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Bond Market Integration in East Asia: A Multivariate GARCH with Dynamic Conditional Correlations Approach+

by

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Abstract:

This study analyzes how and what degree the emerging East Asian local bond markets are integrated with the global bond market, the Japanese bond market and the intra-regional cross-border bond markets by applying the DCC-GARCH model to the local currency bond yield indices. Although the local currency bonds outstanding in the East Asian markets have been greatly enhanced during the first decade of the 21st century, our results reveal that integration of the local bond markets on the external markets remains at the low level for ASEAN-4 (Indonesia, Malaysia, the Philippines and Thailand), South Korea, and China. Hong Kong and Singapore are more integrated with the global market rather than the intra-regional cross-border bond markets. The effects from the Japanese market to the emerging East Asian markets are minimal.

1. Introduction

One of the major reasons for 1997 Asian financial crisis was the excessive dependence of the Asian economies on commercial banks for domestic financing. The region failed to diversify its sources of corporate financing as it relied mainly on banks since its other types of available financing, namely bond markets, were still underdeveloped and small. Furthermore, the peg-currencies to the US dollar minimized the currency risks for both borrowers and lenders. This encouraged foreign capital inflow excessively. On the other hand, the Asian corporate sector borrowed short-term foreign currency loans from commercial banks, which they used for financing their long-term domestic investment. When debt service on short term loans matured but credit dried up, these corporate borrowers were not able to borrow capital from their outstanding investments. As default cases increased, it became more difficult and more expensive to borrow credit. As capital outflow continued, the currency depreciated and this worsened the ability of corporate firms and banks to pay since their debt in local currency had risen significantly. Thus, Asian economies faced the 'double mismatch' problem. (Ito (2007), Bhattacharyay (2013)).

Based upon the above understanding, East Asian countries individually made persistent efforts to develop more efficient and stable financial systems and also collectively progressed dialogues to cooperate through the regional financial initiatives. The most important initiatives are regional economic surveillance processes in the Association of Southeast Asian Nations (ASEAN) and ASEAN+3 (ASEAN plus China, Japan, and South Korea), the Chiang Mai Initiative, the Asian Bond Markets Initiatives, and the Asian Bond Fund Initiative[1]. The region took the opportunity to deepen market-led integration and policy-induced cooperation and also promoted cross-border financial transactions through financial market deregulation and capital account liberalization. There have been many studies on these initiatives and the development of bond markets, for example, Kawai (2007), Spiegel (2011), Felman et al. (2011) among others. Thanks to the both individual and collective policy endeavors, the bond markets in the East Asian countries have steadily progressed in terms of outstanding volumes during the past fifteen years after the Asian financial crisis of 1997.

Despite the regional financial market development, the integration of the emerging East Asian bond markets seems insufficient. Several studies also suggest relatively weak intraregional link among Asian financial markets compared with their global links (Kim et al. (2008), Park and Lee (2011)). It is important to understand the degree and dynamics of financial integration in emerging Asia not only for economic growth and development, but also for financial stability. Financial integration, in theory, offers many benefits, such as better consumption smoothing through international risk sharing, more efficient allocation of capital for investment, and enhanced macroeconomic and financial discipline. However, tighter financial linkages also generate a higher risk of cross-border financial contagion in practice. (Eichengreen (2006)).

[1] A project under the ABMI published a comprehensive two volume report to foster standardization of market practices and harmonization of regulations relating to cross-border bond transactions in the region. See "ASEAN+3 Bond Market Guide" published by ADB(2012).

The purpose of this paper is to examine how and what degree the emerging east Asian bond markets are integrated with external markets[2]. Most of the past researches investigated the institutional and historical aspects of bond markets in the region with only a few exceptions. Plummer and Click (2005) reviewed the development and level of integration for the bond markets in the Association of Southeast Asian Nations (ASEAN). Johansson (2008) examined the conditional correlations between the limited numbers of the East Asian markets. Park and Lee (2012) convincingly argue the problems on integration of the emerging Asian local bond market as well as stock market among the intra-regional and global markets.

For analyzing the local currency bond yield indices, we apply a multivariate GARCH model which is now commonly used for assessing the degree of co-movements in asset prices among different markets. Engle (2002) proposed a dynamic conditional correlation model. This model and its extended models are now widely used for analyzing the assets markets such as Bauwens et al.(2013), Grier and Smallwood (2013), Conner and Suurrlaht (2013), and Syllignakis and Kouretas (2013) among others. Skintzi and Refenes (2006) examined the dynamic linkages among the European bond markets. They model the price and volatility spillovers from the US bond market and the aggregate Euro area bond market to twelve individual European bond markets using an EGARCH model that allows for a dynamic correlation structure. Our study builds upon the methodology developed by Skintzi and Refenes (2006), more specifically, analyzes the degree of dependencies in the emerging East Asian local bond markets on the global bond market, the Japanese bond market and the intra-regional cross-border bond markets.

The results reveal that the dependency of the local bond markets on the external markets remains at the low level for ASEAN-4 (Indonesia, Malaysia, the Philippines and Thailand), South Korea, and China, implying integration of the emerging East Asian bond markets are limited. However, Hong Kong and Singapore are more integrated to the global market rather than the intra-regional cross-border bond markets. The effects from the Japanese market to the emerging East Asian markets are minimal. Our result confirms Park and Lee (2011) while we employ statistically more coherent method than they did. Further efforts both individual and collective are expected to deepen the bond market integration.

The paper is organized as follows. Section 2 briefly reviews a development in the emerging East Asian bond markets during the last decade. Section 3 provides an econometric methodology to examine quantitatively the degree of integration of each of the emerging Asian local bond market on the global market, the Japanese market, and the intra-regional cross border markets in a statistically coherent manner. After stating the data description and preliminary analyses in Section 4, Section 5 indicates the empirical results. Section6 gives some concluding remarks.

2. Integration of the Emerging East Asian Bond Markets

[2] Emerging East Asia in this paper denotes Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, South Korea, and Hong Kong.

There exists no unanimously agreed definition of the term "integration" of the financial markets. In this paper, regional integration means a process that leads to greater interdependence within a region, whether market-driven or policy-led or a combination of both. Global integration refers to a similar process operating globally. Regional interdependence indicates regional economic interaction through investment, finance, and other channels. The degree of interdependence affects the way of a region's economies move together and how changes are transmitted among them[3]. Fully integrated financial markets can be seen as a situation in which traders can transact financial assets freely within an area. To gauge the extent of financial integration, we have basically two measures: volume and price measures.

This section briefly provides an overview of the emerging East Asian bond markets such as the size of bonds outstanding in comparison with the world total, and bond market development for the recent years after the Asian financial crisis. Thereafter, we show cross-border holdings in the region, which provides some evidence on financial integration. In later sections, we analyze price measures yields co-movements in detail. Table 1 shows the local currency (LCY) bonds outstanding in the world's major bond markets. The share of emerging East Asia's LCY bonds in the world's total has reached 8.8% in March 2012, which surpasses those of France (5.2%), Germany (3.8%), and the United Kingdom (2.7%). China and Korea continued to be the largest bond markets in the region apart from Japan, accounting for 5.1% and 1.9%, respectively, of the global total. Emerging East Asia LCY bonds have become an indispensable asset class for global investors.

Table 1. The Local Currency Bonds Outstanding in the World's Major Markets

Figure 1(a) illustrates the LCY bond outstanding in the emerging East Asian markets of eight countries since the end of December 2000. With the regional efforts, as well as individual countries' commitments, the bond markets have grown rapidly, more than seven times since 2000, reaching $6.5 trillion in 2012. The size of China is largest and more than half of the total size. Then, Korea and Hong Kong follow. ASEAN five come last. The LCY bond markets can play alternative channel for financing in the region in addition to the banking system. Figure 1(b) indicates the LCY bond outstanding relative to GDP. The relative size measured by the ratio to GDP exhibits different prospects. Korea and Malaysia are grouped as highest countries, while China stays rather lower group. Most countries have increased the ratio through the periods.

Figure 1. LCY Bonds (USD billions) Outstanding in the emerging East Asia

[3] See Asian Economic Integration Monitor (2012) for the definition of integration.

Figure 2(a) and (b) illustrates the LCY corporate bond outstanding in the emerging East Asian markets of eight countries since the end of December 2000. China's ratio is small though the size of bond outstanding is itself is largest because of the scale of the economy. The corporate bond markets have also expanded more than six times since 2000. The speed of expansion was accelerated in Korea and China. The relative size of the corporate bonds outstanding to the total bonds is approximately one third. The other two thirds are government bonds.

Figure2. LCY corporate Bonds (USD billions) outstanding in the emerging East Asia

Coordinated Portfolio Investment Survey (CPIS) reports data on international portfolio asset holdings by providing a breakdown of a country's stock of portfolio investment assets by the issuer's country of residency available annually since 2001.[4] Figure 3(a) indicates intra-regional cross-border debt securities investment from each of the East Asian countries seen from the offer side. Intra-regional cross-border holdings of eight East Asian countries of Hong Kong, Singapore, Japan, Thailand, Malaysia, Korea, Philippines, and Indonesia amount to 300 USD billion. The data for China is no available. Hong Kong and Singapore are the largest countries, and Japan comes next. The volumes of intra-regional cross-border holdings have steadily increased during the last elven years. The speed of growth was accelerated after the global financial crisis. This speed acceleration is more clearly observed from Figure 3(b). For example, Gong Kong goes up from 18% in2009 to 42% in 2011. The average ratio of intra-regional cross-border investment over the region except for Japan goes up from 22 % to 34% for the same period. This implies that the bond markets in the emerging East Asia have developed integration steadily during the last decade in terms of the volume of cross-border bond holding.

Figure.3 Intra-regional Cross-Border Debt Securities Investment from Each of the East Asian Countries: Seen from Offer Side

3. Econometric Methodology

This section provides an econometric methodology to examine quantitatively the dependencies of each of the emerging Asian local bond market on the global market, the Japanese market, and the intra-regional cross border markets in a statistically coherent manner. Let us consider a Gaussian vector autoregressive (VAR) model with a finite order for an n-dimensional vector time series

$Y_t = \left(y_{1,t}, \cdots, y_{n,t}\right)'$:

[4] The CPIS database provides information on economies' year end cross-border holdings of portfolio investment securities. See Coordinated Portfolio Investment Survey Guide, second edition by IMF (2002).

$$Y_t = A_0 + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t \quad , \quad t = 1, \ldots, T, \tag{1}$$

for fixed values of $Y_{-p+1}, \ldots, Y_{-1}$ *and* Y_0, X_t is a d-dimensional exogenous variables vector, and ε_t is an n-dimensional error term. Let L denote the lag operator and define $\Psi(L) = I_n - \sum_{i=1}^{p} A_i L^i$. We make the following assumption.

Assumption 1: In the VAR model of (1), we assume that

(i) rank $\Psi(1) = r, \quad 0 < r < n$, so that $\Psi(1)$ can be expressed as $\Psi(1) = -\alpha\beta'$ with α and β both $n \times r$ matrices of full column rank r;

(ii) the characteristic equation $\left| \Psi(\lambda) \right| = 0$ has n - r roots equal to 1 and all other roots outside the unit circle.

Assumption 1 implies that the process Y_t is an I(1) process with cointegration of order r. The columns of $n \times r$ matrix β span the space of cointegrating vectors, and the elements of α denote the corresponding adjustment coefficients. Defining the difference operator $\Delta = 1 - L$, we have the vector error correction model (VECM) representation:

$$\Delta Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \Phi X_t + \varepsilon_t \tag{2}$$

where $\Pi = \alpha\beta'$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$ (i = 1, …, p-1).

The error term follows a multivariate GARCH model with dynamic conditional correlation (DCC) proposed by Engle (2002) as $\varepsilon_t \left| \Omega_{t-1} \right. \sim N\left(\mathbf{0}, \; \mathrm{H}_t\right)$, where Ω_{t-1} denotes the information set up to time t-1. The conditional variance covariance matrix ($\mathbf{H}_t$) is factorized into the product of variance and correlation matrices:

$$\mathbf{H}_t = \mathbf{D}_t \mathbf{R}_t \mathbf{D}_t, \quad \mathbf{D}_t = \mathrm{diag}\left(\mathrm{h}_{11,t}^{1/2}, \cdots, \; \mathrm{h}_{nn,t}^{1/2}\right) \text{ and } \mathbf{R}_t \; , \tag{3}$$

where $\mathbf{D}_t$ is a diagonal matrix of variances, and $\mathbf{R}_t$ is an n x n correlation matrix. The conditional variance of the i-th element follows as a univariate GARCH (1, 1) model

$$\mathrm{h}_{ii,t} = \alpha_{i0} + \alpha_{i1}\varepsilon_{i,t}^2 + \beta_{i1}\mathrm{h}_{ii,t-1} \quad \text{for } i=1, \cdots, \; n \, . \tag{4}$$

Using normalized error term vector

$$u_t = D_t^{-1/2} \varepsilon_t \; , \tag{5}$$

the conditional correlation matrix of ε_t is given by $R_t = E(u_t u_t^{'} | I_{t-1})$. We specify an innovation of the conditional correlation matrix as

$$\mathbf{Q}_t = (1-a-b)\bar{\mathbf{Q}} + b\mathbf{Q}_{t-1} + au_{t-1}u'_{t-1} \tag{6}$$

where $\bar{\mathbf{Q}}$ is an overall mean of $\mathbf{Q}_t$. Then, we can obtain the relation

$$\mathbf{R}_t = \mathrm{diag}\left(q_{11,t}^{-1/2}, \cdots, q_{nn,t}^{-1/2}\right)\mathbf{Q}_t\,\mathrm{diag}\left(q_{11,t}^{-1/2}, \cdots, q_{nn,t}^{-1/2}\right).$$

The i, j element of R_t can be written as

$$\begin{aligned}\rho_{ij,t} &= \frac{q_{ij,t}}{\left\{q_{ii,t}q_{jj,t}\right\}^{-1/2}} \\ &= \frac{(1-a-b)\bar{q}_{ij} + bq_{ij,t-1} + au_{i,t-1}u_{j,t-1}}{\left\{\left[(1-a-b)\bar{q}_{ii} + bq_{ii,t-1} + au_{i,t-1}^2\right]\left[(1-a-b)\bar{q}_{j,j} + bq_{j,j,t-1} + au_{j,t-1}^2\right]\right\}^{-1/2}}\end{aligned} \tag{7}$$

We note that the correlation coefficients are nonlinear functions of two unknown parameters a and b. The covariance between the i-th and j-th elements is expressed accordingly as

$$h_{ij,t} = \rho_{ij,t}\left\{h_{ii,t}h_{jj,t}\right\}^{1/2}. \tag{8}$$

Let θ denote the full set of parameters for both the mean equations and for the multivariate DCC-GARCH specification. Based on a sample of size T, the log-likelihood function becomes

$$\mathcal{L}(\theta; Y_1, \cdots, Y_t) = -\frac{1}{2}\sum_{t=1}^{T}\left\{n\log(2\pi) + \log\det(H_t) + \varepsilon_t^{'}H_t^{-1}\varepsilon_t\right\}. \tag{9}$$

We use the maximum likelihood method to estimate the parameters of θ, after determining the number of cointegration relations and the order of the VAR model in (2).

In the next section, we apply this DCC- GARCH model with four variables for analyzing dependency of each emerging East Asian local market on the external markets.

4. Data Description and Preliminary Analysis

We assess how much the emerging East Asian local bond market is integrated with the global bond market, the Japanese bond market, and the intra-regional cross border emerging East Asian markets by using the bond yields index data. We suppose that the bond yield movements are driven by four level hierarchical chocks in the one way direction. The global shocks spread to the Japanese market, the intra-regional cross-border East Asian markets (hereafter referred to (aggregated) regional market), and the local markets. The shocks occurred in the Japanese market affect to the aggregated regional market and local markets. The shocks in the regional market will affect the local markets. The contagion is one-way direction: Global to Japan to regional and to local markets, but not reverse way. This assumption is reasonable for the purpose of this paper.

4.1 Data Description

Data of this study consists of weekly bond yields indices from eight emerging East Asian countries and Japan and the United States. Emerging Asia in this paper includes ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore, and Thailand), PRC, South Korea, and Hong Kong. The data are sampled weekly (Wednesday-to-Wednesday) over the period from 1 January 2001 to 31 December 2012 with sample size of 628. Data for emerging East Asia are taken from Asia Bonds Online published by Asian Development Bank (ADB). The bond yield indices for the USA, and Japanese markets are approximated by the yields on the ten year maturity government bond. The USA bond market is regarded as the global market in this paper. We employ the following notations:

$R_{k,t}$: $Yield$ on the bond index of the k-th local mrket at time t

$R_{k,t}^{EA}$: Yield on the aggregate regional markets, which is defined by yield on the intra-regional cross-border emerging East Asia market for the k-th local market at time t;

$R_{k,t}^{EA} = \sum_{j=1,\neq k}^{m} w_{j,t}^{(k)} R_{j,t}$, where $w_{j,t}^{(k)} = GDP_{j,t} \Big/ \sum_{l=1,\neq k}^{m} GDP_{l,t}$ and $GDP_{j,t}$ is the gross domestic product (GDP) of the j-th country at time t.[5]

R_t^G, R_t^J : Yields respectively on the global and Japanese bond market index at time t.

Figure 4 (a) to (c) indicates the yields on the bond indices. "Asia" in the figure denotes the GDP-weighted average yields over the eight emerging East Asian markets which are shown in each panel as a benchmark for the convenience of comparison. From visual inspection, we observe some characteristics: (i) Bond yields in all markets change over time. (ii) Emerging East Asian local markets are classified into three groups according to the level of yields in recent years after the global financial crisis of 1998/99: low yield markets (Hong Kong and Singapore), middle yield markets (Korea, Malaysia, Thailand and China) and high yield markets (Indonesia and the Philippines). (iii) The series of bond yields for the most markets seem to have tendency converging to the ranges from 2 to 6% points, while degree of fluctuations are amplified during the periods of the Global Financial Crisis from 2008 to 2009 for many markets.

Figure 4. Yields of Bond Indices

[5] This idea of making an aggregate regional index appears in Skintzi and Refenes (2006).They exclude the yield of the market under consideration in order to focus only on shocks that are external to the specific local market.

Table 2 indicates descriptive statistics for the log difference of yields. The stylized facts for the asset returns such as weakly significant skewness, high kurtosis, strongly significant autocorrelation of squared yields process are observed from Table 2. Table 3 shows the contemporaneous unconditional correlations of log-difference yields among the different markets. The eight emerging East Asian local markets are ordered according to the magnitudes of correlation with the global market. Hong Kong and Singapore are among the highest markets, Philippines and Indonesia are the lowest ones, and the remaining countries fall in the middle range. All the countries grouped by the unconditional correlation coincide with those classified by the yield level in Figure 4. It is noteworthy that China has very small correlation with the global markets even though the size of bond outstanding is extremely large among the emerging East Asia.

Table 2: Descriptive Statistics for the Log Difference Bond Yields

Table 3: Contemporaneous Unconditional Correlations among Bond Markets

4.2 Unit Root Tests and Cointegrations Tests

Before apply the multivariate GARCH model for the LCY bond yields, we have to check the stationarity of time series data, and further test whether cointegration relations exist among the bond yield series if not stationary. Table 4 indicates the Augmented Dickey Fuller (ADF) test for unit root. All of time series of the yields follow the integrated of order one I(1) except for Malaysia.

Table 4: Unit root tests

We analyze the yields by using the model in Section 2 with four variables for each local market defying $Y_t = \left(\log R_t^G,\ \log R_t^J,\ \log R_{k,t}^{EA},\ \log R_{k,t}\right)'$. We specify the model

$$\Delta Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \alpha\beta' Y_{t-1} + \varepsilon_t,\quad \varepsilon_t \mid \Omega_{t-1} \sim N(0, \Sigma_t) \tag{10}$$

and test the hypothesis $H_0: rank(\beta) = r$ vs $H_1: rank(\beta) = 4$, by using the Johansen's trace test[6].

The lag-lengths are determined by the SIC (Schwartz Information Criterion). Table 5 indicates that the lag-length is p = 2, and there is no cointegration relation for all the local markets.

Table 5: Cointegration testss

[6] Strictly speaking, neither the ADF nor Johansen's test are not applicable because the DCC-VECM does not satisfy the assumption of i.i.d. normal distribution for the error term. However, we ignore these aspects in this paper for simplicity. See Seo (1999, 2007) for more in detail.

5. Empirical Study

5.1 Parameter Estimates and the Conditional Correlations

Based on preliminary analysis in the previous subsection, we estimate the VAR model

$$\Delta \mathbf{Y}_t = \boldsymbol{\mu} + \Gamma \Delta \mathbf{Y}_{t-1} + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t | \Omega_{t\text{-}1} \sim N(\mathbf{0}, \mathbf{H}_t), \tag{11}$$

with equations (4) and (7). The estimates of parameters are shown in Table 6. The parameters of $\gamma_{41}, \gamma_{42}, \gamma_{43}$, and γ_{44} in the last row of Γ indicate the coefficients for the emerging East Asia local market in the equation (11)[7].

The results in Table 6 reveal the following findings: (i) All the estimates for the GARCH terms of α_{41}, β_{41}, are highly significant, for the DCC terms of a and b are also strongly significant except for the parameter of a in Malaysia. This result implies that the DCC-GARCH specification makes sense for the yields of the emerging East Asian bond markets. (ii) The effects of global markets (γ_{41}) on the mean of the local market are significant for all the emerging East Asia except for Indonesia and China. The increase of yield of the previous period in the global market has positive effect on the yield in this period for the most local markets. Exceptions are Indonesia and China. In particular, China is not affected from the global market since its t-value is very small in absolute value. (iii) The Japanese effect (γ_{42}) is significant only for Singapore and are insignificant for all other countries. The Japanese bond market does not much cause the yields movement in the merging East Asian markets. (iv)The aggregated regional effects (γ_{43}) are significant for the five markets out of the eight markets. The markets of Korea, Singapore, Thailand, Philippines, and Indonesia are significant, but Hong Kong, Malaysia and China are not. (v) China is very different from other emerging markets. The bond yields of China depend only on its previous value but not on other markets even though its outstanding value is more than half of the emerging East Asia. This may reflect that China imposes strict controls on the capital flows, so that the openness of China bond market is low.

Table 6: Estimates of Parameters

Next, we consider the conditional correlations between the k-th emerging East Asia local market and the global, Japanese, and regional markets expressed by $\rho_{4j,t}^{(k)} = h_{4j,t}^{(k)} \Big/ \left\{ h_{jj,t}^{(k)} h_{44,t}^{(k)} \right\}^{1/2}$, for j = 1, 2, and 3 respectively. Figure 5(a)-(c) indicate the average conditional correlations over the

[7] Esimates of other parameters are omitted for the save of space.

subgroups of individual emerging Asia's markets, namely $\bar{\rho}_{4j,t} = \dfrac{1}{m}\sum_{k=1}^{m}\rho_{4j,t}^{(k)}$ for j = 1, 2, and 3, where m denotes the number of countries within the subgroup. The markets are again classified into the same groups as in Figure 4 according to the characteristics of conditional correlation: (i) The markets of Hong Kong and Singapore are highly correlated with all external markets for all the periods. The correlations with the global market are strongest among the three groups, and are always higher than 0.4. The second strongest one is the Japanese market. The regional market comes last, but still more than 0.2 for most periods. (ii) For the middle yield markets of Korea, China, Malaysia and Thailand, the situations are quite different from the low yields markets. The correlations are weaker than those of the low yield markets in general. The levels in the regional markets are comparable to the global market. The correlations with Japan are weakest and almost zero for most periods. (iii) For the high yield markets of Indonesia and Philippines, the correlations are always less than 0.2 though the regional markets are strongest among the three.

Figure 5. Averaged Conditional Correlations

The conditional correlations of $\rho_{4j,t}^{(k)}$ includes not only the direct relation between the two variables but also the indirect relations through other variables. For example, $\rho_{43,t}^{(k)}$ includes not only the specific relation between the k-th individual market and the intra-regional cross border markets but also the indirect effects through the global market and the Japanese market. Hence, it is important to single out the effect specific to each of the stratified level of global, Japan and regional markets.

5.2 The effects of external shocks from the global, Japan and regional markets on the shocks of local market

This subsection assesses how much the shocks of the emerging East Asian local bond market depend on the shocks from the global, Japan, regional, and specific local markets. This assessment is meaningful for measuring the degree of integration of the local markets to the external markets. We assume that the contagion of shocks is one-way directional down from the global market to the Japanese market, the regional market, and finally to the local market, but do not go reverse way. We do not consider the other way of contagion in this paper. The above assumption may be justified because the emerging East Asian bond markets were newly developed relative to the matured markets such as the USA and Japanese bond markets.

The triangular factorization of the conditional covariance matrix in Appendix A provides a building block for the following discussion. We decompose the shock in the local market into a weighted sum of the independent shocks occurred in the global, Japan, regional and local markets by applying the triangular factorization to the conditional variance covariance matrix $\mathrm{H}_t^{(k)}$:

$$\varepsilon_{4,t}^{(k)} = L_{41,t}^{(k)}\tilde{\varepsilon}_{1,t}^{(k)} + L_{42,t}^{(k)}\tilde{\varepsilon}_{2,t}^{(k)} + L_{43,t}^{(k)}\tilde{\varepsilon}_{3,t}^{(k)} + \tilde{\varepsilon}_{4,t}^{(k)} \quad , \tag{12}$$

where $\tilde{\varepsilon}_{1,t}^{(k)}$, $\tilde{\varepsilon}_{2,t}^{(k)}$, $\tilde{\varepsilon}_{3,t}^{(k)}$, and $\tilde{\varepsilon}_{4,t}^{(k)}$ indicate the independent random shocks in each level of the markets[8]. The coefficient $L_{4j,t}^{(k)}$ represents the degree of sensitivity to the specific shock in the j-th external market.

We have two alternative measures for assessing the relations among the emerging East Asian local bond market and the external markets: conditional correlation $\rho_{4j,t}^{(k)}$ and sensitivity $L_{4j,t}^{(k)}$ .The former shows a simple correlation between $\varepsilon_{4,t}$ and $\varepsilon_{j,t}$ conditional on the information up to time t-1, so that includes the indirect relations through other variables. On the other hand, the latter measures a pure relation between $\varepsilon_{4,t}$ and $\varepsilon_{j,t}$ after removing the indirect effects from the previous variables of $\varepsilon_{1,t}, \cdots, \varepsilon_{j-1,t}$ conditional on the information up to time t-1. Hence, these two measures are not necessary same conceptually as well as numerically.

The triangular factorization in (12) has an alternative interpretation. Let us define the vector of error term as $\varepsilon_t^{(k)} = (\varepsilon_{G,t}^{(k)}, \varepsilon_{J,t}^{(k)}, \varepsilon_{EA,t}^{(k)}, \varepsilon_{k,t}^{(k)})' \equiv (\varepsilon_{1,t}^{(k)}, \varepsilon_{2,t}^{(k)}, \varepsilon_{3,t}^{(k)}, \varepsilon_{4,t}^{(k)})'$, for the k-th emerging East Asian local market. The expectation of $\varepsilon_{4,t}^{(k)}$ conditional on $\varepsilon_{1,t}^{(k)}, \varepsilon_{2,t}^{(k)}$, and $\varepsilon_{3,t}^{(k)}$ is given by

$$\mathrm{E}\left\{\varepsilon_{4,t}^{(k)} \,\middle|\, \varepsilon_{1,t}^{(k)}, \varepsilon_{2,t}^{(k)}, \varepsilon_{3,t}^{(ik)}\right\} = L_{41,t}^{(k)}\tilde{\varepsilon}_{1,t}^{(k)} + L_{42,t}^{(k)}\tilde{\varepsilon}_{2,t}^{(k)} + L_{43,t}^{(k)}\tilde{\varepsilon}_{3,t}^{(k)}. \tag{13}$$

The shocks of $\tilde{\varepsilon}_{1,t}^{(k)}, \tilde{\varepsilon}_{2,t}^{(k)}$, and $\tilde{\varepsilon}_{3,t}^{(k)}$ represent the global shock, the Japanese specific shock after removing the indirect effects through global shock, and the intra-regional cross border specific shock after removing the global market and Japanese market shocks. Then, $\tilde{\varepsilon}_{4,t}^{(k)} = \varepsilon_{4,t}^{(k)} - \mathrm{E}\left\{\varepsilon_{4,t}^{(k)} \,\middle|\, \varepsilon_{1,t}^{(k)}, \varepsilon_{2,t}^{(k)}, \varepsilon_{3,t}^{(ik)}\right\}$ is interpreted as a prediction error and an intrinsic shock to the local market.

Figure 6 draws the graphs of sensitivity of the local market to the j-th external factor $\bar{L}_{4j,t} = \frac{1}{m}\sum_{k=1}^{m} L_{4j,t}^{(k)}$ for j = 1, 2, and 3 averaged over the subgroups. By comparing Figure 6 with

8 The idea of explaining the local shock by the global and regional shocks appears in Park and Lee (2011). But they failed to decompose the local shocks to mutually independent factors.

Figure 5, we observe the following facts: (i) The two measures of dependency give different values for some of the local bond markets. For the low yield markets, the sensitivity to the global market ($\bar{L}_{41,t}$) in the panel (a) is the largest one among the three sensitivities for most of the periods, but is very close to that of the regional market ($\bar{L}_{43,t}$) for the periods of after the global financial crisis in 2008. The sensitivity to the Japanese markets is the smallest one. On the other hand, the conditional correlation measure for the low yiled markets give the Japanese market ($\bar{\rho}_{42,t}$) higher position than the regional market ($\bar{\rho}_{43,t}$). (ii) The regional sensitivity ($\bar{L}_{43,t}$) plays relatively stronger roles in Figure 6 than the conditional correlation ($\bar{\rho}_{43,t}$) do in Figure 5. (iii) The Japanese market plays a minimal role among the three external markets in terms of sensitivity measure. This fact implies that the effect of the Japanese markets on the emerging East Asian local markets is indirect through the global market. (iv) The sensitivities to the global market is highest for the high yield countries, but become weaker as the levels of yields are getting decrease. The sensitivity to the regional markets is highest for the lowest yield countries, and is getting decrease as the yields become higher.

Figure 6. Averaged Sensitivities of the Individual Markets to the External Shocks

5.3 Contribution of the Global, Japanese and Regional Markets on the Volatility of the Local Market

We investigate how much the global, Japanese and regional markets contribute to the volatility of the local market. Applying (A.6) in Appendix A, the conditional variance of the emerging East Asian local market is decomposed into the weighted sum of conditional variances of the independent random variables

$$h_{44,t}^{(k)} = Var(\varepsilon_{4,t}^{(k)} | \Omega_{t-1}) = \xi_{1,t}^{(k)} + \xi_{2,t}^{(k)} + \xi_{3,t}^{(k)} + \xi_{4,t}^{(k)} \tag{14}$$

where $\xi_{j,t}^{(k)} = (L_{4j,t}^{(k)})^2 Var(\tilde{\varepsilon}_{j,t}^{(k)} | \Omega_{t-1})$ for j = 1, 2, 3, 4 , and $L_{44,t}^{(k)} \equiv 1$. The relative contributions of each factor in the right hand side to the total variation of the local market are evaluated by $\xi_{j,t}^{*(k)} = \xi_{j,t}^{(k)} / h_{44,t}^{(k)}$). We note that $\xi_{1,t}^{*(k)} + \xi_{2,t}^{*(k)} + \xi_{3,t}^{*(k)} + \xi_{4,t}^{*(k)} = 1$.

Figure 7 denotes the relative contribution of each factor to the individual volatility $\bar{\xi}_{j,t}^{*} = \frac{1}{m}\sum_{k=1}^{m} \xi_{j,t}^{*(k)}$ averaged over the subgroups.

The results reveal the following facts: (i) The local market specific factor is dominant and higher than 60% for all the emerging East Asian markets and for all the ample periods ($\bar{\xi}^*_{4,t}$). (ii) The contributions of the global factor are relatively large in the low yield markets (Hong Kong, Singapore), while those in the middle and high yield markets are less than 10 % for all the periods. (iii) The Japanese contributions are negligible for all the local markets. (iv)The regional factor contributes approximately 10 % in the middle yield markets. These observations imply that the intra-regional integration still remains at the low level, while some markets such as Hong Kong and Singapore are integrated to the global market the intra- regional markets. Furthermore, we do not observe any clear upward trends in the bond market integration.

Table 5 shows the relative percentage contributions of the external factors to the volatilities of the individual local markets averaged over the sample periods. We find that: (i) Hong Kong and Singapore bond markets are highly integrated to the global markets. China, Indonesia and Philippines are not integrated to any external markets. (ii) The regional integrations are at low level.

Figure 7. Averaged Relative Contributions of External factors to the Volatility of individual local markets

Table 7. Average contributions of foreign factors to the individual volatility

5.4 Implications

The LCY bond outstanding in the emerging East Asian markets rapidly developed during the past fifteen years after the Asian financial crisis of 1997. The share of emerging East Asia's LCY bonds in the world's total in 2012 surpasses those of the advanced European bond markets such as France, Germany, and the United Kingdom. Emerging East Asia LCY bonds are now an indispensable asset class for global investors. Regional integration means a process that leads to greater interdependence within a region, whether market-driven or policy-led or a combination of both. Integration could enhance the developments of bond markets in the region. The volumes of intra-regional cross-border holdings steadily increased during the last elven years of our sample period, in particular after the global financial crisis. The emerging East Asia deepened integration in terms of cross-border holdings. However, investigation in this paper by using the DCC-GARCH model clarifies that integration is still limited in terms of price co-movements or yield co-movements except for Hong Kong and Singapore. Hong Kong and Singapore are integrated more with the global market than with the regional markets. Our result confirms Park and Lee (2011) while we employ statistically more coherent method than they did. In order to foster the bond market integration, further efforts both individual and collective are required.

6. Conclusions

This study examined how and what degree the emerging East Asian local bond markets are integrated with the global bond market, the Japanese bond market and the intra-regional cross-border bond markets by applying the DCC-GARCH model to the local currency bond yield indices. Triangular factorization of the conditional variance covariance matrix played a key role to define a measure of assessing the dependency of the local market on each of the above external markets. Although the bond outstanding in the East Asian markets have been greatly enhanced during the first decade of the 21st century, the empirical results reveal that the dependency of the local bond markets on the external markets remains at the low level for ASEAN-4 (Indonesia, Malaysia, the Philippines and Thailand), South Korea, and China. This implies that integration of the emerging East Asian bond markets is limited. However, Hong Kong and Singapore are more integrated to the global market rather than the intra-regional cross-border bond markets. The effects from the Japanese market to the emerging East Asian markets are minimal. Further efforts both individual and collective are expected to put forward the bond market integration.

While we focused on the analysis of the emerging East Asian local bond markets, the method in this paper is readily applied to the stock markets in the region. Several modifications and extensions of the analysis in this paper are fairly straight forward. (i) In addition to the investigation in this paper, we can further go to examine the impulse-response behavior of the local markets. (ii)An alternative multivariate GARCH model of BEKK formulation proposed by Engle and Kroner (1995) to DCC model might be interesting because the BEKK model is more flexible than the DCC. (iii) It is worth to examine whether the conditional variance and covariance of the past periods affect the yields of the present time as Grier and Smallwood (2013) did in a different context. (iv) Maekawa and Setiawan (2012) proposed an alternative estimation method of generalized least squares (GLS), which is free from the normality assumption for the distribution of error terms and seems to be robust against deviation from the normality assumption. Hence, the GLS method of estimation might be promising to try. However, these studies are left for future researches.

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Appendix A: Triangular Factorization of a Positive Definite Symmetric Matrix and Transformation of Normal Random Variables

This appendix explains triangular factorization of a positive definite symmetric matrix. Then this factorization is used for transforming the random variables into a set of independent random variables. Let $x = (x_1, \cdots, x_n)'$ be an n-dimensional normal random vector with zero mean and a nonsingular covariance matrix A: $x \sim N(0, A)$, where

$$A = \begin{pmatrix} A_{11} & \cdots & A_{1n} \\ \vdots & & \vdots \\ A_{n1} & \cdots & A_{nn} \end{pmatrix}. \tag{A.1}$$

Then there exists a unique triangular factorization such that

$$A = L\Lambda L' \tag{A.2}$$

where L is an upper triangular matrix with diagonal elements of ones and D is a diagonal matrix;

$$L = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ L_{21} & 1 & & \vdots \\ \vdots & & 1 & 0 \\ L_{n1} & \cdots & L_{nn-1} & 1 \end{pmatrix}, \text{ and } \Lambda = diag(\Lambda_1, \cdots, \Lambda_n) \tag{A.3}$$

We transform the random vector x into a new random vector

$$\tilde{x} = (\tilde{x}_1, \cdots, \tilde{x}_n)' = L^{-1}x \text{ or equivalently } x = L\tilde{x} . \tag{A.4}$$

Then, the covariance matrix of $\tilde{x}$ is $Var(\tilde{x}) = \Lambda$ implying that its elements are independent each other. The i-th element of x is a linear combination of independent random variables $(\tilde{x}_1, \cdots, \tilde{x}_i)$;

$$x_i = L_{i1}\tilde{x}_1 + \cdots + L_{ii-1}\tilde{x}_{i-1} + \tilde{x}_i , \tag{A.5}$$

and its variance is decomposed into the weighted sum of variances of independent random variables $\tilde{x}_i$ s

$$Var(x_i) = (L_{i1})^2 \Lambda_1 + \cdots + (L_{ii-1})^2 \Lambda_{i-1} + \Lambda_i . \tag{A.6}$$

The conditional expectation of x_i on $(x_1, \cdots, x_{i-1})$ is given by

$$\mathrm{E}\{x_i \mid x_1, \cdots, x_{i-1}\} = L_{i1}\tilde{x}_1 + \cdots + L_{ii-1}\tilde{x}_{i-1} . \tag{A.7}$$

Hence, $\tilde{x}_i = x_i - \mathrm{E}\{x_i \mid x_1, \cdots, x_{i-1}\}$ is interpreted as a prediction error. Equation (A.5) is a minimum variance predictor of x_i . See Hamilton (1994), for instance, for explicitly deriving each element of L and Λ, proving uniqueness of the triangular factorization in (A.2), and optimality of the predictor in (A.5).

Table.1 Local Currency Bonds Outstainding in Major Markets: End-March 2012 (US$ billion)

	LCY Bonds Outstanding	% of World Total
United States	26,391	38.7
Japan	11,897	17.4
France	3,574	5.2
Germany	2,621	3.8
United Kingdom	1,823	2.7
Emerging East Asia	5,886	8.8
of which China	3,448	5.1
of which Korea	1,290	1.9
of which ASEAN-5	957	1.4

Source: Asia Bond Monitor, November 2012

Note: ASEAN-5 refers to the five largest economies of the ASEAN: Indonesia, Malaysia, the Philippines, Singapore, and Thailand.

Table.2 Descriptive Statistics for the Log Difference of Bond Yields

	Mean	Std.Dev	Skew	Kurt	Min	Max	Q(4)	Q(4)-2
Global	−0.002	0.041	0.05	2.92	−0.20	0.18	10.9*	108.8*
Japan	−0.002	0.065	1.57	8.39	−0.16	0.50	19.0*	45.1*
Asia	−0.001	0.013	−0.28	4.98	−0.07	0.06	92.0*	293.9*
Hong Kong	−0.003	0.049	0.20	2.04	−0.21	0.22	7.5	113.8*
Singapore	−0.001	0.036	0.52	4.07	−0.14	0.20	5.7	78.4*
Korea	−0.001	0.026	0.37	4.00	−0.12	0.14	7.4	20.1*
Thailand	0.000	0.032	0.63	6.41	−0.19	0.19	37.1*	76.5*
Malaysia	0.000	0.019	1.11	10.59	−0.08	0.15	38.8*	40.1*
China	0.000	0.017	0.16	9.11	−0.12	0.12	106.7*	58.1*
Philippines	−0.002	0.027	1.88	20.09	−0.11	0.26	12.5*	18.9*
Indonesia	−0.002	0.028	0.64	14.12	−0.20	0.23	7.1	171.8*

Note : "Asia" denotes GDP-weighted average yields over the eight emerging East Asian markets. Q(4) denotes the Ljung-Box Statistics with lag of 4 for the log-difference process and Q(4)-2 denotes those of squared process. The critical value of Q(4)-statistic at 5% significance level is 9.49, and "*" in Q test denotes 5% significance.

Table.3 Contemporaneous Unconditional Correlations among Bond Markets

	GLO	JPN	HOK	SG	KOR	THA	MAL	PRC	PHI	IND
Global	1.00									
Japan	0.33	1.00								
HongKong	0.60	0.38	1.00							
Singapore	0.49	0.31	0.56	1.00						
Korea	0.27	0.18	0.25	0.24	1.00					
Thailand	0.28	0.14	0.29	0.29	0.32	1.00				
Malaysia	0.13	0.06	0.22	0.21	0.22	0.29	1.00			
China	0.10	0.03	0.10	0.01	0.10	0.12	0.09	1.00		
Philippines	0.00	0.02	0.09	0.08	0.05	0.08	0.06	0.02	1.00	
Indonesia	−0.04	−0.07	−0.01	0.08	0.05	0.19	0.14	0.00	0.30	1.00

Note: The eight emerging East Asian local markets are ordered according to the magnitudes of correlation with the global market.

Table.4 ADF Tests for Unit Root

	ADF test	
	Level	1st Difference
Global	−0.91	−26.96
Japan	−1.91	−24.64
HongKong	−0.13	−22.86
Singapore	−1.63	−23.52
Korea	−1.39	−23.20
Thailand	−2.52	−20.05
Malaysia	−3.56*	−20.81
China	−2.52	−8.58
Philippines	−1.20	−24.12
Indonesia	−0.65	−23.45

Note : For yields of each the local market, we specify the model as

$$\Delta y_t = \boldsymbol{\mu} + \sum_{i=1}^{p-1} \gamma_i \Delta y_{t-i} + \delta y_{t-1} + \boldsymbol{\varepsilon}_t, \quad \boldsymbol{\varepsilon}_t \sim N(\mathbf{0}, \sigma^2).$$

The ADF statistic tests the hypothesis $H_0 : \delta = 0$ vs $H_1 : \delta < 0$.

Similarly we carry out the ADF tests for the log-differences of the yields. The critical point of ADF test is at 5% level. The lag lengths are determined by the SIC (Schwartz Information Criterion).

Table.5 Cointegration Tests

	Lag	p−1 = 0	p−1 = 1	p−1 = 2	p−1 = 3	p−1 = 4
Hong Kong	SIC	−15.92	−15.95*	−15.88	−15.78	−15.70
	Trace test(r=0)	47.86	35.27	34.00	34.88	32.96
	p−value	(0.160)	(0.710)	(0.768)	(0.729)	(0.812)
Singapore	SIC	−16.32	−16.33*	−16.23	−16.13	−16.09
	Trace test(r=0)	49.93	41.68	39.75	43.58	37.34
	p−value	(0.112)	(0.389)	(0.483)	(0.305)	(0.607)
Korea	SIC	−16.71	−16.73*	−16.62	−16.53	−16.47
	Trace test(r=0)	36.95	27.66	26.21	27.37	26.25
	p−value	(0.626)	(0.958)	(0.977)	(0.963)	(0.976)
Thailand	SIC	−16.49	−16.53*	−16.43	−16.34	−16.25
	Trace test(r=0)	39.68	34.62	35.57	37.37	35.57
	p−value	(0.487)	(0.741)	(0.696)	(0.605)	(0.696)
Malaysia	SIC	−17.39	−17.42*	−17.33	−17.25	−17.19
	Trace test(r=0)	41.96	35.86	38.21	36.59	36.51
	p−value	(0.376)	(0.681)	(0.562)	(0.645)	(0.649)
China	SIC	−16.93	−17.00*	−16.90	−16.81	−16.74
	Trace test(r=0)	55.47	39.82	36.68	35.71	33.02
	p−value	(0.037)	(0.480)	(0.641)	(0.689)	(0.810)
Philippines	SIC	−16.65	−16.65*	−16.57	−16.49	−16.41
	Trace test(r=0)	47.27	40.12	41.18	41.68	38.67
	p−value	(0.176)	(0.464)	(0.413)	(0.389)	(0.538)
Indonesia	SIC	−16.45	−16.49*	−16.41	−16.32	−16.24
	Trace test(r=0)	51.11	38.46	37.22	36.07	31.74
	p−value	(0.090)	(0.549)	(0.613)	(0.671)	(0.858)

Note : We specify theVECM as

$$\Delta Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma),$$

and test the hypothesis $H_0 : rank(\Pi) = r$ vs $H_1 : rank(\Pi) = 4$ in order to determine the number of cointegration relations for each of lag lengths of p = 1 to 5 by using Johansen's trace test. The test determines r = 0 for all the markets and for all p = 1 to 5 except for only two markets of China and Indonesia with p = 1, for which r = 1. The SIC is calculated based on the number of cointegrations determined by the hypothesis tests. The "*" denote the smallest SIC. The entry in parenthesis indicates p-value.

Table.6 Estimates of Parameters

	γ_{41}	γ_{42}	γ_{43}	γ_{44}	α_{41}	β_{41}	a	b
HongKong	0.252	−0.021	0.098	−0.024	0.119	0.867	0.020	0.943
	(6.23)	(−1.12)	(0.97)	(−0.78)	(8.97)	(68.83)	(3.54)	(63.76)
Singapore	0.111	−0.035	0.169	−0.006	0.162	0.760	0.010	0.972
	(4.36)	(−2.41)	(2.54)	(−0.15)	(16.85)	(104.12)	(3.30)	(84.46)
Korea	0.115	−0.001	0.110	−0.015	0.214	0.712	0.018	0.949
	(6.61)	(−0.07)	(2.23)	(−0.39)	(17.33)	(81.74)	(4.03)	(58.49)
Thailand	0.075	0.020	0.234	0.134	0.147	0.834	0.009	0.970
	(3.86)	(1.90)	(3.48)	(3.79)	(22.01)	(183.38)	(3.10)	(68.45)
Malaysia	0.025	−0.002	0.062	0.113	0.234	0.811	0.015	0.957
	(2.60)	(−0.28)	(1.71)	(2.46)	(20.42)	(142.82)	(1.49)	(26.42)
China	0.005	0.003	−0.030	0.330	0.307	0.650	0.012	0.961
	(0.44)	(0.47)	(−0.95)	(6.96)	(7.53)	(18.12)	(2.74)	(54.97)
Philippines	0.029	0.010	0.156	−0.036	0.318	0.714	0.019	0.955
	(2.09)	(0.97)	(3.57)	(−1.40)	(32.03)	(121.83)	(4.64)	(77.66)
Indonesia	−0.027	0.016	0.149	0.145	0.423	0.553	0.032	0.619
	(−1.58)	(1.52)	(2.55)	(3.52)	(10.28)	(20.25)	(2.52)	(4.00)

Note : The estimated VAR model is

$$\Delta \mathbf{Y}_t = \boldsymbol{\mu} + \Gamma \Delta \mathbf{Y}_{t-1} + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t | \Omega_{t-1} \sim N(\mathbf{0}, \mathbf{H}_t).$$

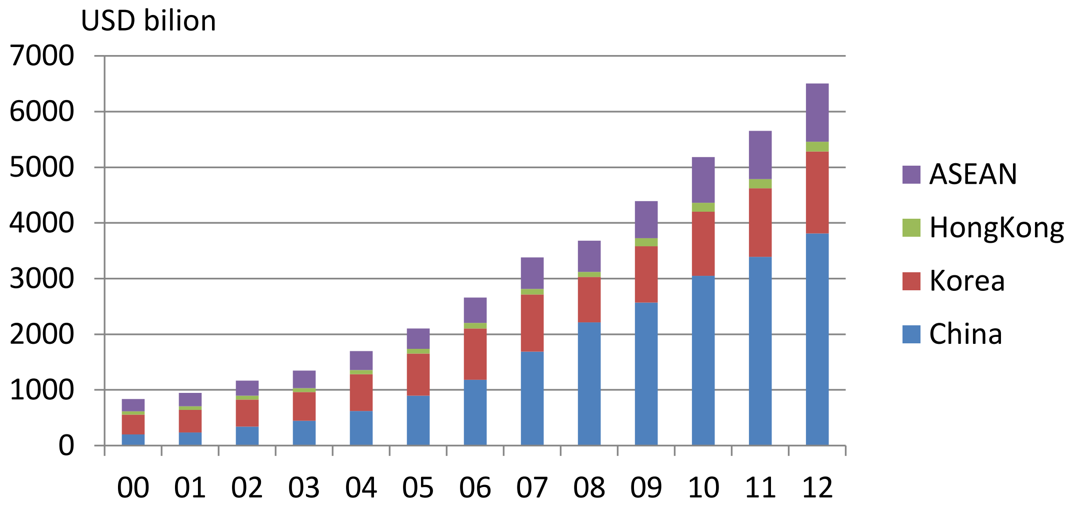
The parameters of $\gamma_{41}, \gamma_{42}, \gamma_{43}$, and γ_{44} respectively indicate the coefficients for the emerging East Asia local market in the above equation (2). The t-values are in parenthesis. The asterisks of $\gamma_{41}, \gamma_{42}, \gamma_{43}$, and γ_{44} denote significance at the 5% level. All the estimates of α_{41}, β_{41}, a and b are highly significant except for the estimate of a in Malaysia.

Table.7 Averaged Relative Contributions of External Factors to the Emerging Asian Individual local markets

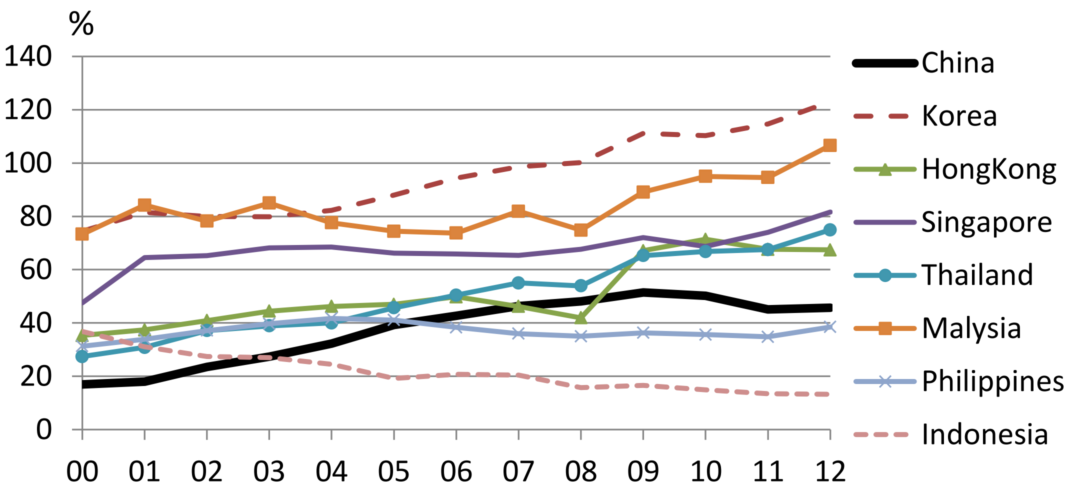
	Global	Japan	Regional	Local
HongKong	36.85	3.50	1.36	58.29
Singapore	24.01	2.51	1.44	72.04
Korea	7.90	0.97	1.93	89.19
Thailand	8.10	0.40	8.44	83.06
Mlaysia	1.99	0.14	5.27	92.60
China	1.04	0.14	0.51	98.31
Phiolippines	0.38	0.41	3.75	95.46
Indonesia	0.35	0.49	1.34	97.83

Note : Numerical values indicate the averaged relative contributions over the sample periods : $\xi_j^{(k)} = \frac{1}{T}\sum_{t=1}^{T}\xi_{j,t}^{(k)}$ for j = Global, Japan, regional and local factors and for each of the emerging East Asian local markets.

Figure 1. LCY Bonds Outstanding in Emerging East Asia
(a) Size of the Markets

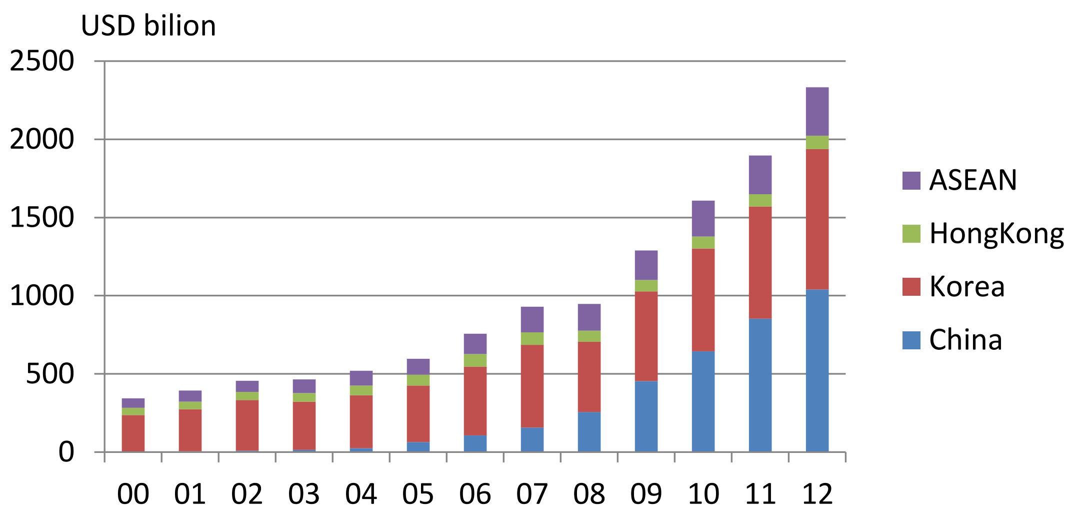


(b) Ratio to GDP

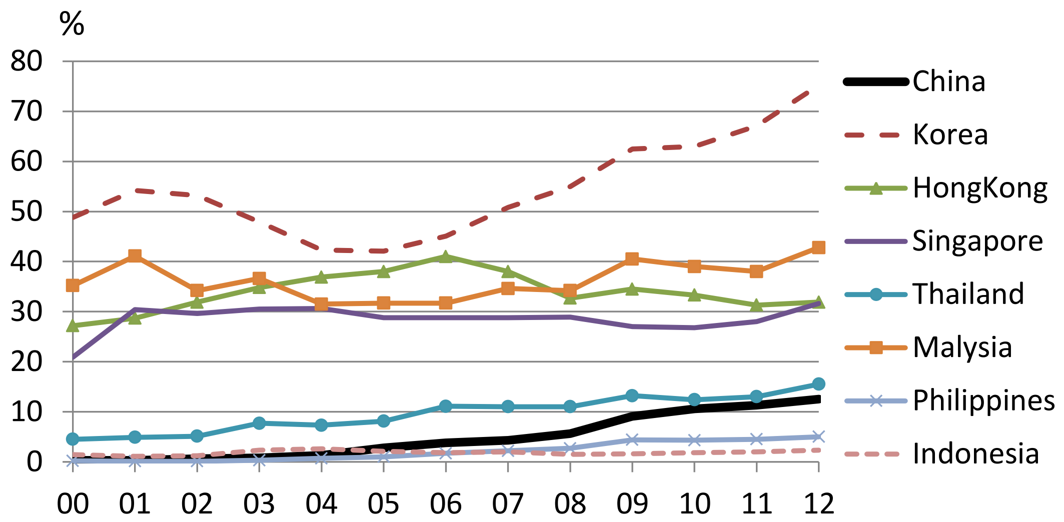


Source: Asian Bonds Online

Figure 2. LCY Corporate Bonds Outstanding in Emerging East Asia
(a) Size of the Markets



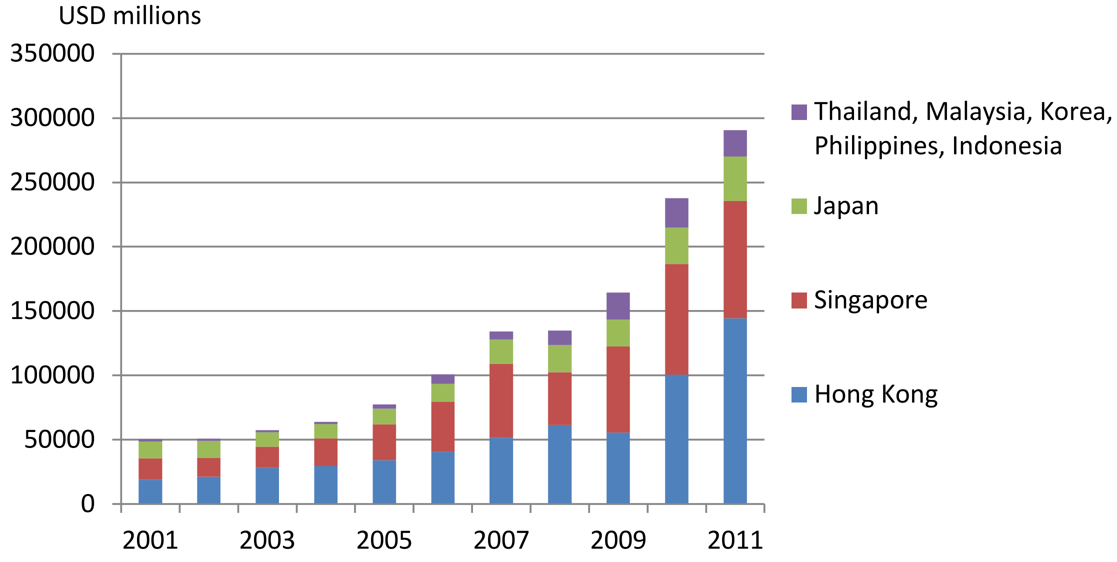
(b) Ratio to GDP



Source: Asian Bonds Online

Figure.3 Intra-regional Cross-Border Debt Securities Investment from Each of the East Asian Countries: Seen from Offer Side

(a) Amounts of Investment



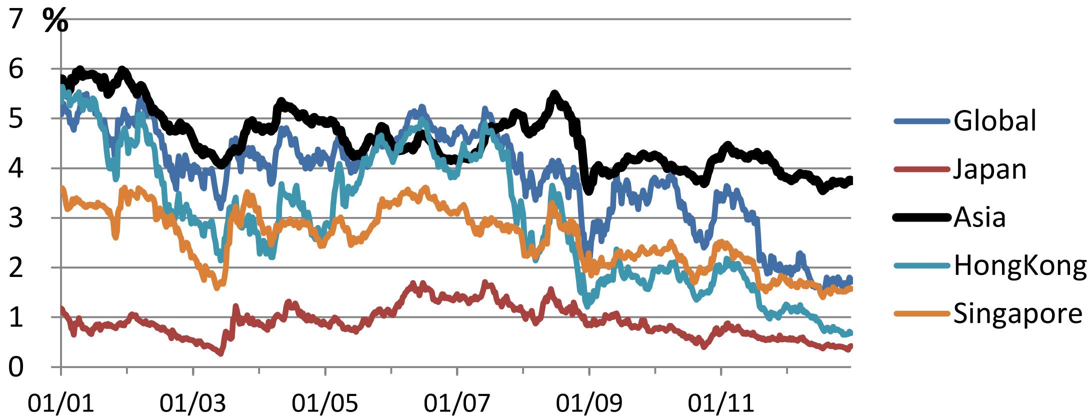
(b) The Ratio of Intra-regional Cross-Border Investment to the Total Cross-Border Investment for Each Country and the Region (%)

	2001	2003	2005	2007	2009	2011
Hong Kong	17	15	16	20	18	42
Indonesia	20	11	26	17	22	17
Korea	20	8	5	6	6	7
Malaysia	13	12	13	20	35	47
Philippines	5	7	14	15	9	32
Singapore	21	12	18	23	25	28
Thailand	29	2	25	8	78	53
Japan	1	1	1	1	1	1
Region	4	3	4	5	6	8
Region ex. Japan	19	14	16	19	22	34

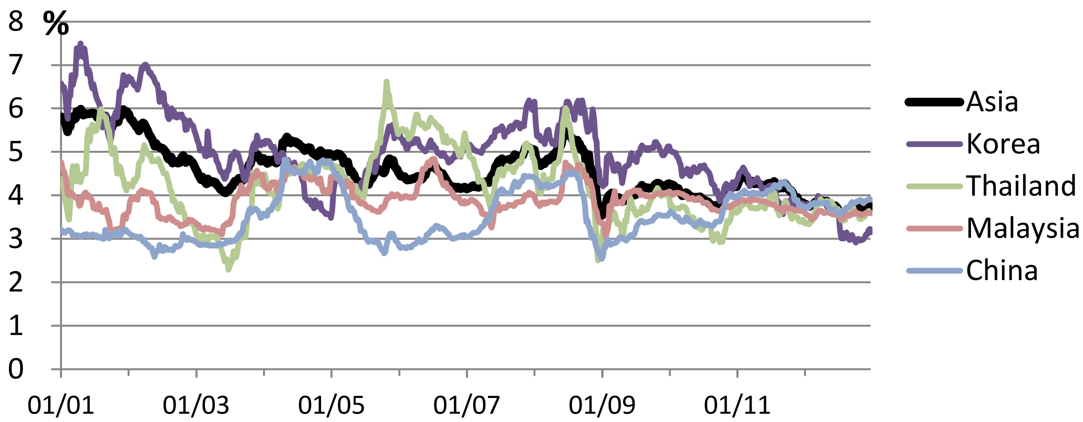
Source: Coordinated Portfolio Investment Survey (CPIS) reports, IMF.
Note: East Asian region consists of Hong Kong, Singapore, Japan, Thailand, Malaysia, Korea, Philippines, Indonesia, and China. The data for China is not available.

Figure.4 Yields of Bond Indices

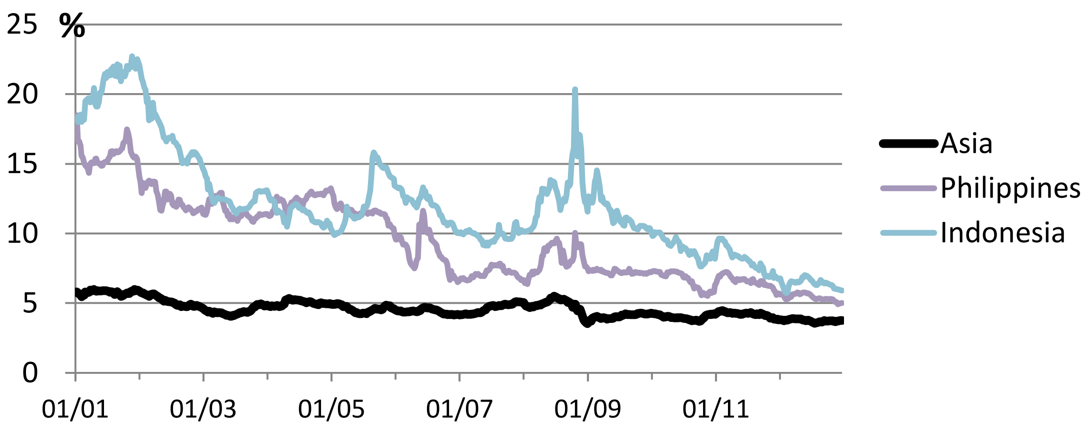
(a) Low Yield Markets (Hong Kong, Singapore)



(b) Middle Yield Markets (Korea, China, Malaysia, and Thiland)



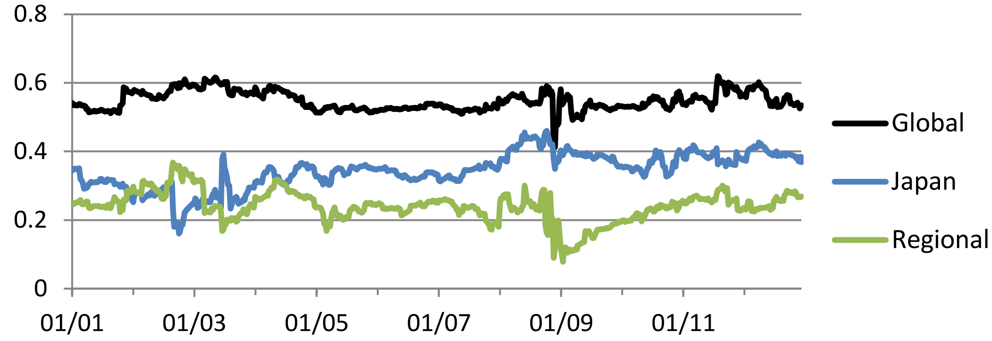
(c) High Yield Markets (Philippines, Indonesia)



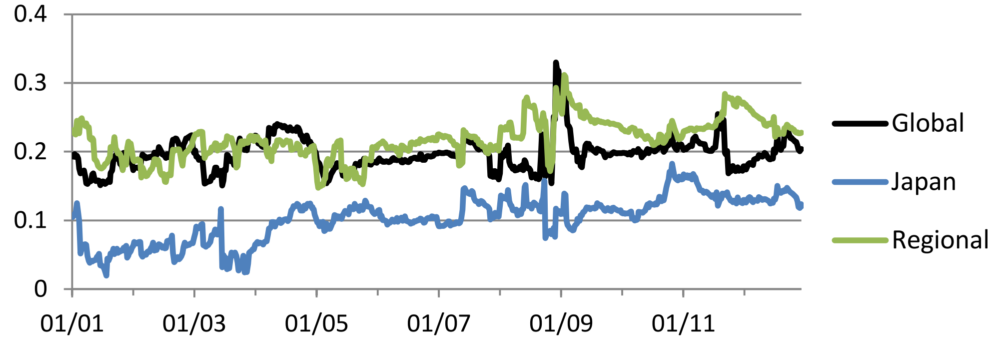
Note : "Asia" denotes the GDP-weighted average yields over the eight emerging East Asian markets considered in this paper. The yields of "Asia" are shown in each panel as a benchmark for the convenience of comparison.

Figure.5 Averaged Conditional Correlations of the Local Market with Global, Japan and Regional Markets ($\bar{\rho}_{4j,t}$)

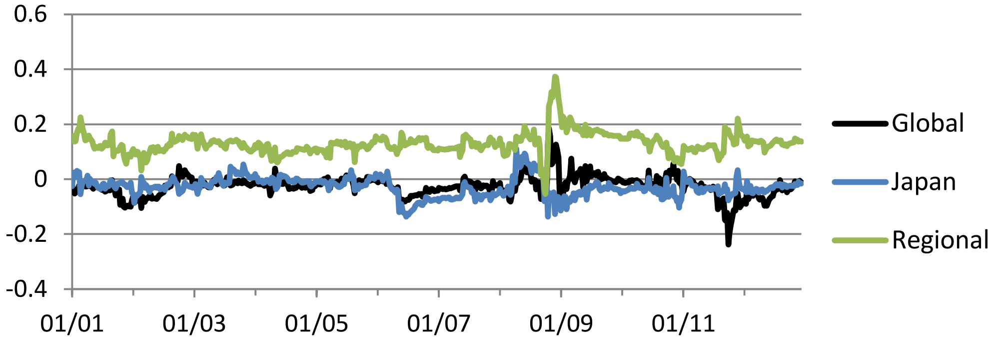
(a) Averages over Low Yield Markets (Hong Kong, Singapore)



(b) Averages over Middle Yield Markets (Korea, China, Malaysia, and Thiland)



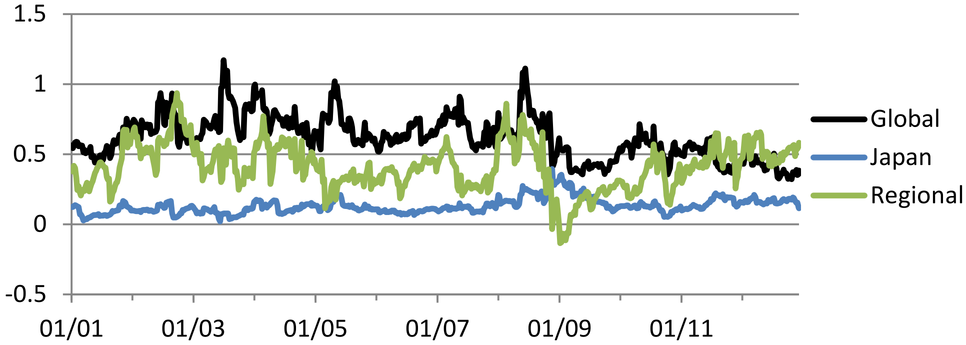
(c) Averages over High Yield Markets (Philippines, Indonesia)



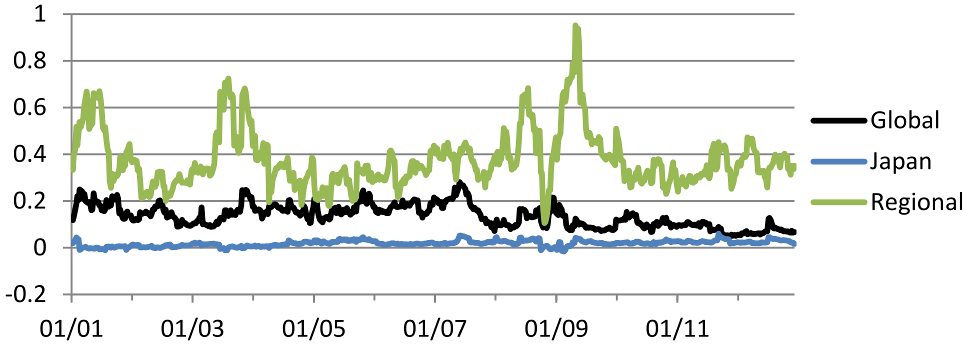
Note: $\bar{\rho}_{4j,t} = \dfrac{1}{m}\sum_{k=1}^{m}\rho_{4j,t}^{(k)}$ for j = Global, Japan, and Regional; indicate the averaged conditional correlations over the subgroups.

Figure.6 Averaged Sensitivities to the External Shocks ($\bar{L}_{4j,t}$)

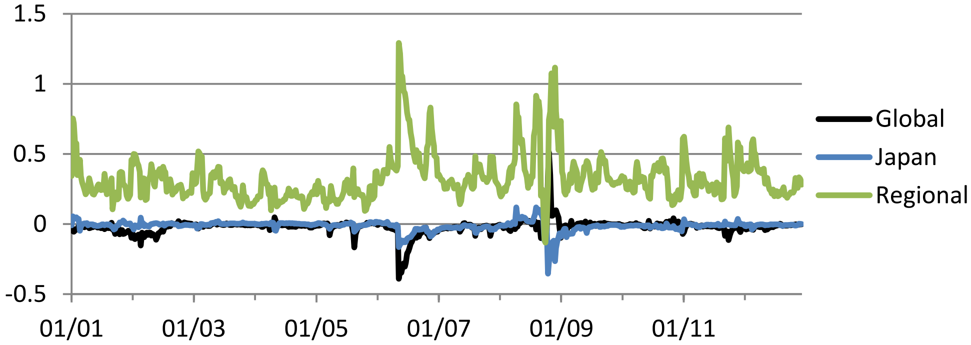
**(a) Averages over Low Yield Markets
(Hong Kong, Singapore)**



**(b) Averages of Middle Yield Markets
(Korea, China, Malaysia, and Thiland)**



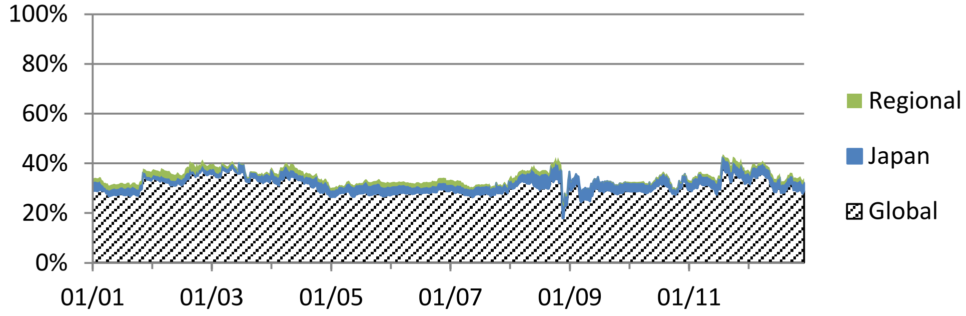
**(c) Averages of High Yield Markets
(Philippines, Indonesia)**



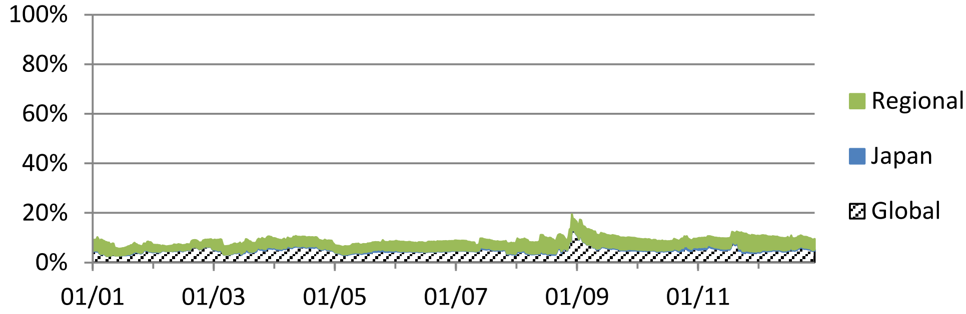
Note: $\bar{L}_{4j,t} = \dfrac{1}{m}\sum_{k=1}^{m} L_{4j,t}^{(k)}$ for j = Global, Japan, and Regional; indicate the sensitivities to the external shocks averaged over the subgroups

Figure.7 Average Relative Contributions

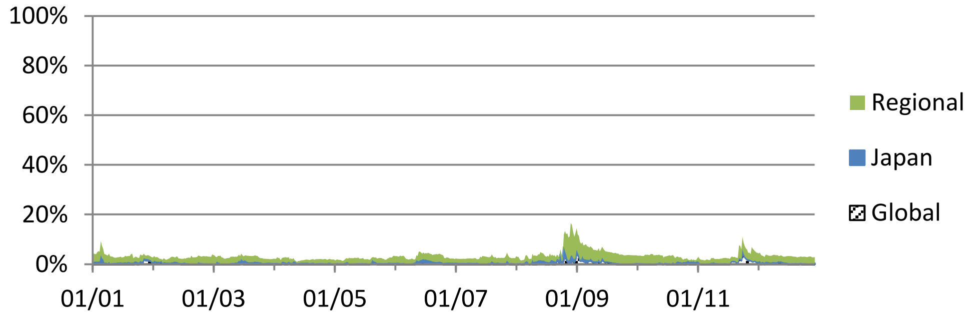
(a) Averages over Low Yield Markets (Hong Kong, Singapore)



(b) Averages over Middle Yield Markets (Korea, China, Malaysia, and Thiland)



(c) Averages over High Yield Markets (Philippines, Indonesia)



Note: The relative contribution of each factor to the volatility of individual local market is given by $\bar{\xi}^{*}_{j,t} = \frac{1}{m}\sum_{k=1}^{m} \xi^{*(k)}_{j,t}$ for j = Global, Japan, Regional, and Intrinsic local markets averaged over the subgroups.