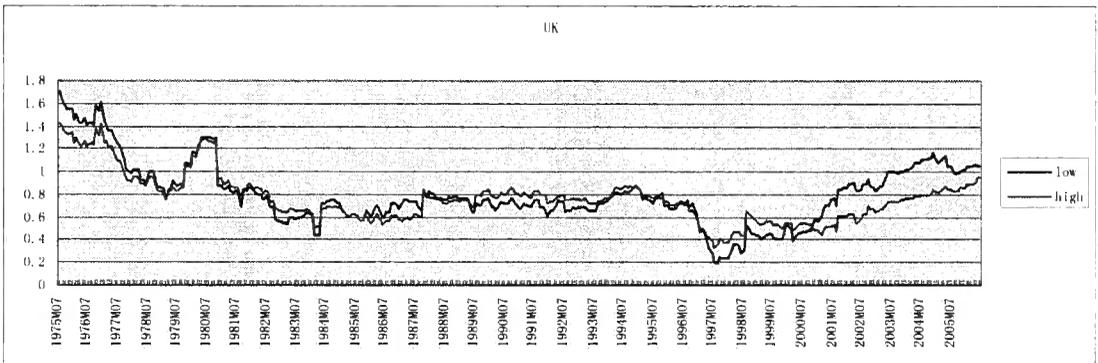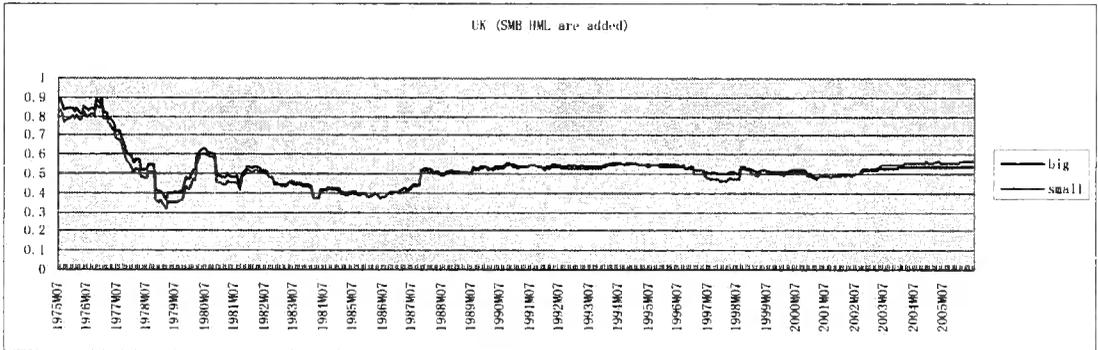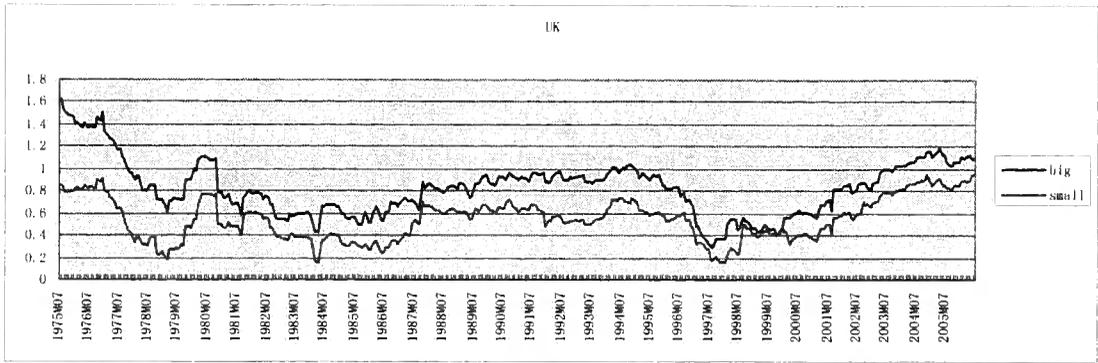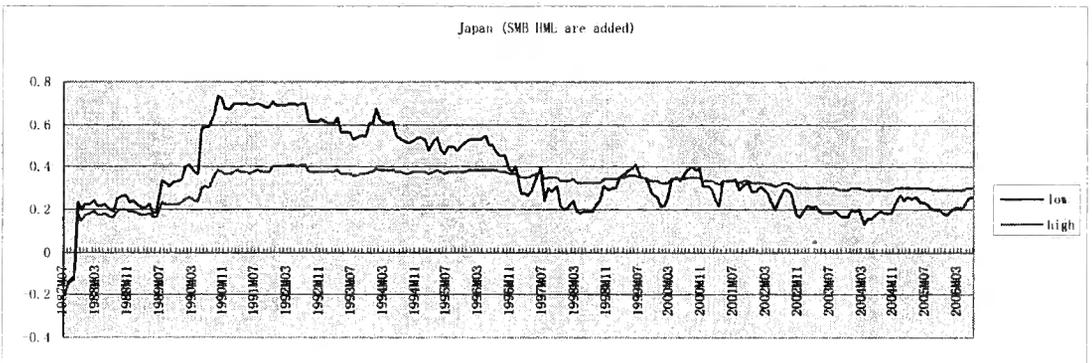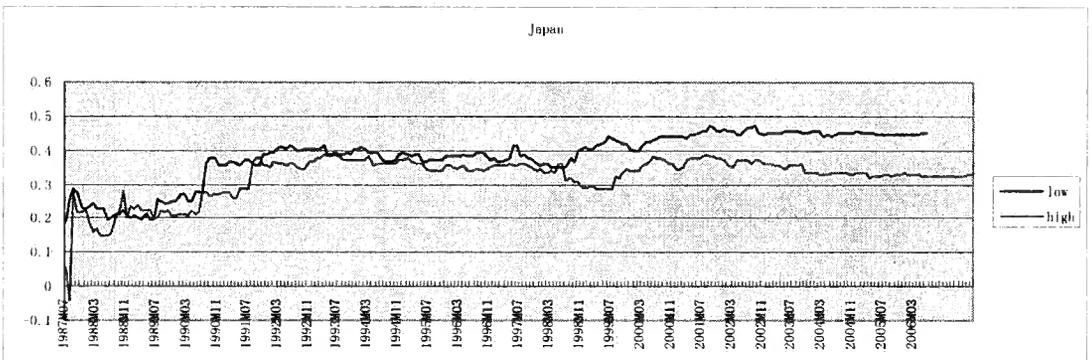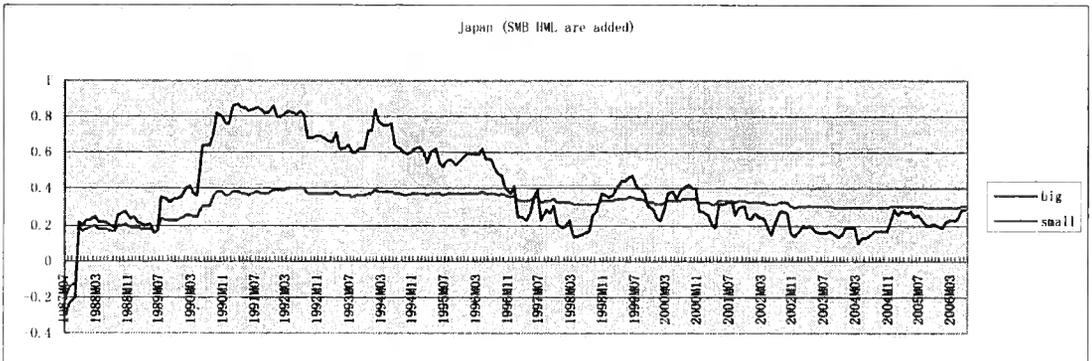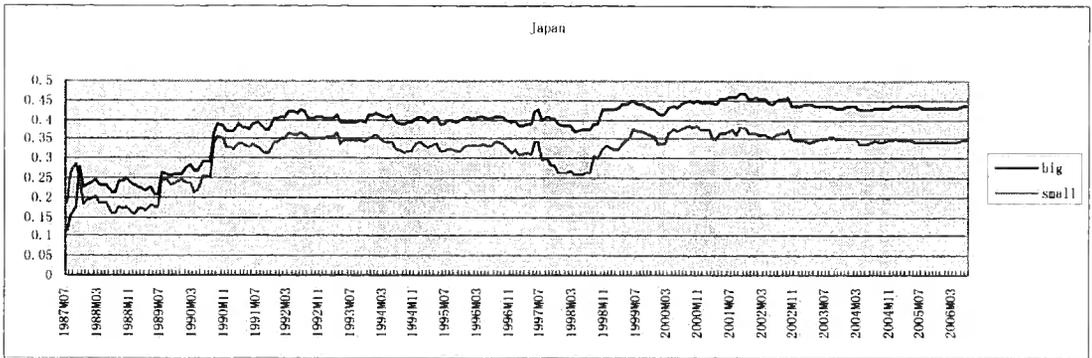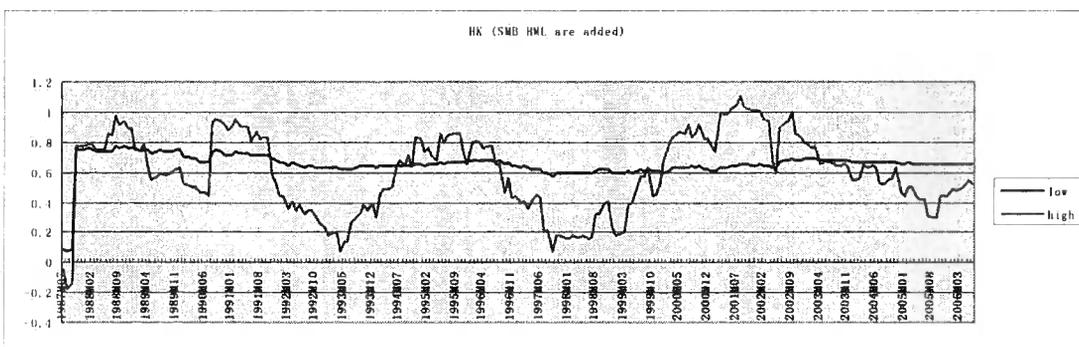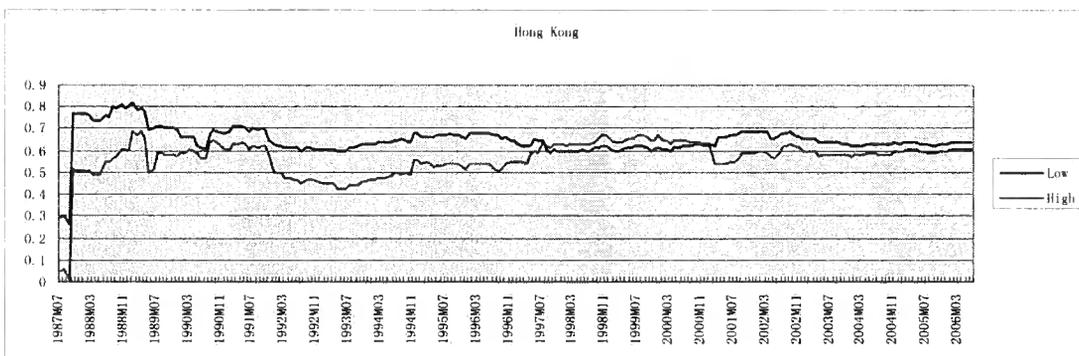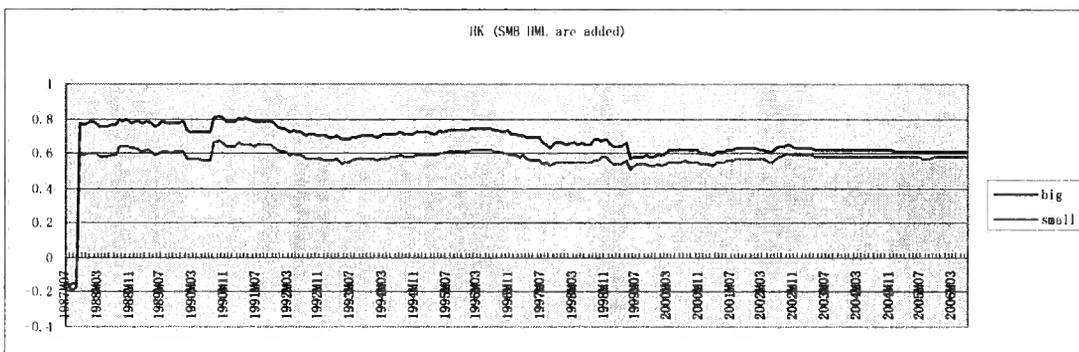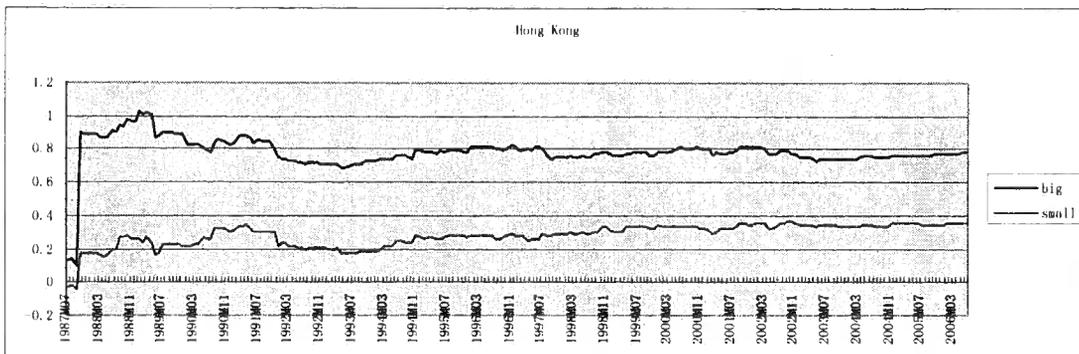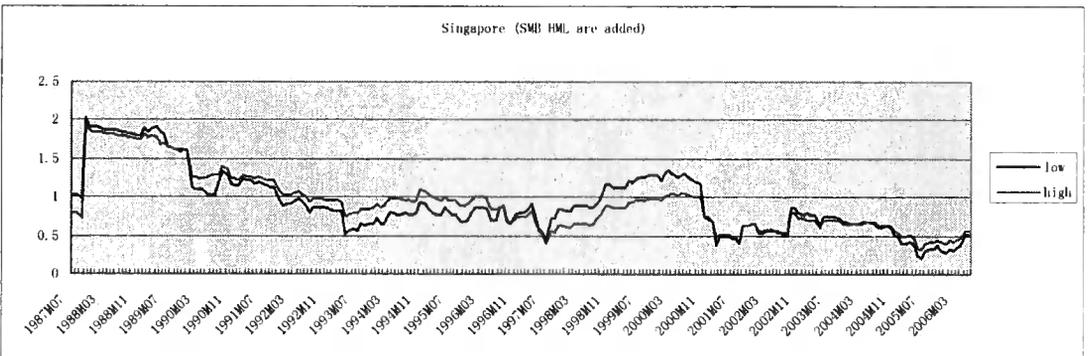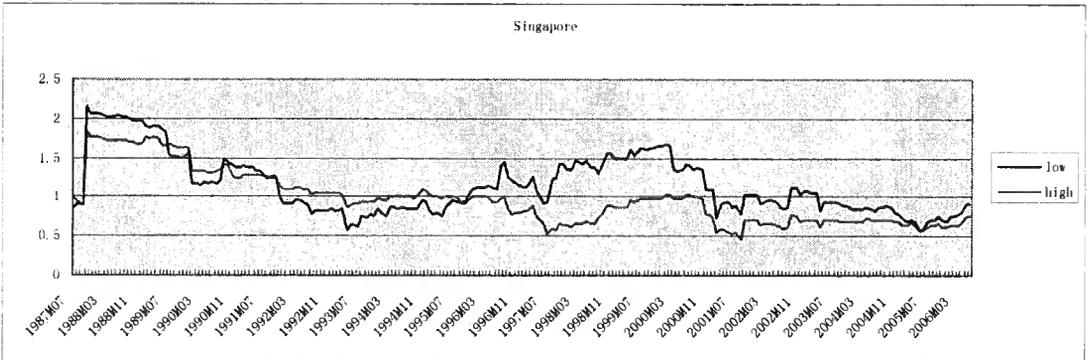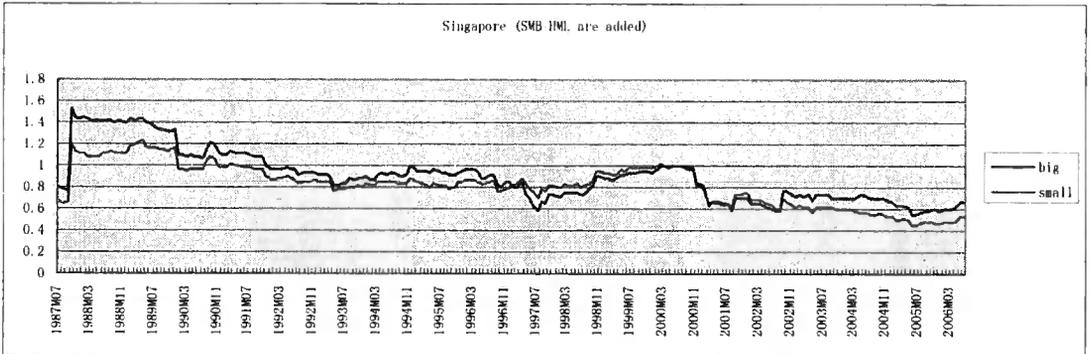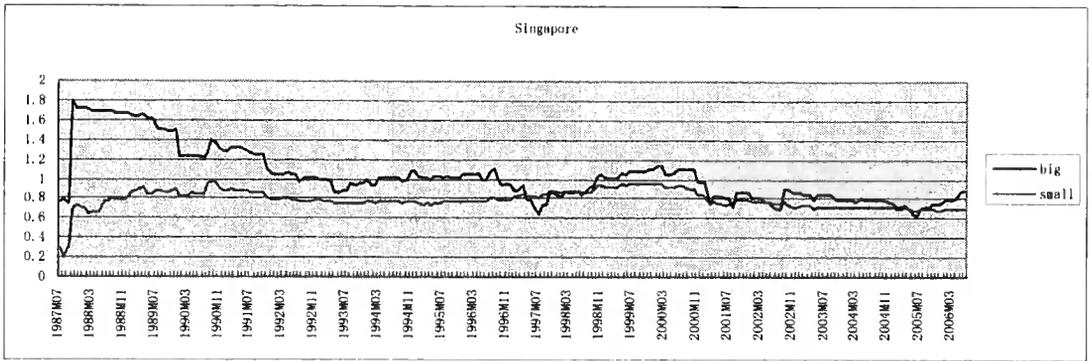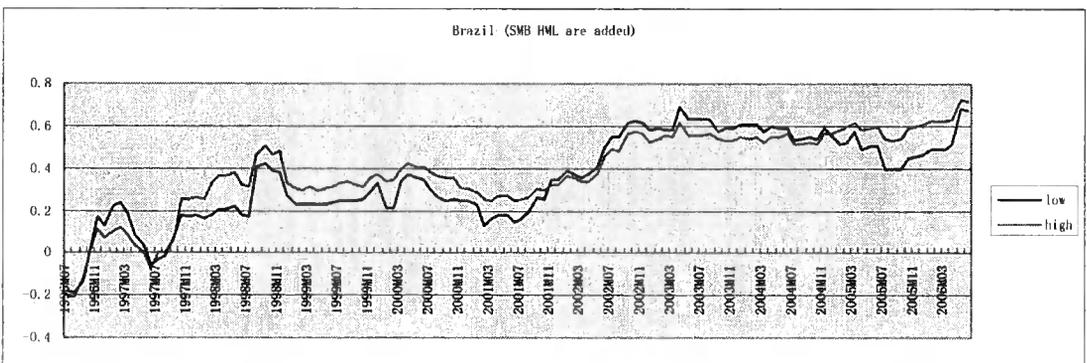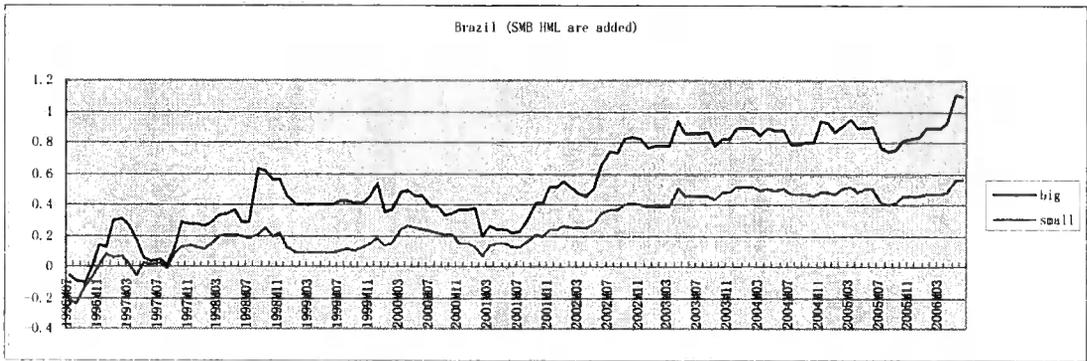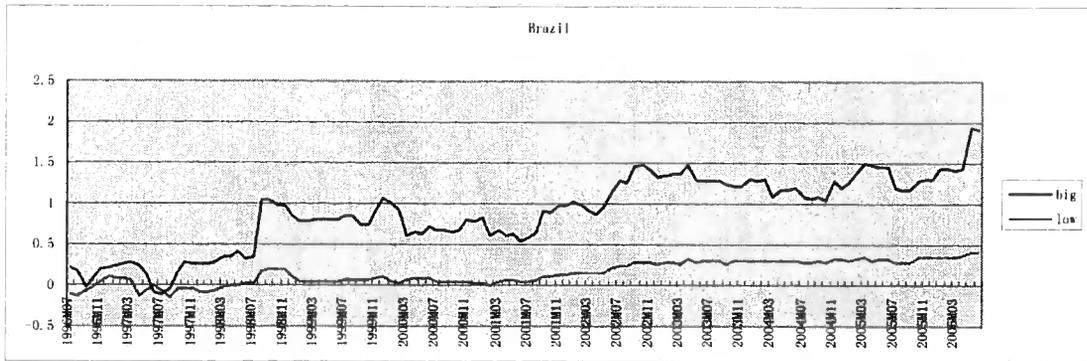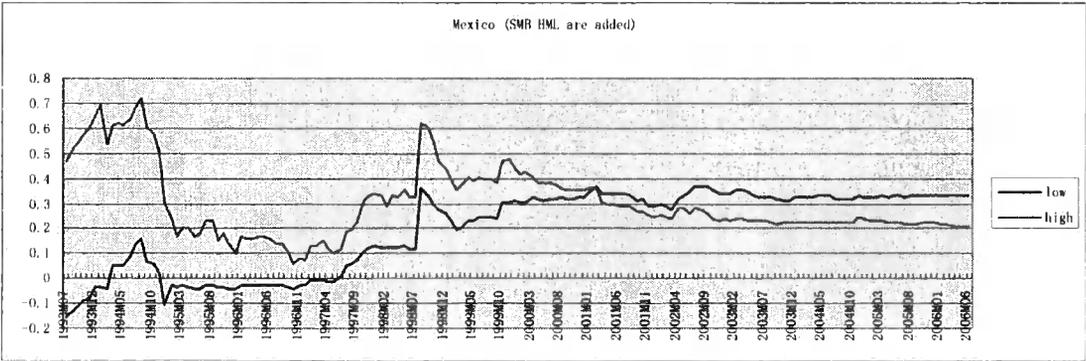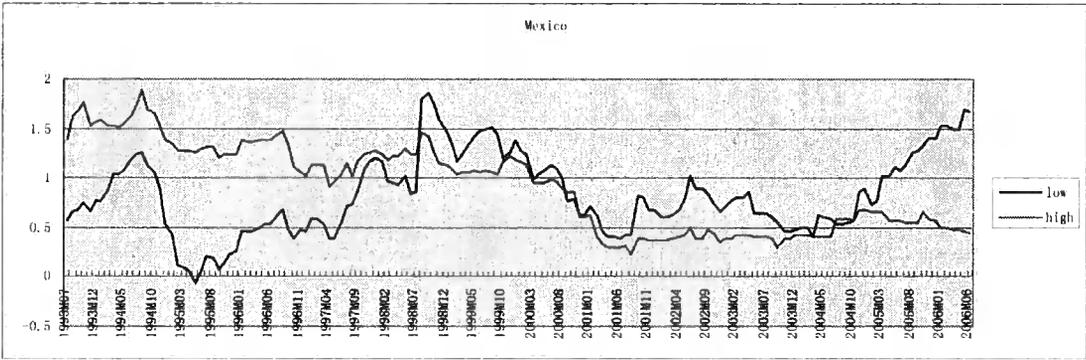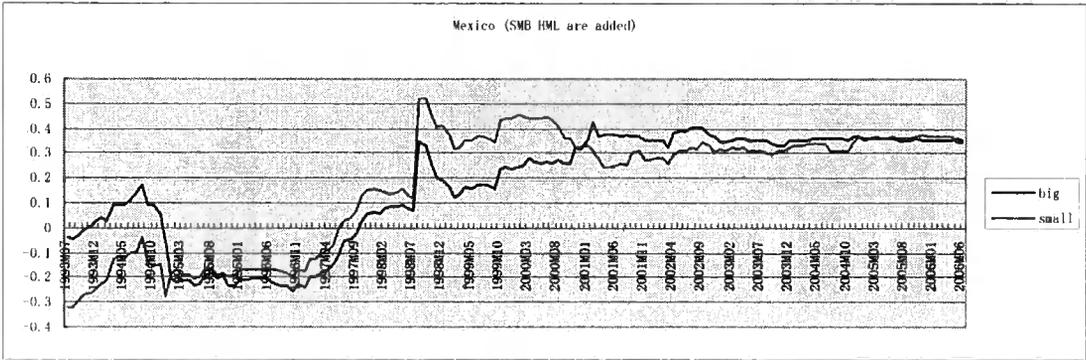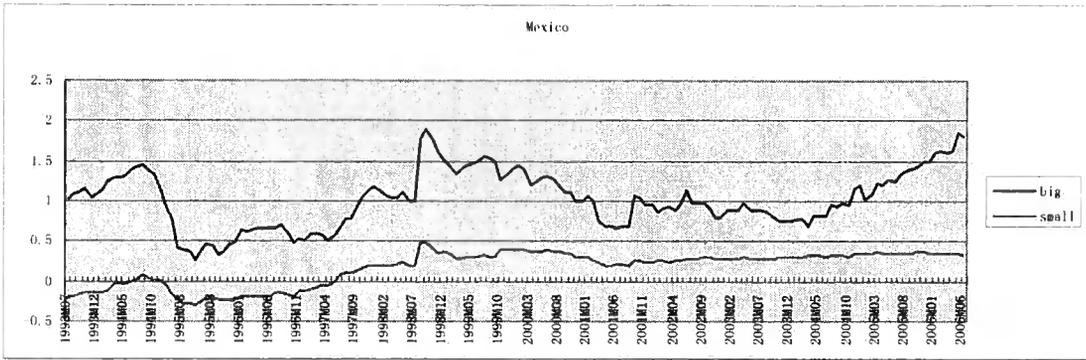
Figure 3.3: The Integration Levels of Different Portfolios with the World and National Markets.

The following model is estimated:

$$r_{i,t} = \mu_{i,t-1} + \varepsilon_{i,t},$$

$$\mu_{i,t-1} = \delta_i X_{i,t-1} + \delta_x X_{x,t-1} + \delta_w X_{w,t-1}$$

$$\varepsilon_{i,t} = \gamma_{iw,t-1} e_{w,t} + \gamma_{ix,t-1} e_{x,t} + e_{i,t} \qquad \gamma_{iw,t} = \gamma_{iw,t-1} + \eta_{iw,t}, \quad \gamma_{ix,t} = \gamma_{ix,t-1} + \eta_{ix,t},$$

$$h_{i,t} = \mathrm{var}(e_{i,t} \mid \Omega_{t-1}) = \alpha_{i0} + \alpha_{i1} e_{i,t-1}^2 + \alpha_{i2} h_{t-1} + \alpha_{i3} \xi_{i,t-1}^2$$

$\gamma_{iw,t}$ represents the integration level of a specific portfolio with the world market.

$\gamma_{ix,t}$ represents the integration l evel of a specific portfolio with the national market.

UK: big portoflio

UK: small portfolio

UK: low portfolio

UK: high portfolio

230

Japan: big portfolio

Japan: small portfolio

Japan: low portfolio

Japan: high portfolio

231

HK: big portfolio

HK: small portfolio

HK: low portfolio

HK: high portfolio

232

Singapore: big portfolio

Singapore: small portfolio

Singapore: low portfolio

Singapore: high portfolio

233

Brazil: big portfolio

Brazil: small portfolio

Brazil: low portfolio

Brazil: high portfolio

234

Mexico: big portfolio

Mexico: small portfolio

Mexico: low portfolio

Mexico: high portfolio

Figure 3.4: Variance Ratios

The following variance ratios are computed:

$$VR_{iw,t} = \frac{\gamma_{iw,t}^2 \sigma_{w,t}^2}{h_{i,t}}$$

$$VR_{ix,t} = \frac{\gamma_{ix,t}^2 \sigma_{ix,t}^2}{h_{i,t}}$$

UK: big portfolio

UK: small portfolio

UK: low portfolio

UK: high portfolio

237

Japan: big portfolio

Japan: small portfolio

Japan: low portfolio

Japan: high portfolio

238

HK: big portfolio

HK: small portfolio

HK: low portfolio

HK: high portfolio

Singapore: big portfolio

Singapore: small portfolio

Singapore: low portflio

Singapore: high portfolio

240

Brazil: big portfolio

Brazil: small portfolio

Brazil: low portfolio

Brazil: high portfolio

241

Mexico: big portfolio

Mexico: small portfolio

Mexico: low portfolio

Mexico: high portfolio

Figure 4.1: Integration of Different Bond Portfolios with the World and National Market

243

UK: integration with the world stock market

UK: integration with the national stock market

Japan: integration with the world bond market

Japan: integration with the world stock market

Japan: integration with the national stock market

Australia: integration with the world bond market

Australia: integration with the world stock market

Australia: integration with the national stock market

Canada: integration with the world bond market

Canada: integration with the world stock market

Canada: integration with the national stock market

Germany: integration with the world bond market

Germany: integration with the world stock market

Legend: 1-3Y, 3-5Y, 5-7Y, 7-10Y, 10+Y

Germany: integration with the national stock market

Legend: 1-3Y, 3-5Y, 5-7Y, 7-10Y, 10+Y

Figure 4.2: Volatility Explained by the World Bond Market.

US: Volatility explained by the world bond market

UK: Volatility explained by the world bond market

Japan: Volatility explained by the world bond market

Australia: Volatility explained by the world bond market
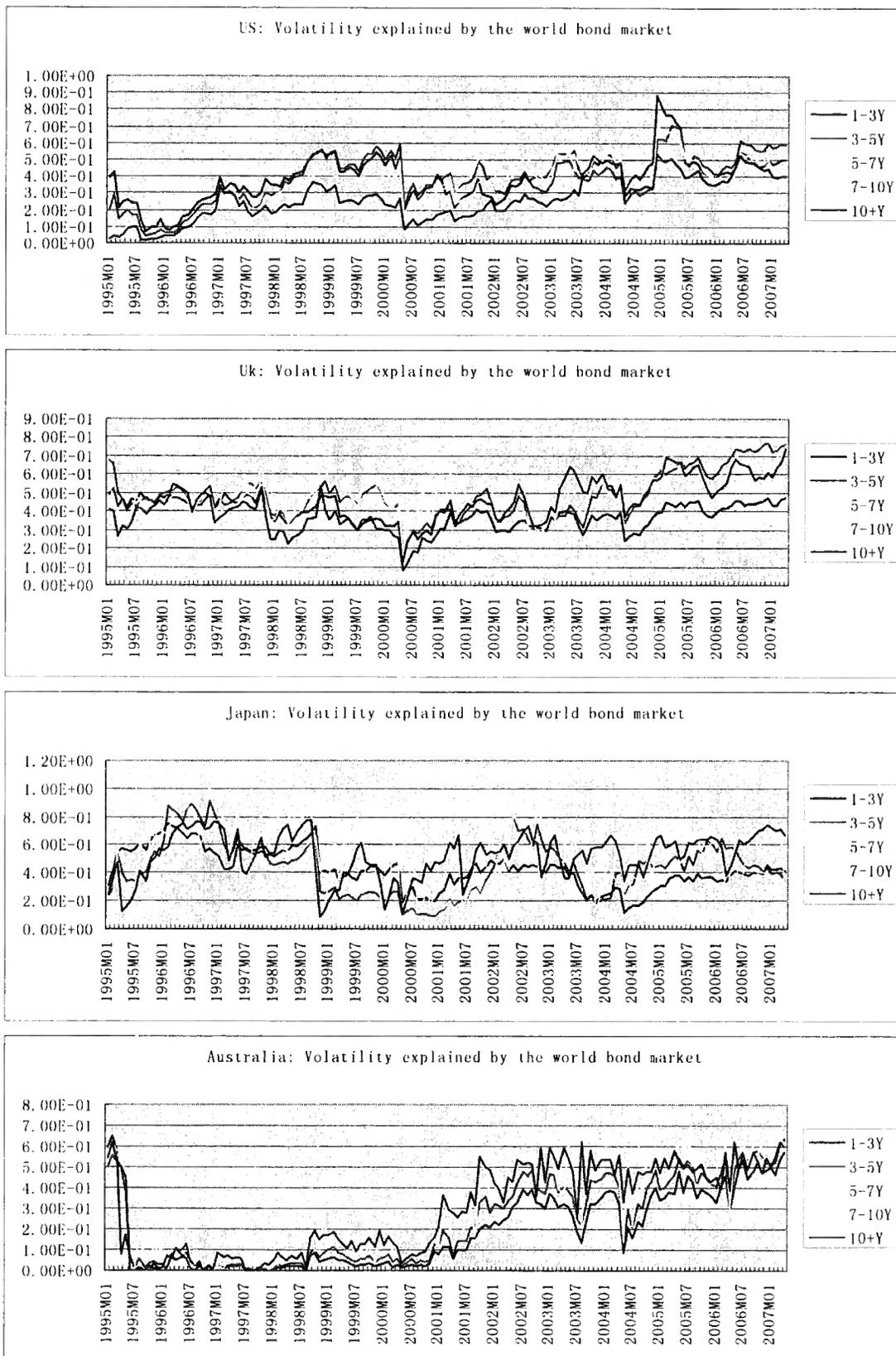
Canada: Volatility explained by the world bond market
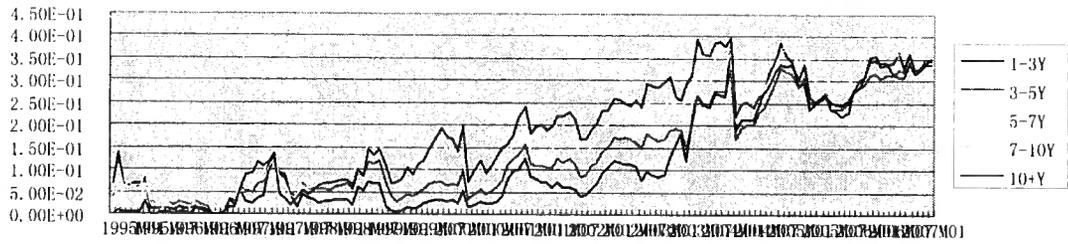
Germany: Volatility explained by the world bond market

249
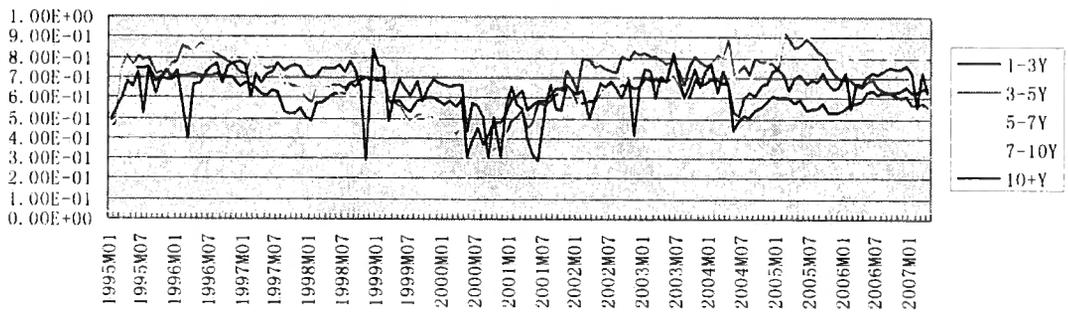
Figure 5.1: The Conditional Variance of Mexico Stock Market
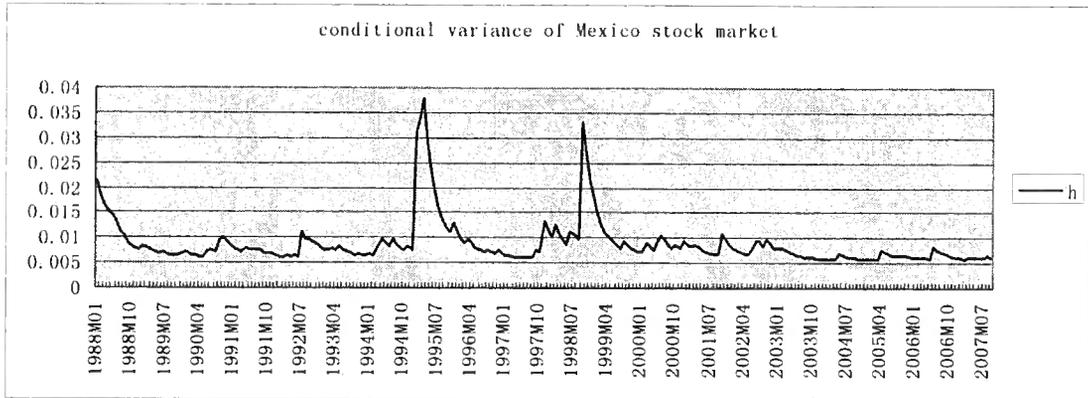
Figure 5.2: Time-varying Integration

Figure 5.2.1: Stock Market

Japan stock market integration

Australia stock market integration

HK stock market integration

UK stock market integration

Germany stock market integration

Brail stock market integration

Mexico stock market integration

Figure 5.2.2: Bond Market

the US bond market integration

UK bond market integration

Japan bond market integration

Australia bond market integration

Canada bond market integration

Germany bond market integration

Figure 5.2.3: Inter-bond-stock Market

the US: integration of inter-bond-stock market
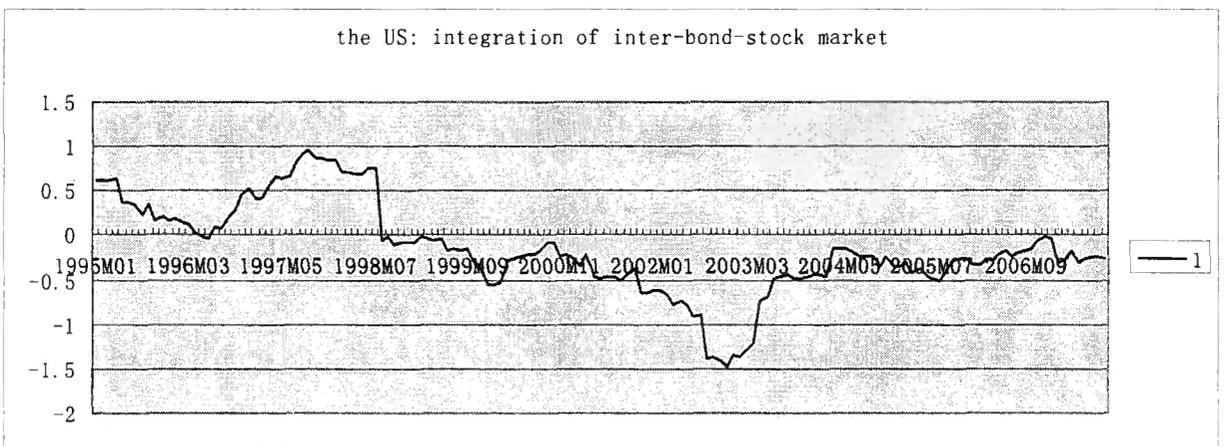
UK: integration of inter-bond-stock market
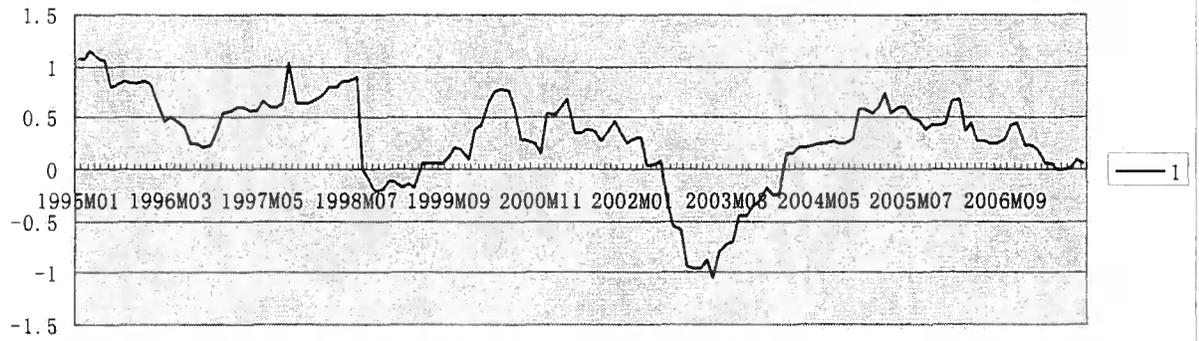
Japan: integration of inter-bond-stock market
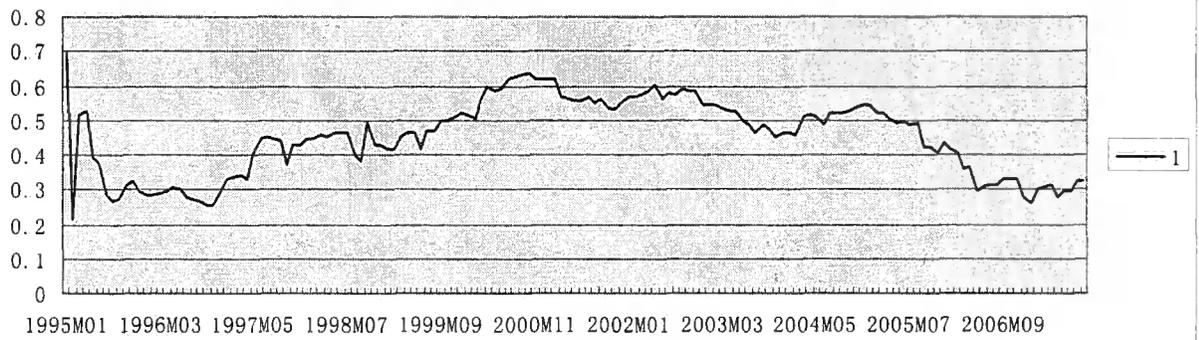
Australia: integration of inter-bond-stock market
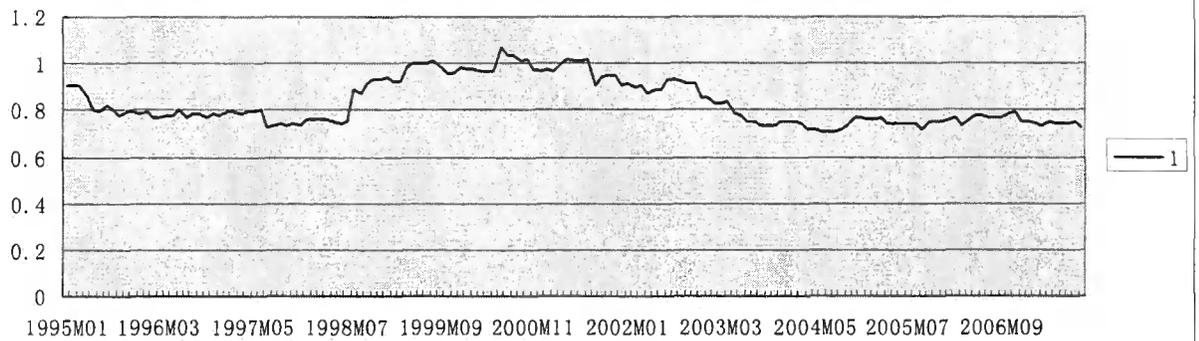
Canada: integration of inter-bond-stock market
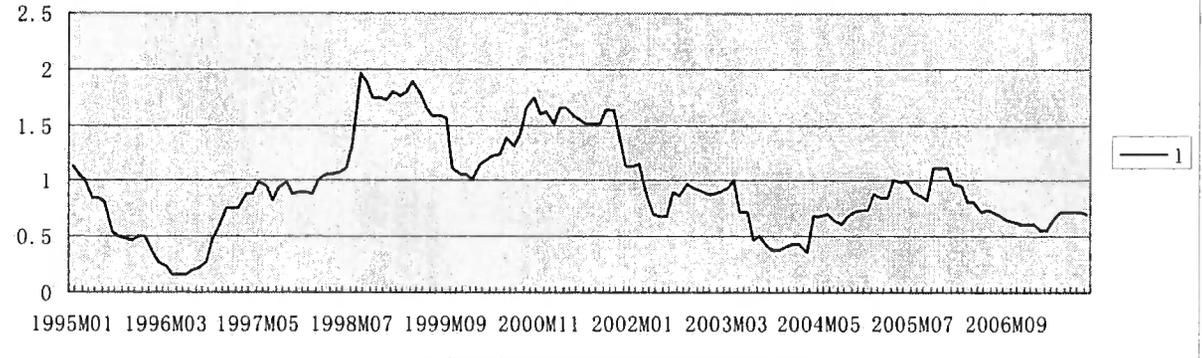
Germany: integration of inter-bond-stock market
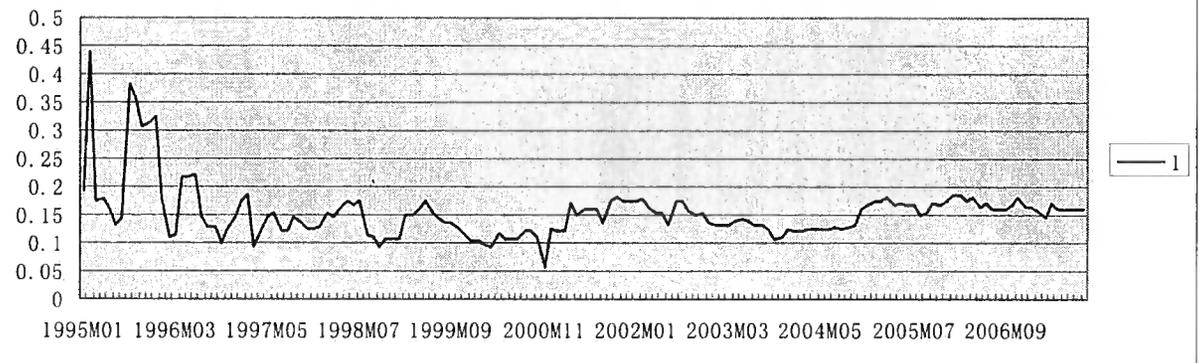
Figure 5.3: The Conditional Variance

US stock: the conditional variance

Canada stock: the conditional variance

Japan stock: the conditional variance

Australia stock: the conditional variance

HK stock: the conditional variance

UK stock: the conditional variance

Germany stock: the conditional variance

Brazil stock: the conditional variance

Mexico stock: the conditional variance

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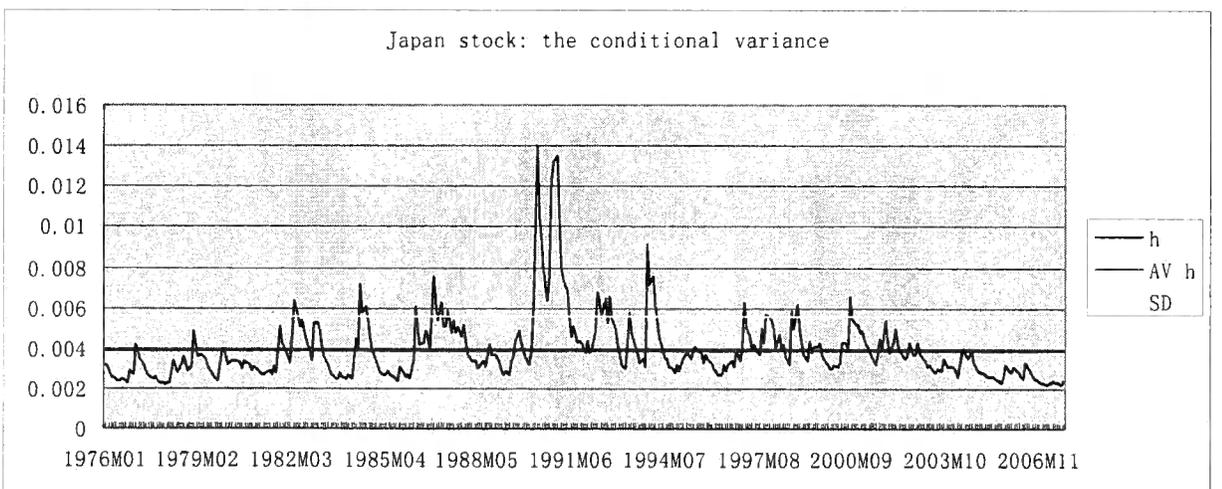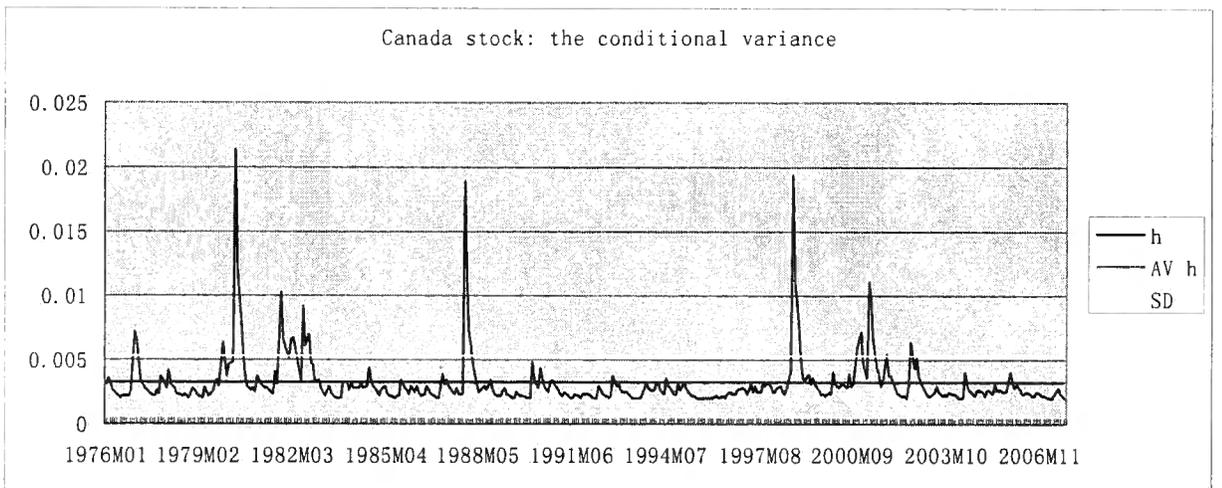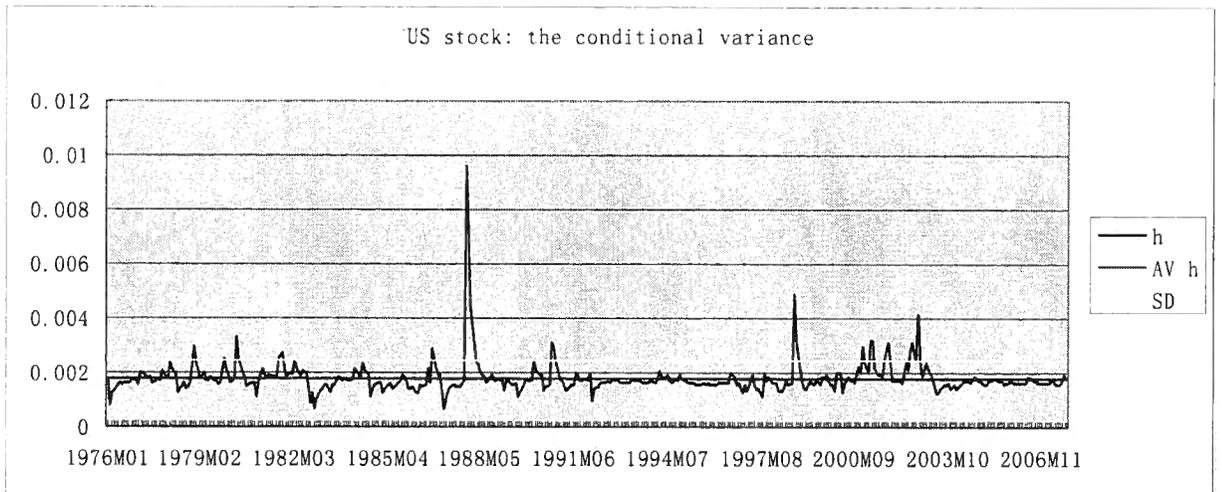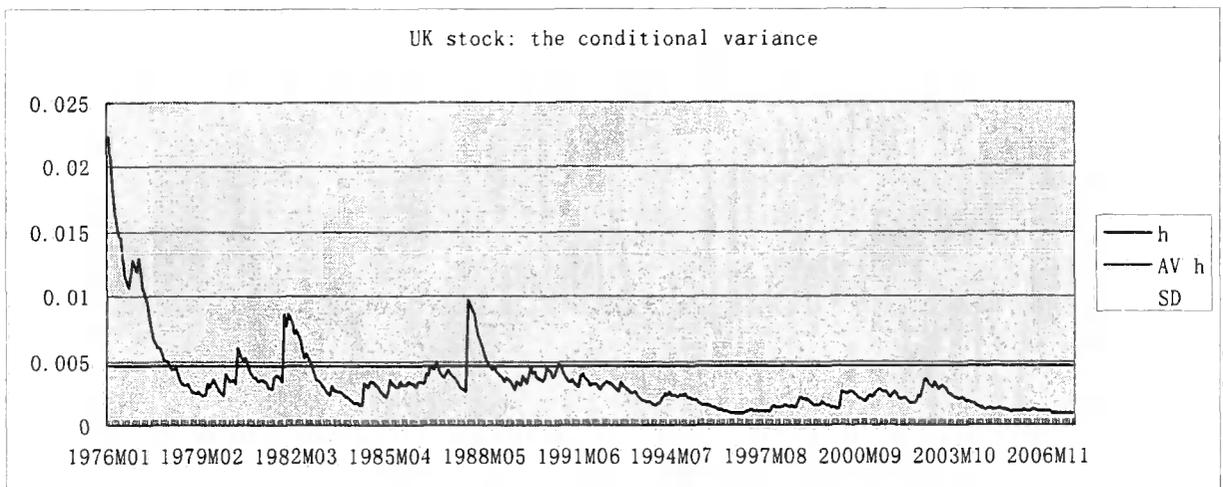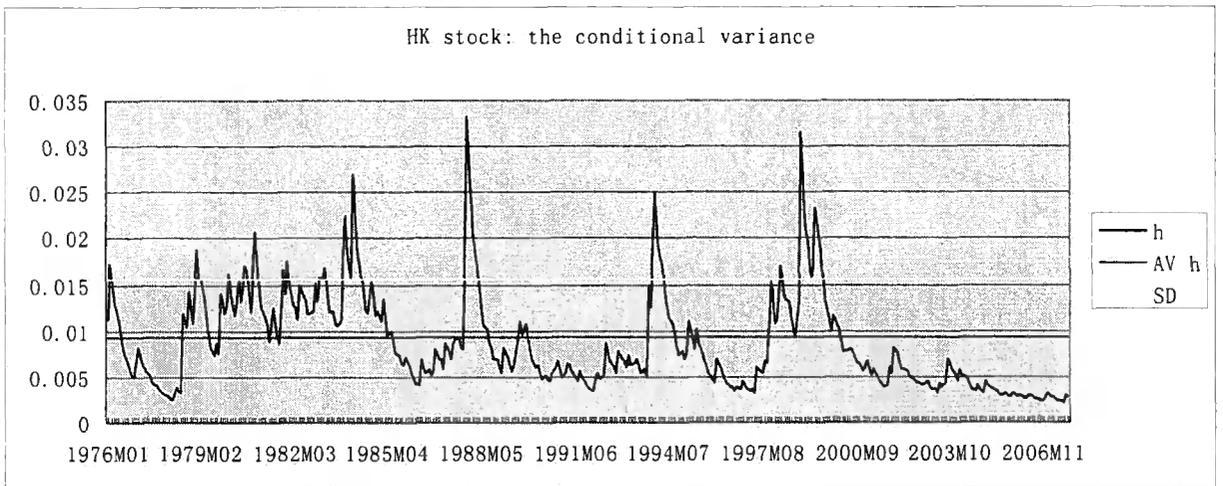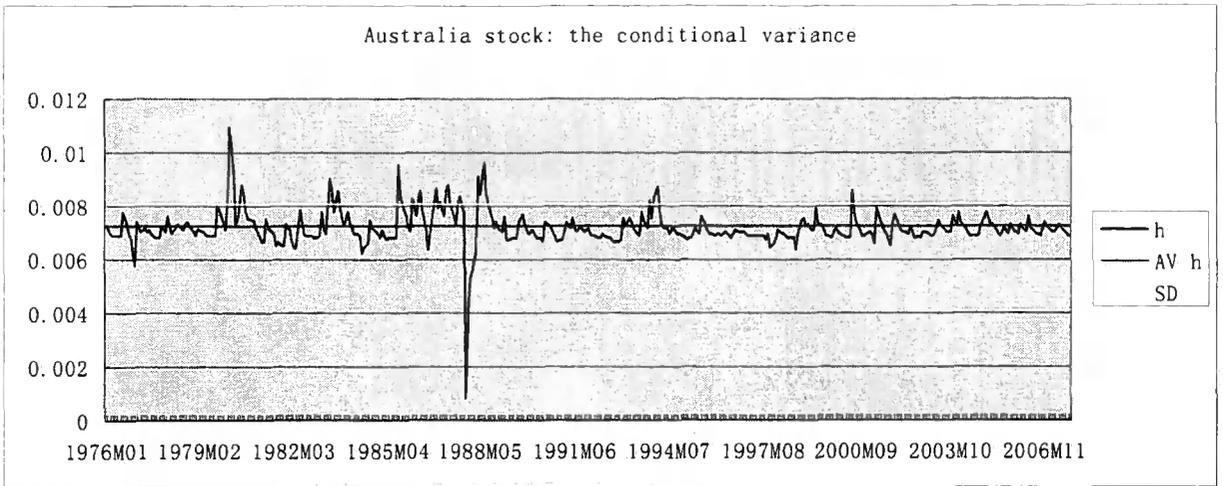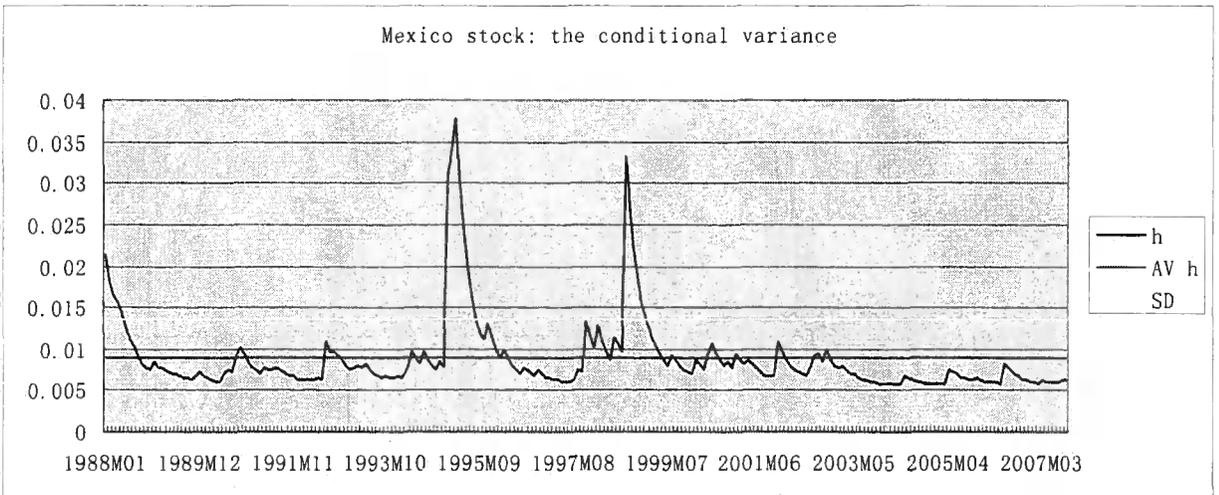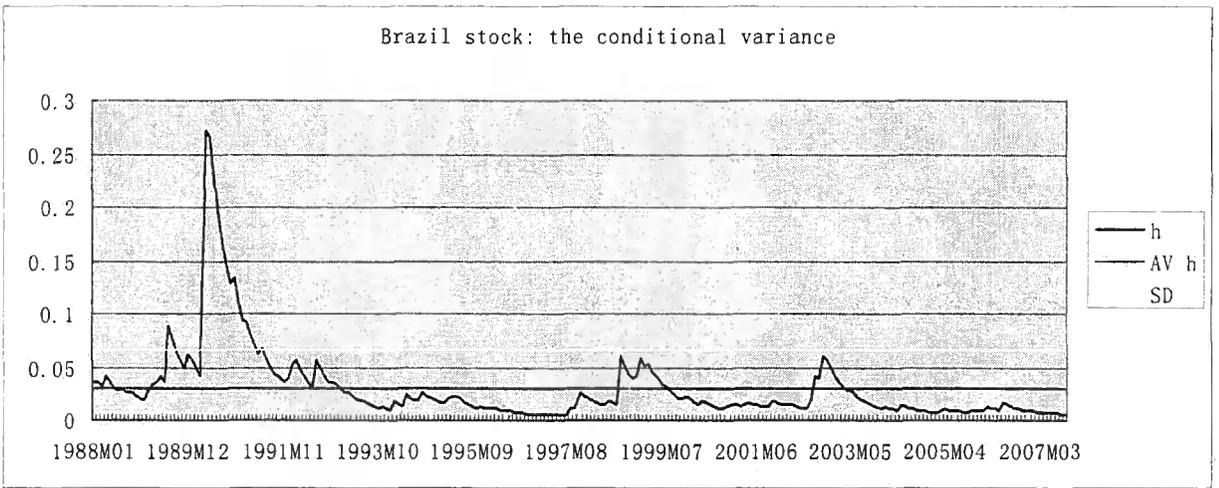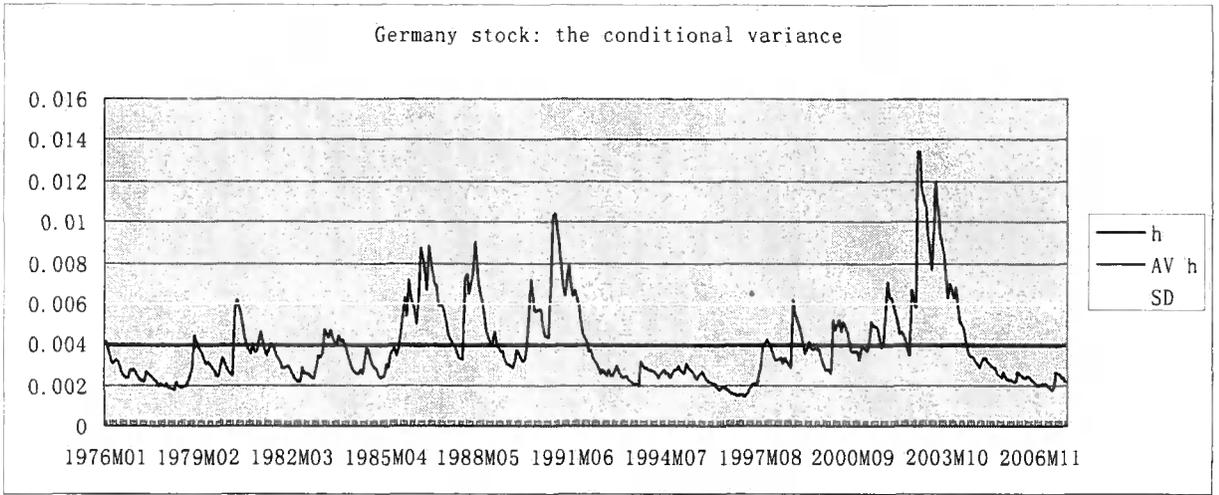
the US bond: the conditional variance
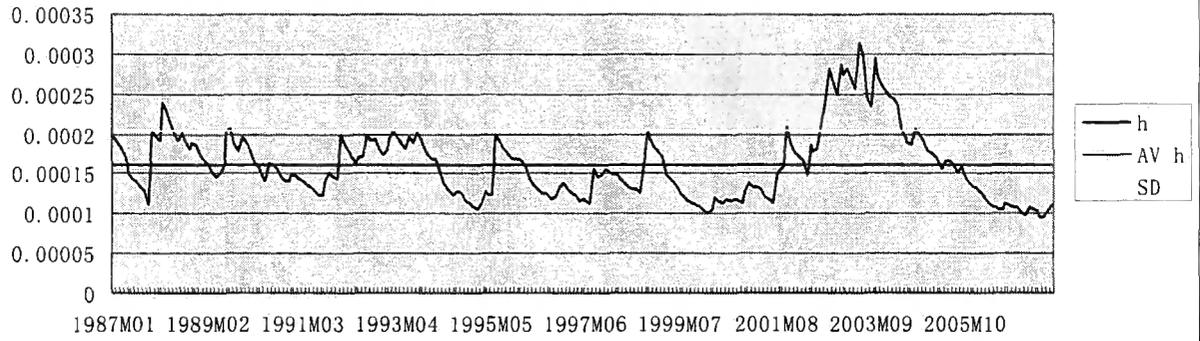
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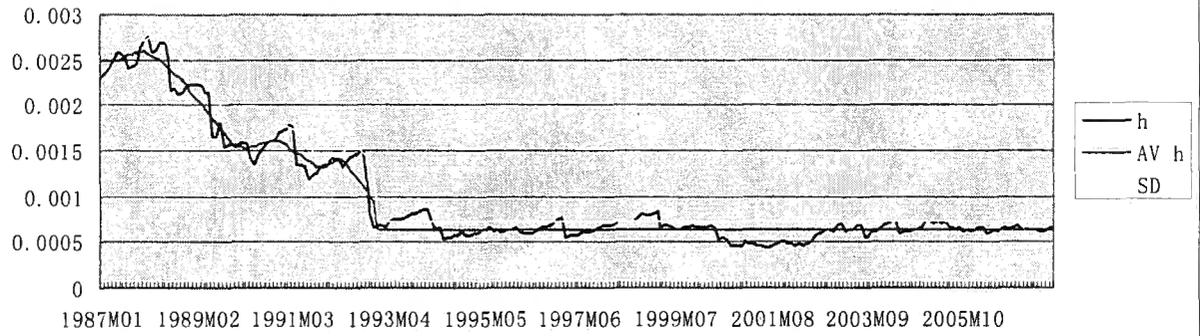
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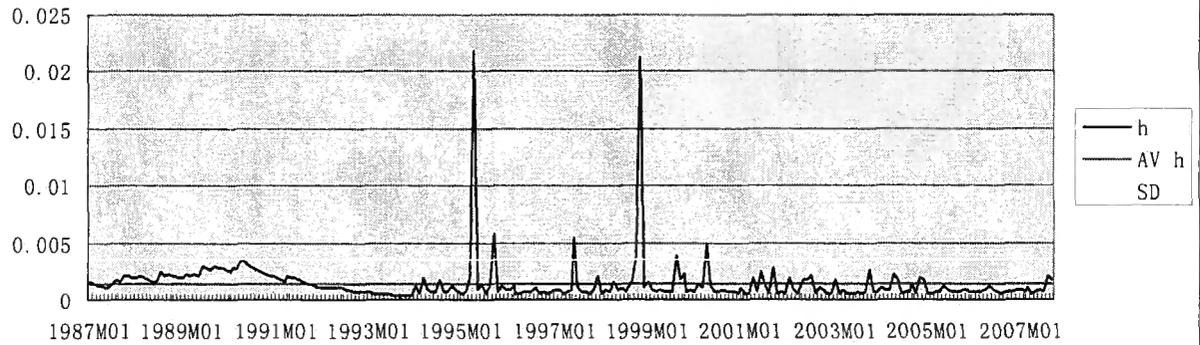
Australia bond: the conditional variance
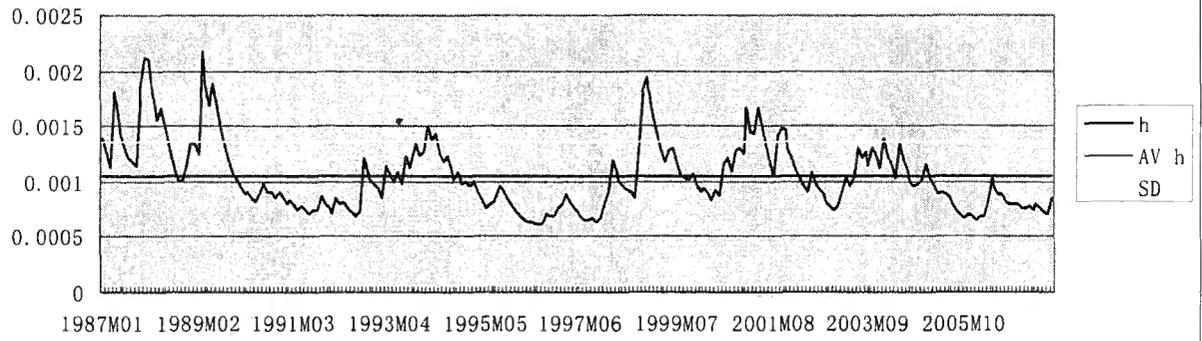
Canada bond: the conditional variance
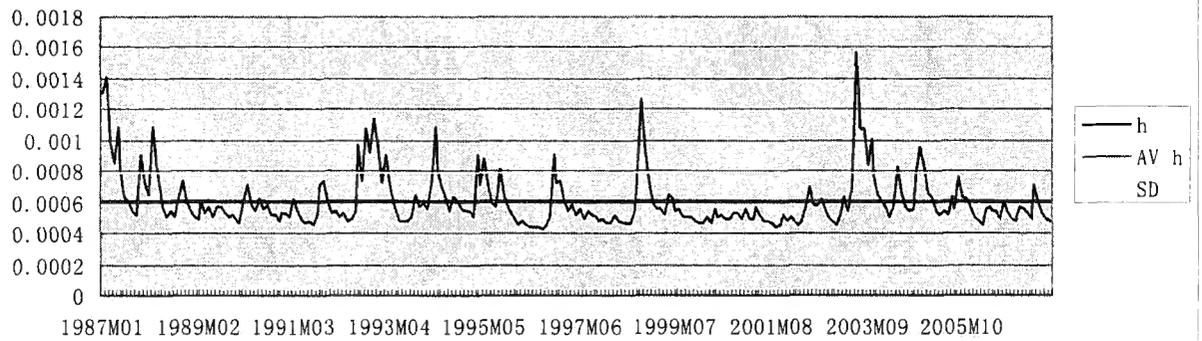
Germany bond: the conditional variance
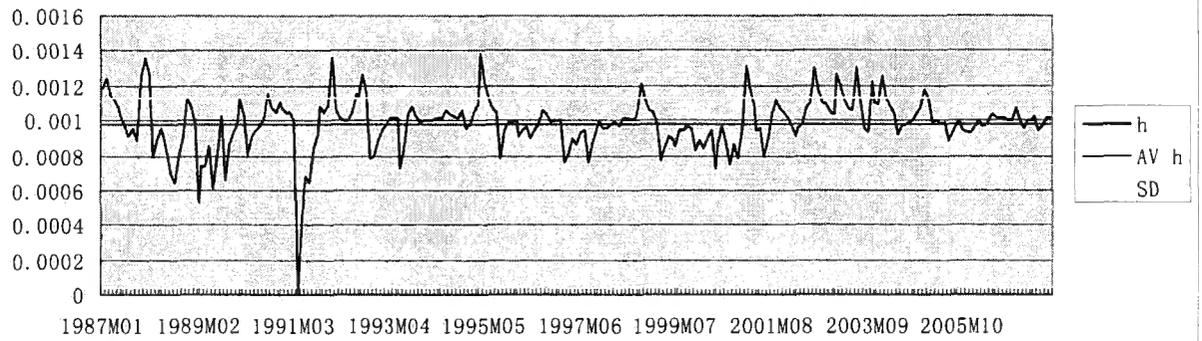
Figure 5.4: The Increased Level of Integration

US stock: increase level of integration

Canada stock: increase level of integration

Japan stock: increase level of integration
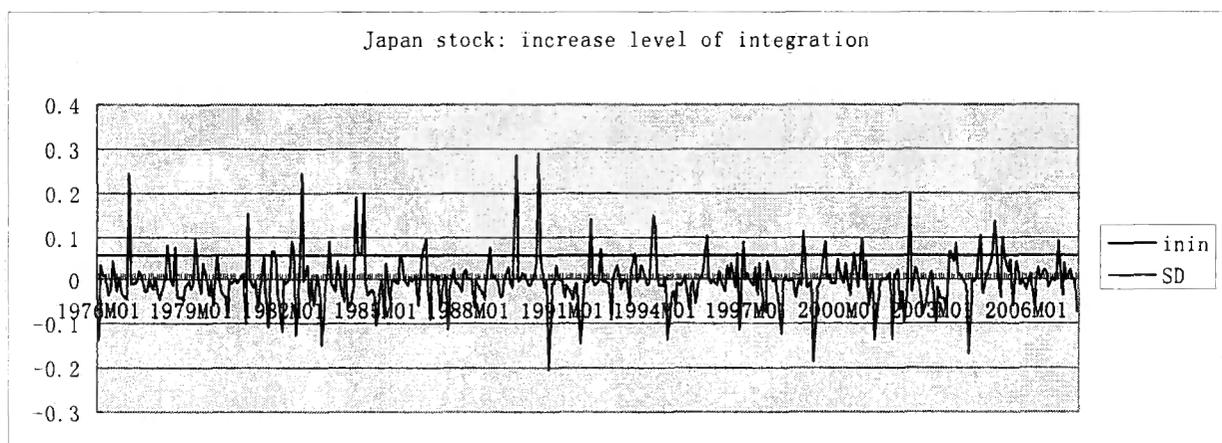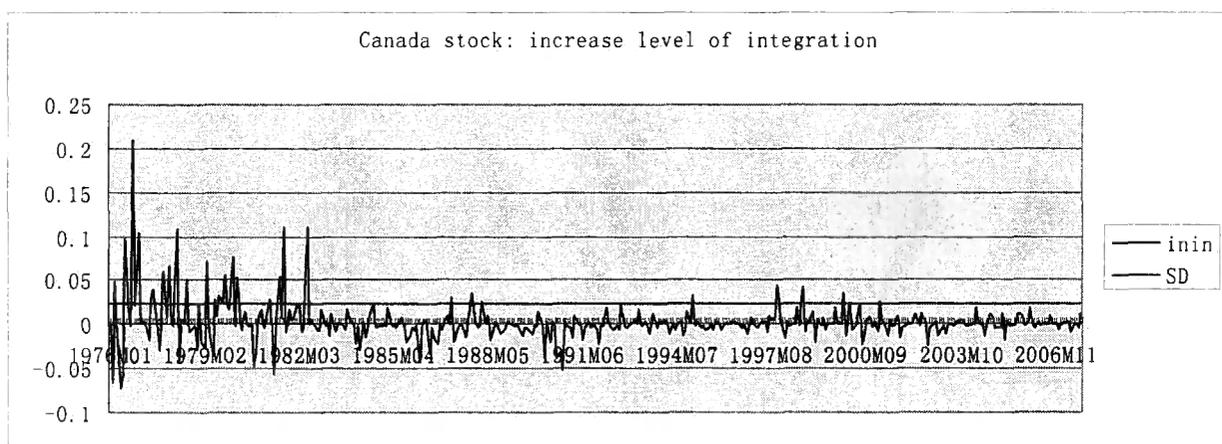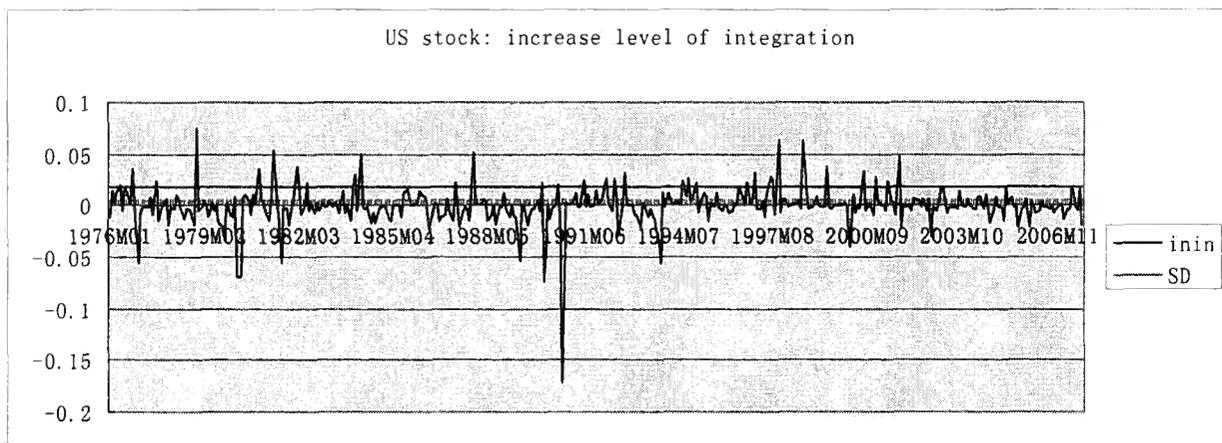
Australia stock: increase level of integration
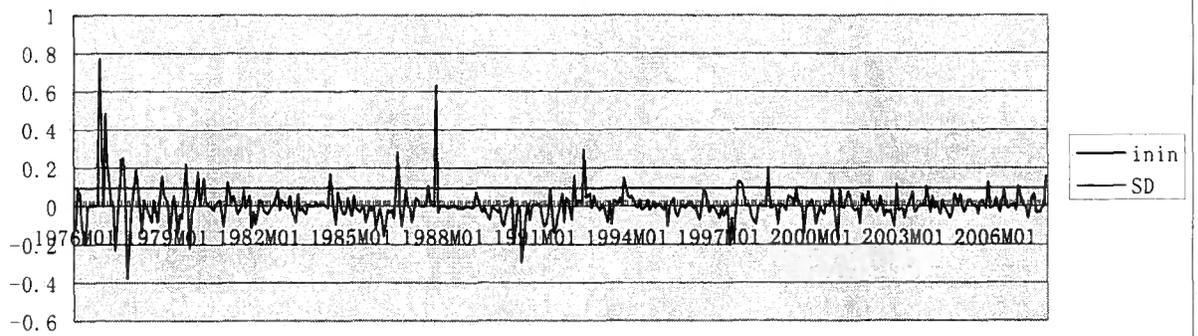
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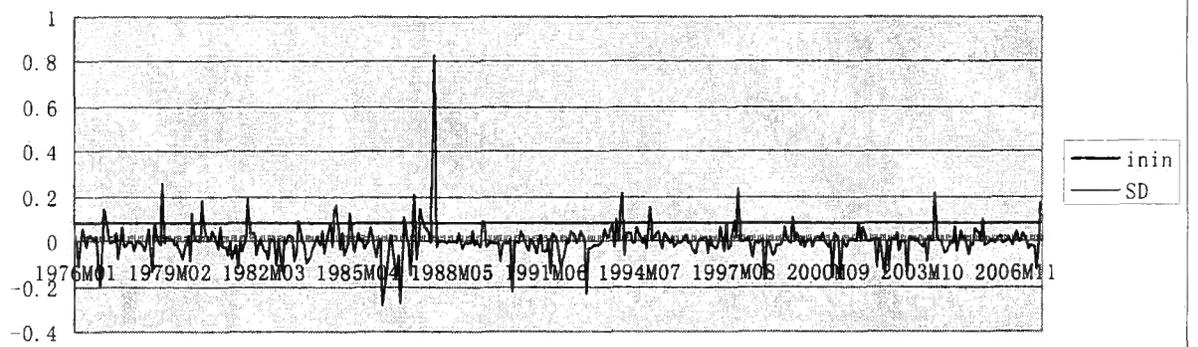
UK stock: increase level of integration
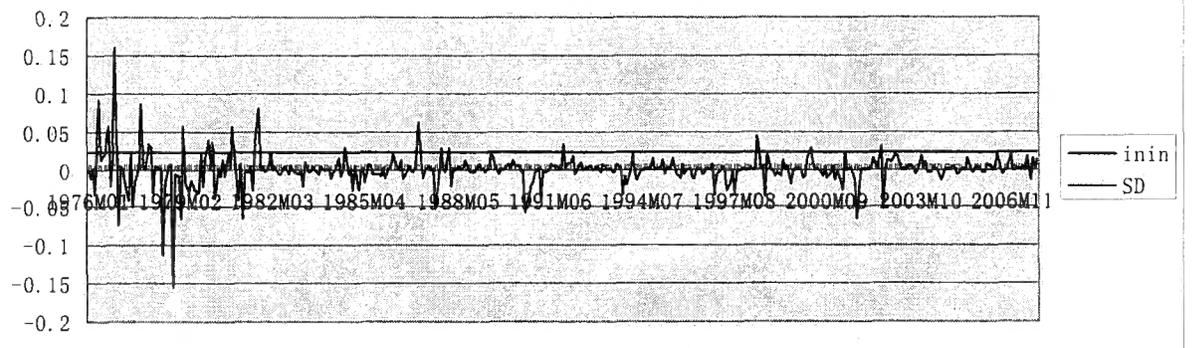
Germany stock: increase level of integration
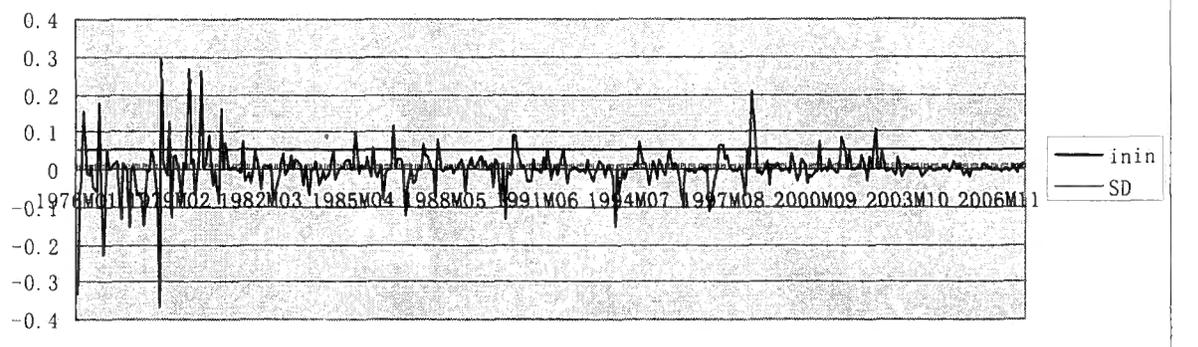
Brazil stock: increase level of integration
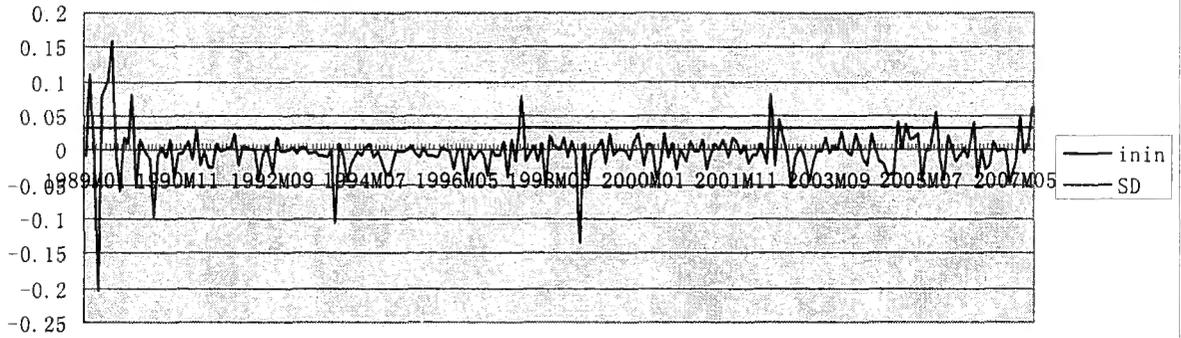
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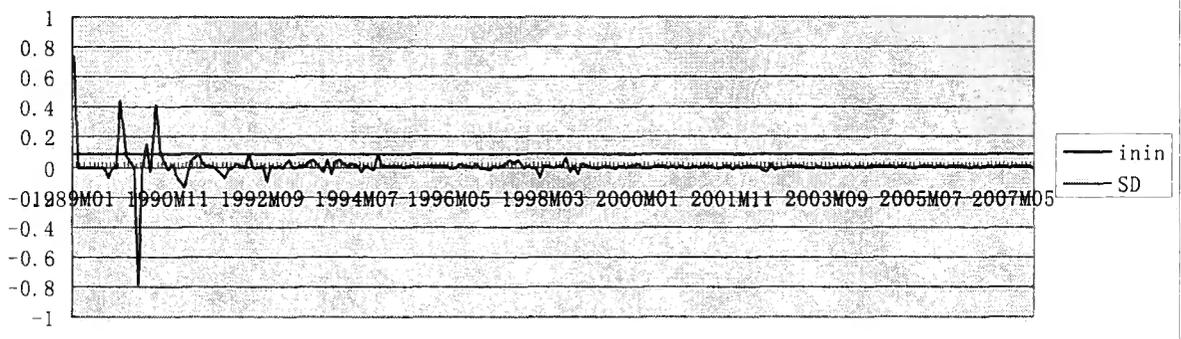
the US bond: increase level of integration
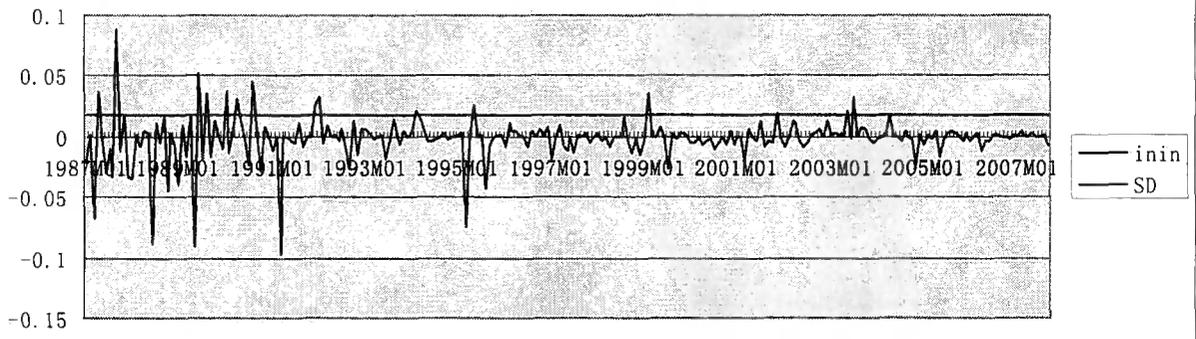
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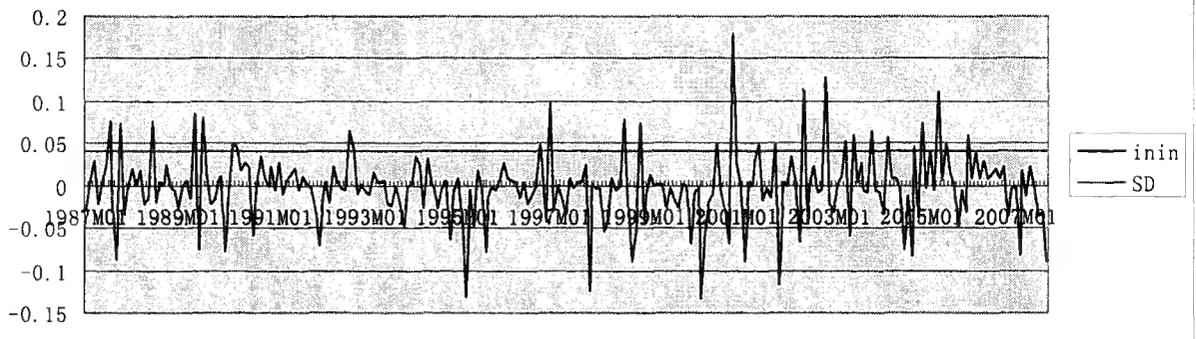
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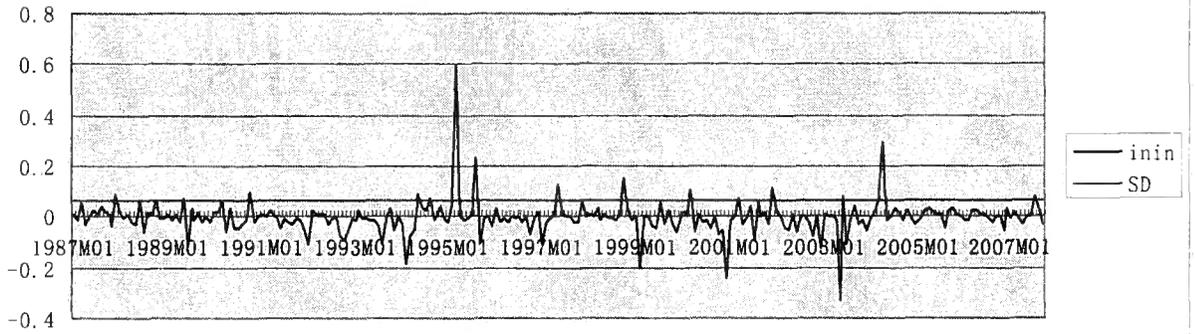
Australia bond: increase level of integration
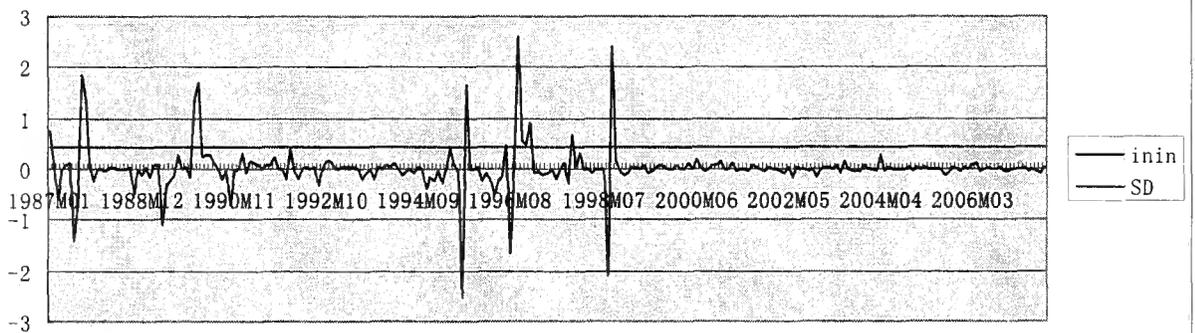
Canada bond: increase level of integration
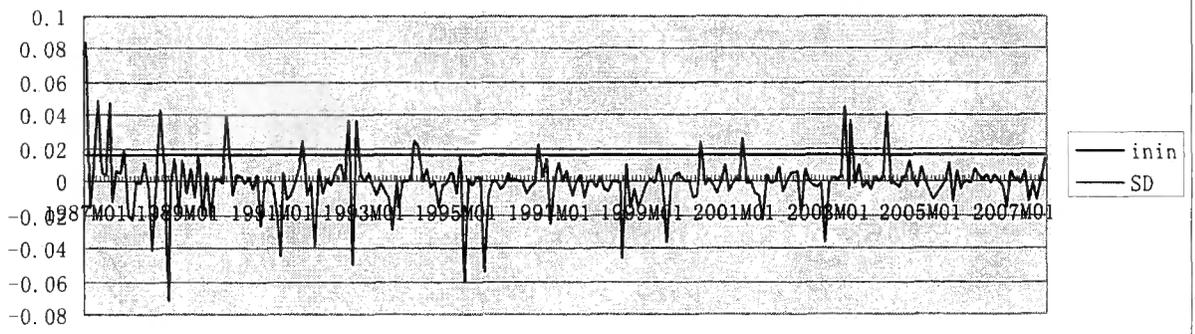
Germany bond: increase level of integration
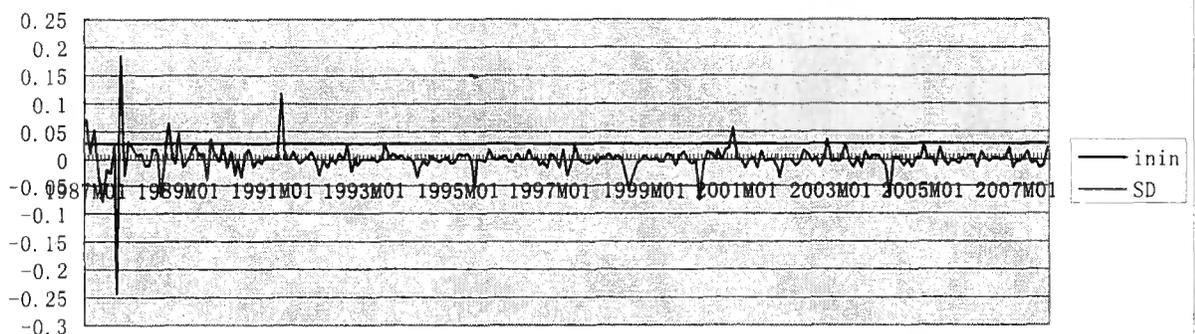
the US bond-stock: increase level of integration
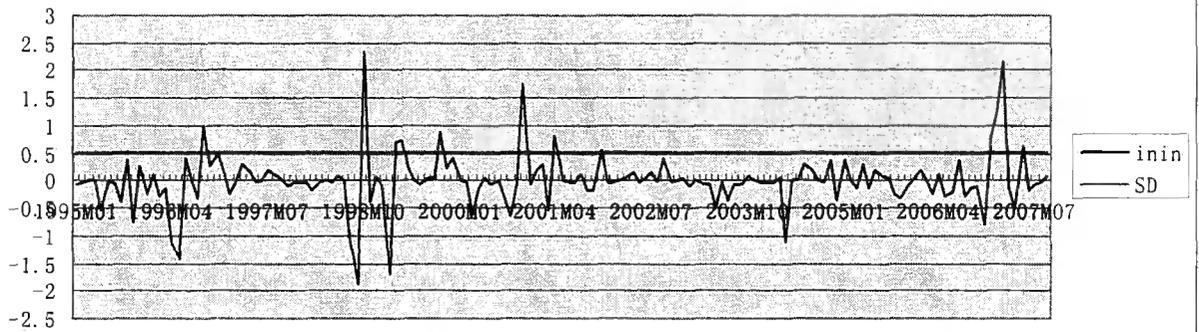
UK bond-stock: increase level of integration
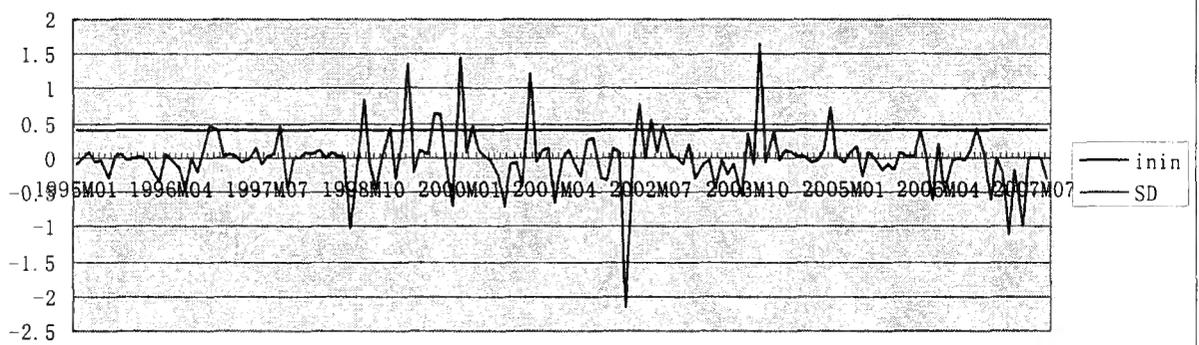
Japan bond-stock: increase level of integration
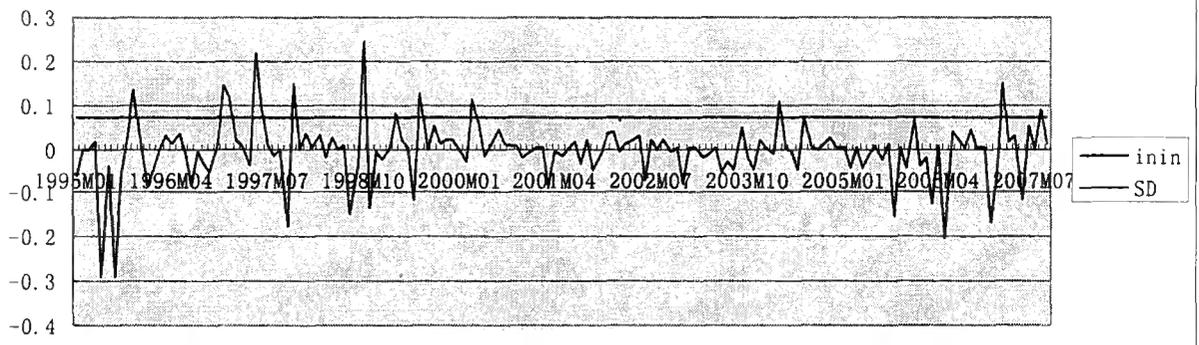
Australia bond-stock: increase level of integration
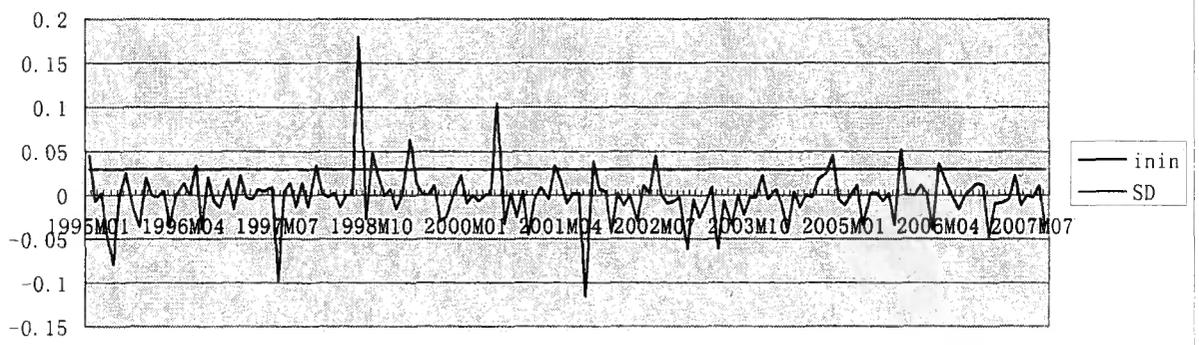
Canada bond-stock: increase level of integration
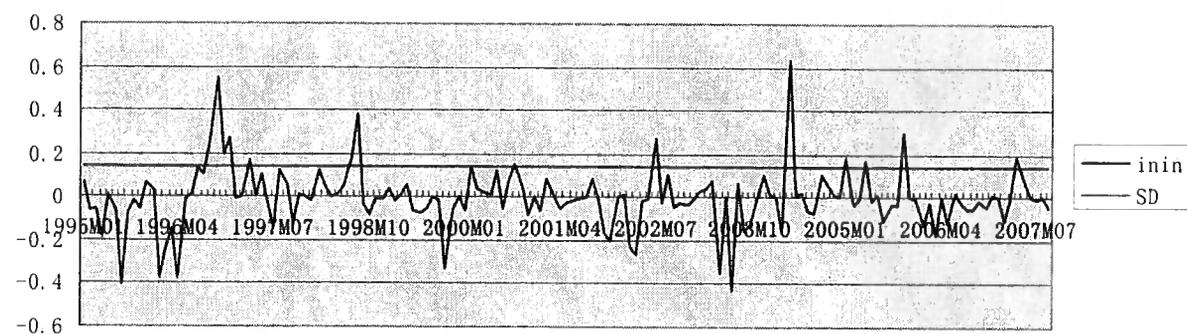
Germany bond-stock: increase level of integration
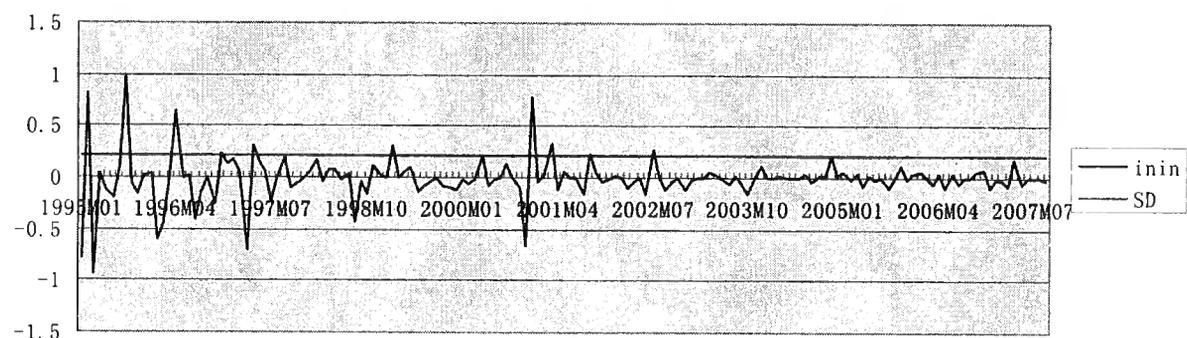
Figure 5.5: The Time-varying Contagion of Stock Market

the US stock: contagion

UK stock: contagion

Japan stock: contagion
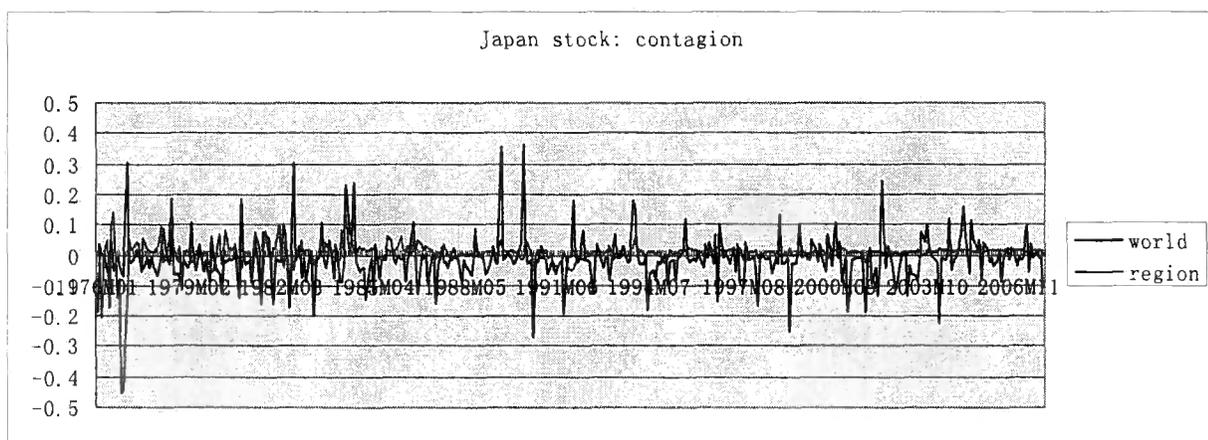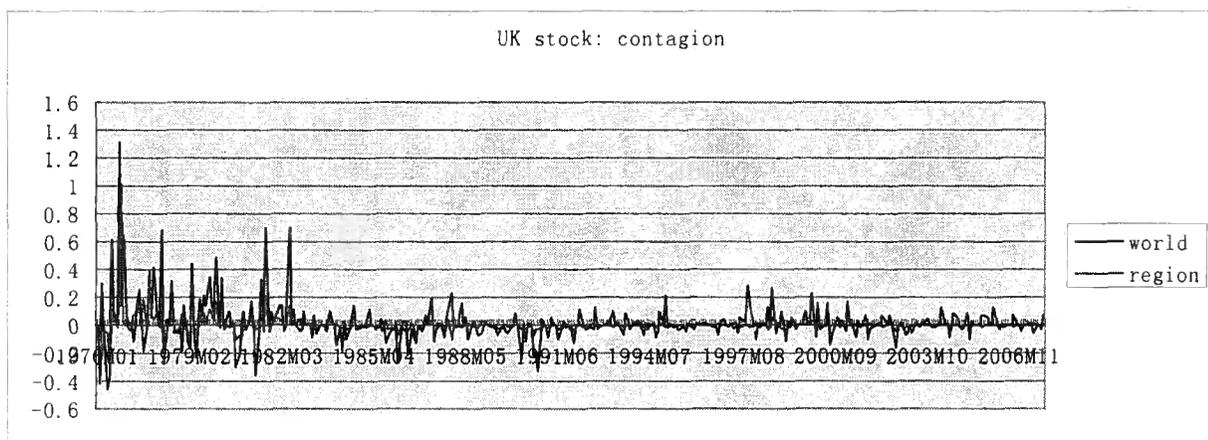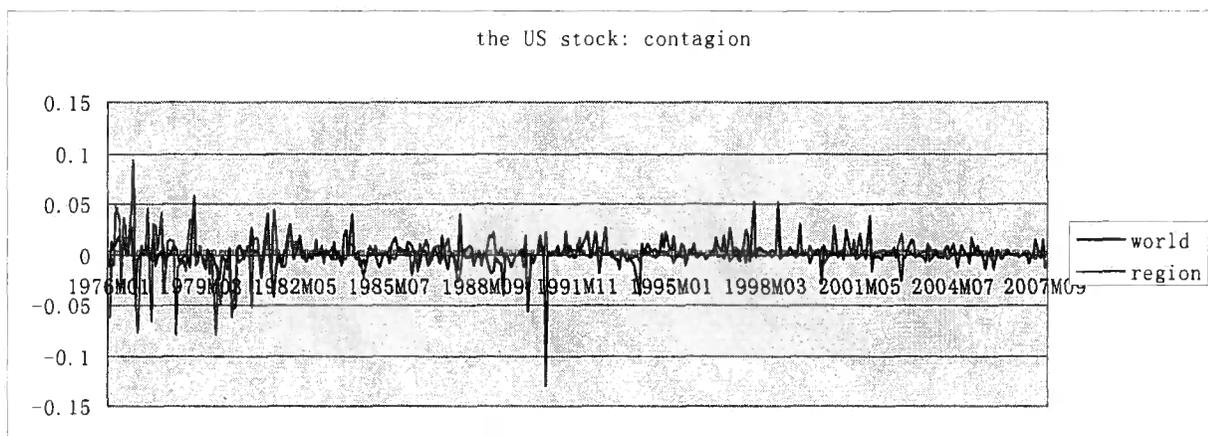
Australia stock: contagion
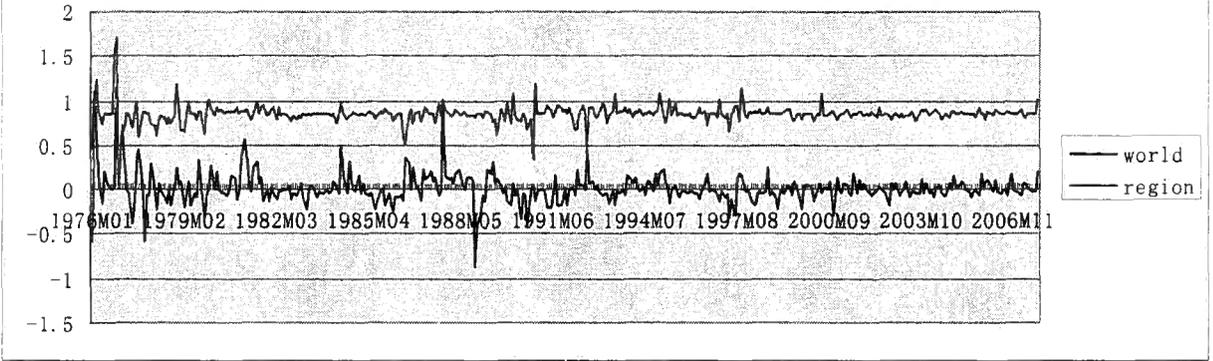
HK stock: contagion
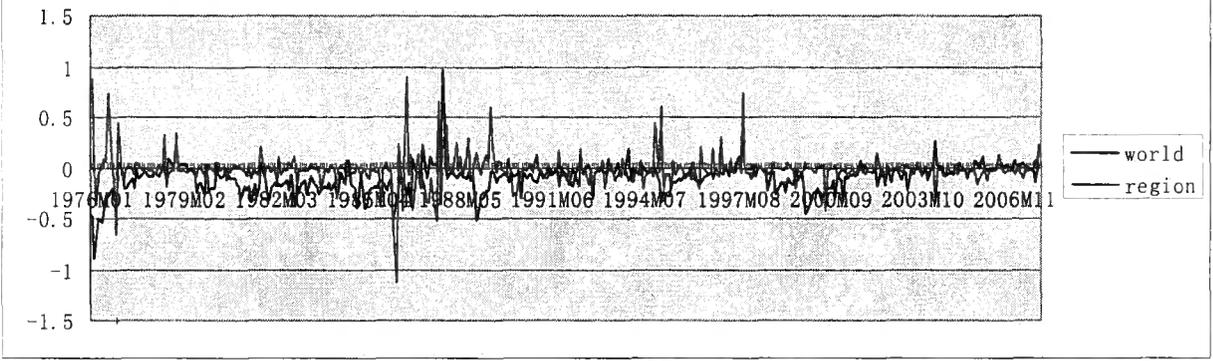
UK stock: contagion
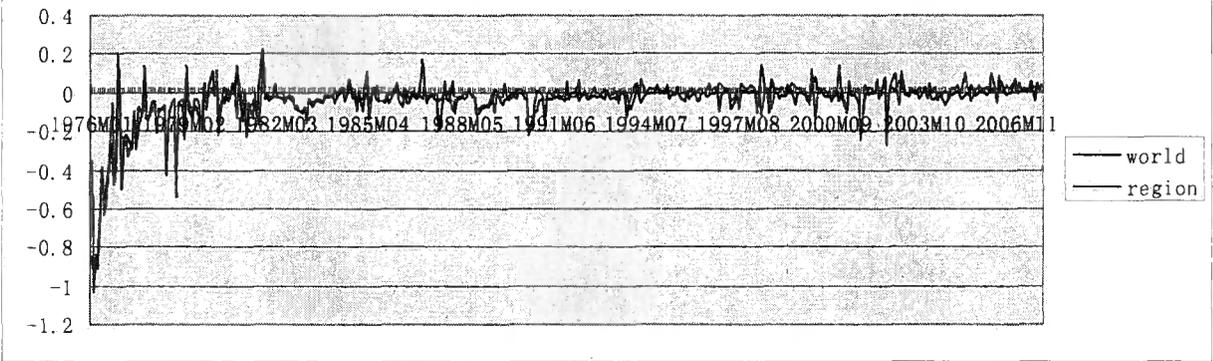
Germany stock: contagion
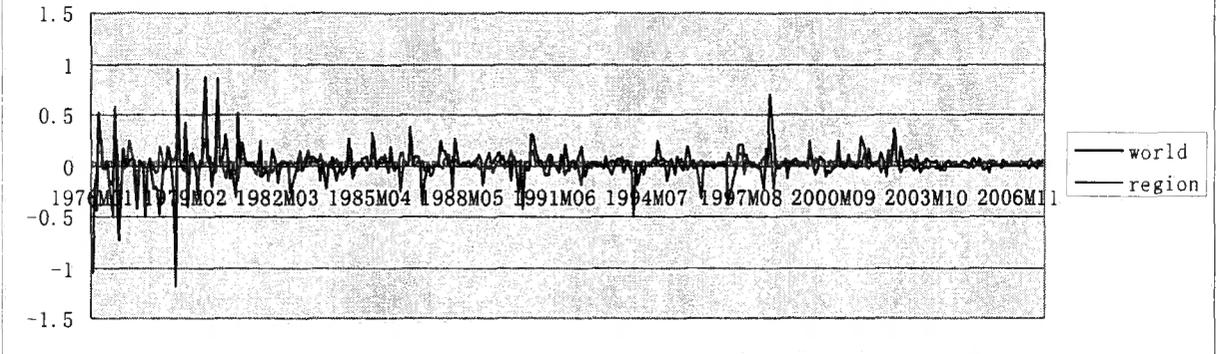
Brazil stock: contagion
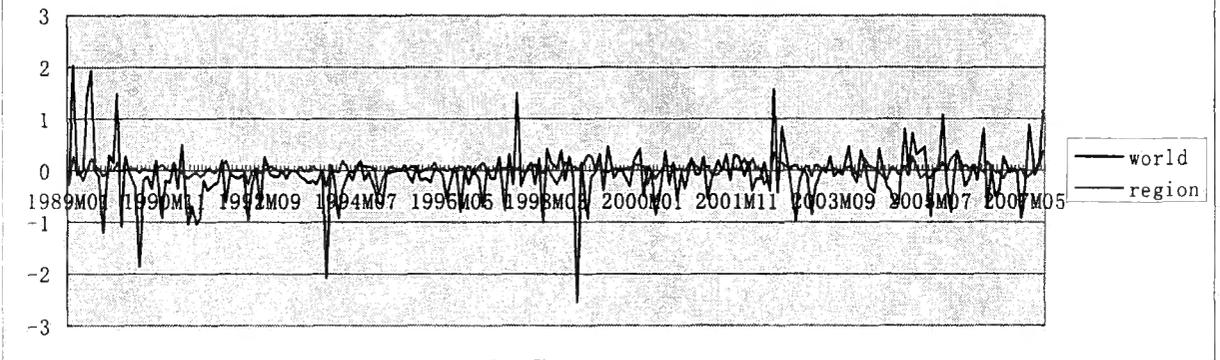
Mexico stock: contagion
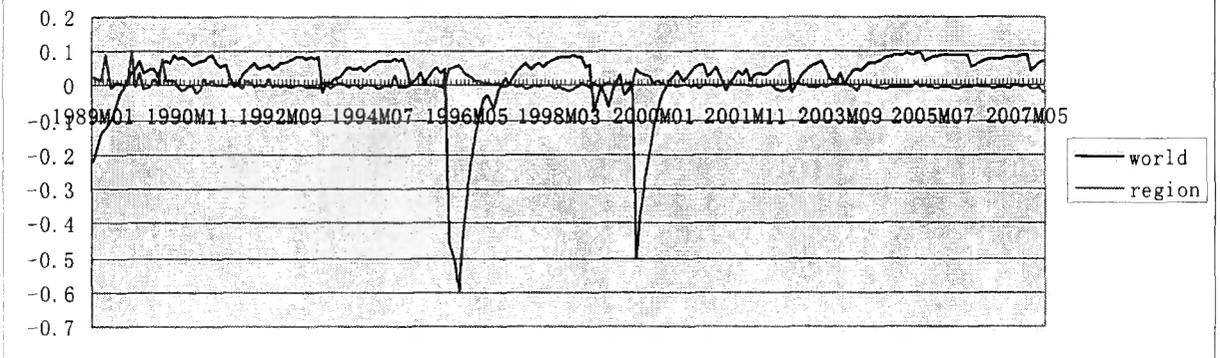
Figure 5.6: The Time-varying Contagion of Bond Market
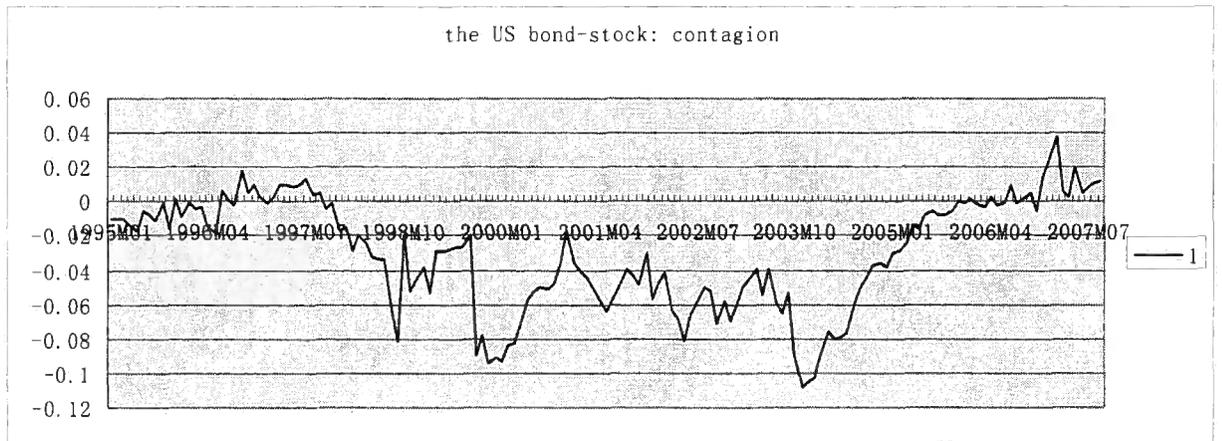

the US bond: contagion

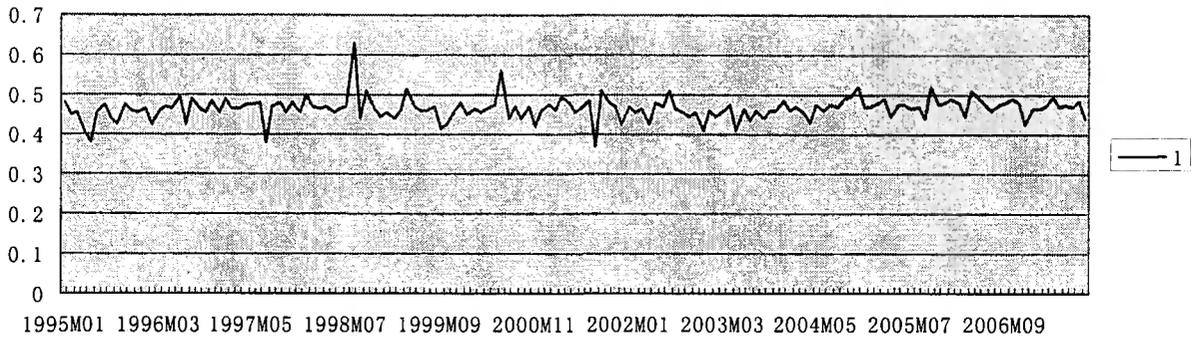UK bond: contagion

Japan bond: contagion
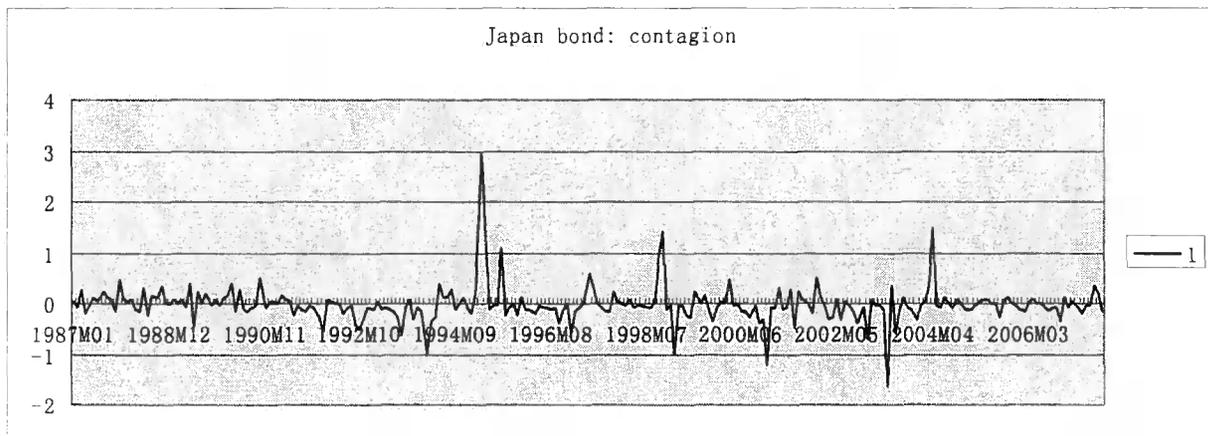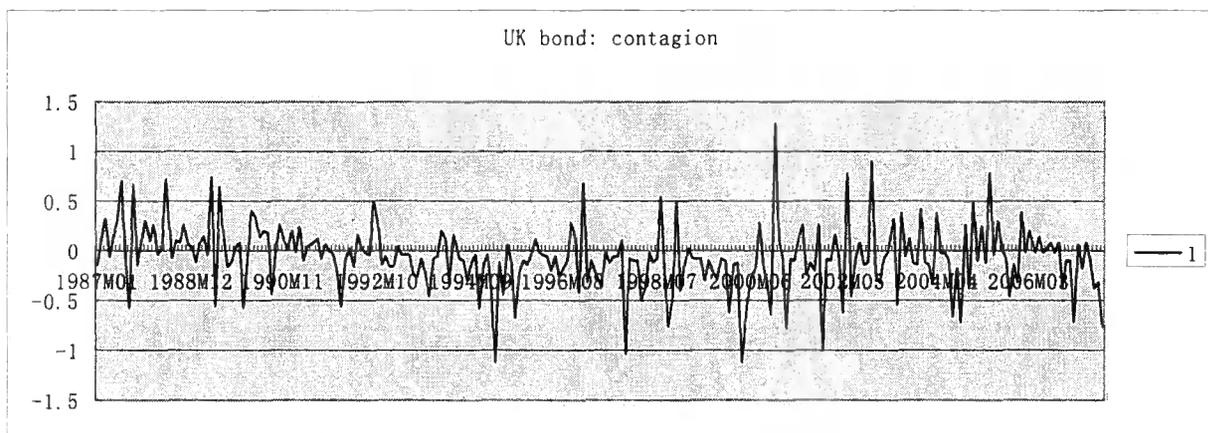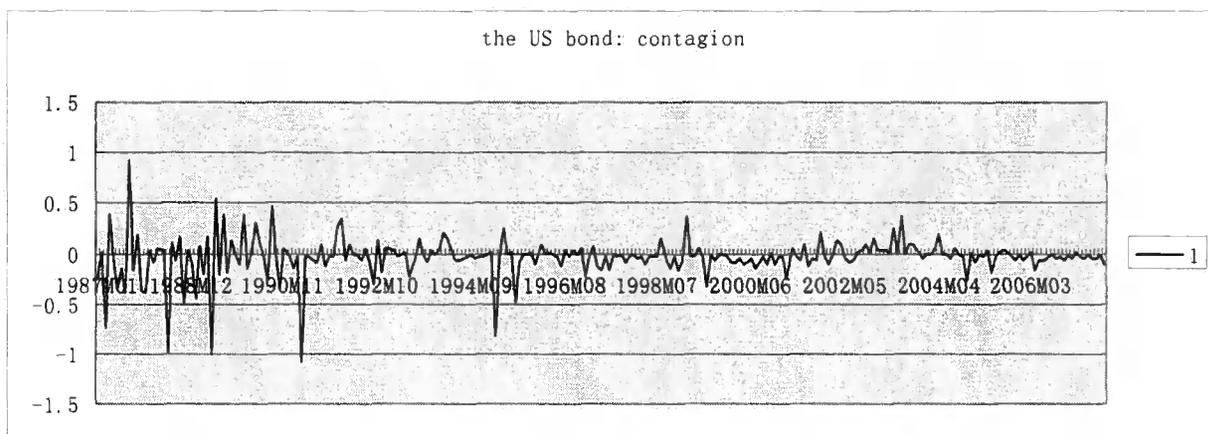
Australia bond: contagion
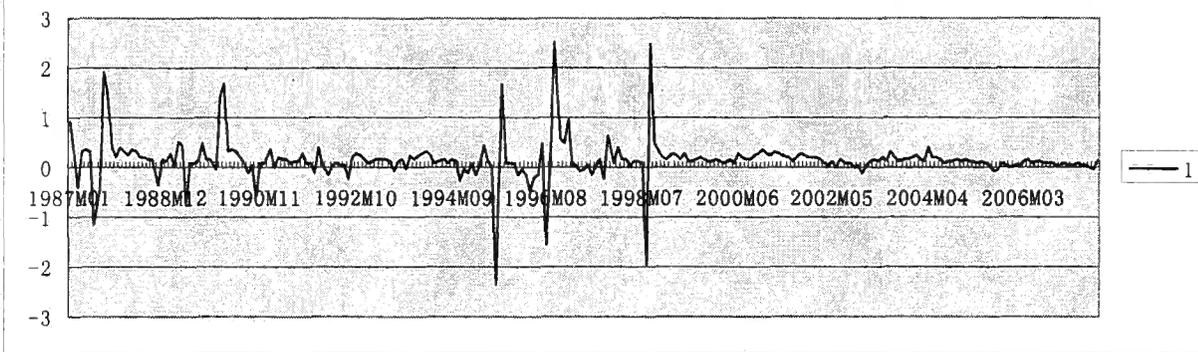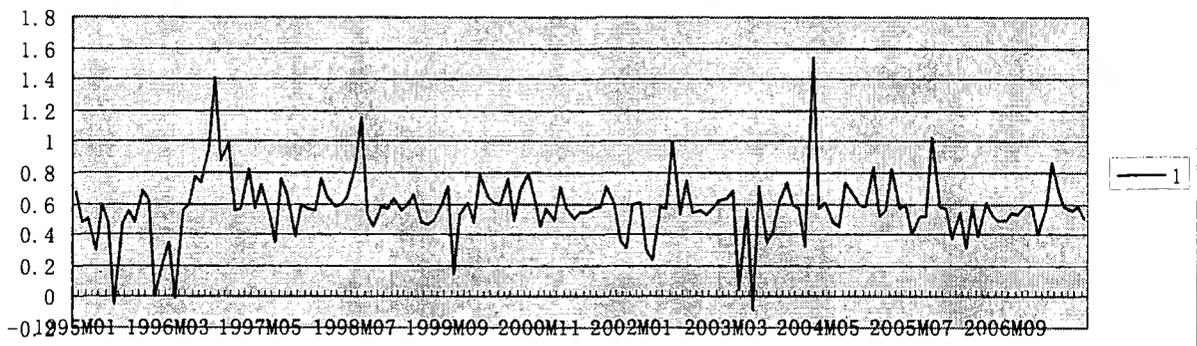

Canada bond: contagion
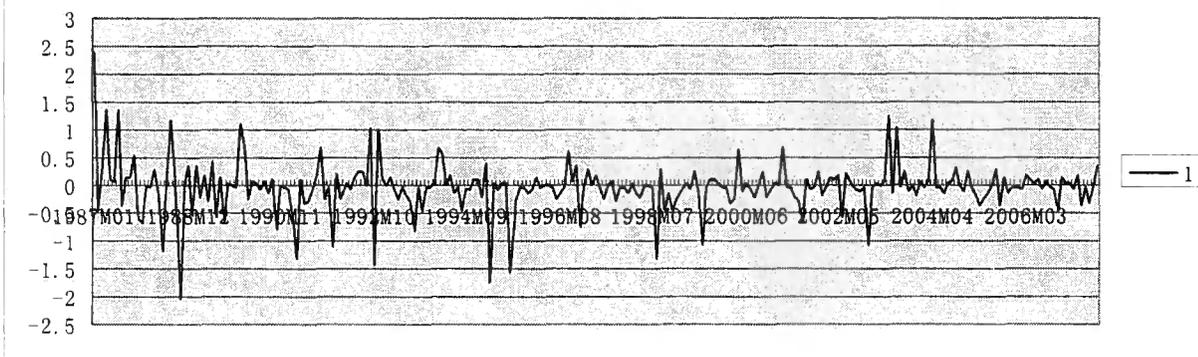
Germany bond: contagion
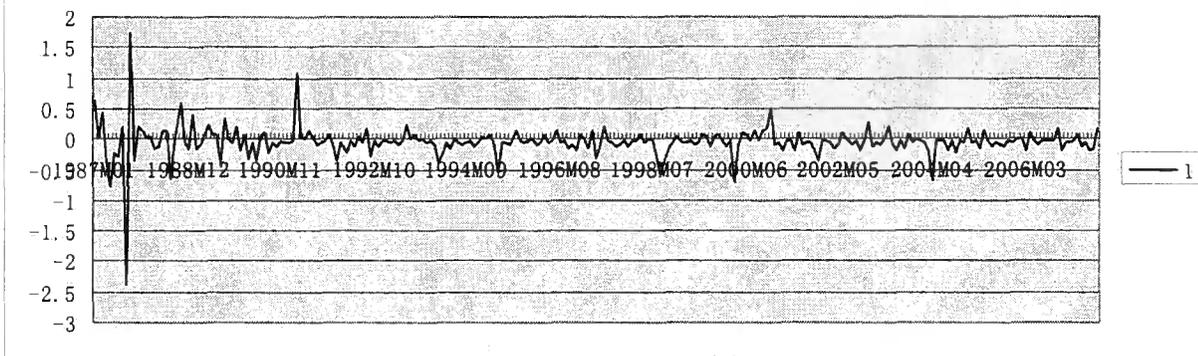
Figure 5.7: The Time-Varying Contagion of Inter-bond-stock Market

the US bond-stock: contagion

UK bond-stock: contagion

Japan bond-stock: contagion
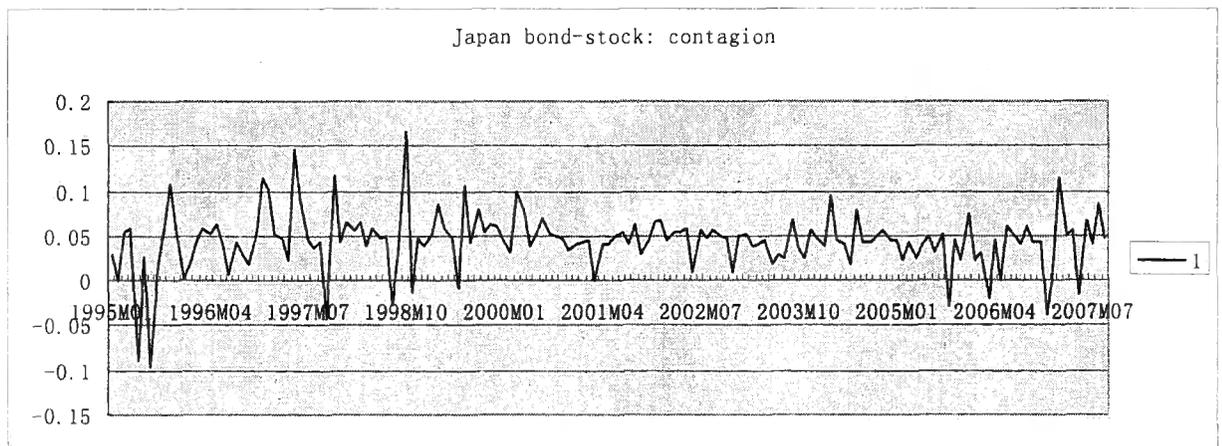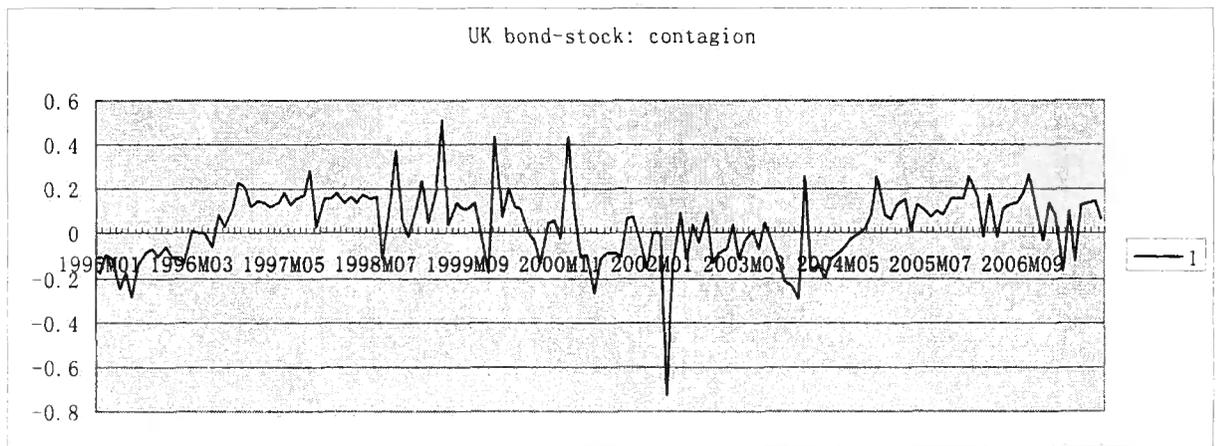
Australia bond-stock: contagion

Canada bond-stock: contagion

Germany bond-stock: contagion