Financial Spillovers from Asian Emerging Economies*

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Abstract

The purpose of this paper is to explore how financial market spillovers between emerging Asia and advanced economies have changed during the past decade. In the first part, we examine spillover effects in stock markets. Estimating the GVAR (Global Vector Autoregressive) model, we find that spillover effects from emerging Asia became significant in the post GFC (Global Financial Crisis) period. However, we also find that most of the spillovers were from shocks in manufacturing sector rather than from those in financial sector. This implies that the spillover effects increased in the post GFC period because of increased manufacturing sector's shocks in emerging Asia. In the second part, we examine spillover effects among short-term and long-term rates. In the tapering period, we find some significant spillovers from emerging Asia to Europe and the USA in 10-year bond markets. But, the spillovers were much smaller than the stock price spillovers in the magnitude. This also supports the view that direct financial linkages from emerging Asia to advanced countries were, if any, limited even after the GFC.

Key words: international spillover, emerging economies, stock markets in Asia

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1. Introduction

Over the past decade, the share of emerging economies in global GDP has risen substantially. IMF's World Economic Outlook (April 2018) forecasted that the share of world total GDP would be 59.25% for emerging market and developing economies and 40.75% for advanced economies based on PPP. Macro fundamental shocks in emerging economies now have substantial spillover effects on advanced economies. However, despite the dramatic output and trade growth, the financial market in emerging economies has developed at a slower pace and from a lower base. As a result, many argue that financial markets in emerging economies still have a limited role in the global financial market.

The purpose of this paper is to explore to what extent spillovers of financial market shocks have evolved between emerging and advanced economies during the past decade. We particularly focus on emerging East Asia and investigate what spillover effects its financial markets have had between emerging Asia and advanced economies. Focusing on emerging East Asia deserves to be noted for the following three reasons. First, among emerging economies, East Asian economies have achieved the most remarkable economic growth called the "East Asian Miracle" and increased the share in global GDP substantially. According to IMF's World Economic Outlook (April 2018), the share of East Asia in world total GDP would exceed 25% based on PPP. [1] Second, despite remarkable economic growth, bond and stock markets have been less developed in these economies until recently. In the 2000s, Asian emerging economies worked on reforming their financial systems. However, despite the reforms, financial market development in the Asian economies still remained far behind those in advanced economies (see, for example, Fukuda [2013]). Third, because Asian financial markets are open only when European and New York markets are closed, the use of daily data allows us to identify direction of spillover effects without simultaneous biases. If the two markets were open in the same time zone, it would be difficult to identify causality of the spillover effects. But thanks to the time difference, we can identify causality from Asian financial market shocks to Europe and the United States.

In the analysis, we estimate GVAR (Global Vector Autoregressive) models and calculate the variance decomposition to see spillover effects across the regions. In the first part, we examine spillover effects in stock markets. We find that while spillovers from Asian stock markets to those in Europe and the United States had been small before the Global Financial Crisis (GFC), they became significant in the post GFC period. However, we also find that most of the significant spillovers were

[1] See also Aizenman and Fukuda (2017) and Didier, Llovet, and Schmukler (2017) both of which discuss growing role of emerging economies in the Pacific Rim.

from shocks in the Asian manufacturing sector rather than those in the financial sector. This implies that spillovers from Asian stock markets to those in Europe and the United States increased in the post GFC period because macro fundamental shocks in emerging Asia had significant impacts on advanced economies.

In the second part, we examine spillover effects among short-term and long-term rates. There was no significant spillover of short-term interest rates either from advanced economies to emerging Asia nor from emerging Asia to advanced economies. In the tapering period, we find some significant spillovers from emerging Asia to Europe and the USA in 10-year bond markets. However, the spillovers were much smaller than the stock price spillovers in the magnitude. This also supports the view that direct financial linkages from emerging Asia to advanced countries were, if any, small even after the GFC.

In literature, a numerous number of studies suggested that financial market shocks in advanced countries had large spillover effects on the rest of the world, especially on emerging market economies (EMEs) during the last decade (see, for example, Gauvin, McLoughlin, and Reinhardt [2014], Engel [2016], and Aizenman, Chinn, and Ito [2017]). In particular, many studies found that US unconventional monetary policy had enormous spillover effects on EMEs after the GFC (e.g., Rogers et al. [2014] and Neely [2015]). Several other studies also found that financial market shocks in advanced countries had large spillover effects on emerging Asian economies (see, for example, Morgan [2011], Park and Um [2016], and Fukuda [2017]). However, relatively limited previous studies explored how large effects financial market shocks in emerging economies had on advanced economies. In particular, few investigated spillovers from Asian financial market shocks to advanced economies.[2] However, the authors such as Gelos and Surti (2016) and Huidrom, Kose, and Ohnsorge (2016) showed the growing importance of financial spillovers from emerging economies in the 2000s, especially after the GFC. It is thus important to examine to what extent spillovers from Asian financial market shocks have risen in global financial markets during the past decade.

Our empirical results suggest that financial market spillovers from advanced economies to emerging Asia were much larger than those from emerging Asia to advanced economies. This is particularly true in bond markets. However, we also find substantial spillovers from Asian stock market to advanced economies in the post GFC period. The industry-level stock price spillovers imply that this happened because of increased manufacturing sector's shocks in emerging Asia. The

[2] Fujiwara and Takahashi (2012) is an exceptional study which found weak spillover effects from Asia in the pre-GFC period.

impact of shocks to economic fundamentals in emerging Asia has been rising in global financial markets. It is likely that spillovers from macro fundamentals to global financial markets will increase considerably in the next few years even if financial market remains less developed.

2. Empirical Methodology

To investigate spillover effects between Asian and advanced financial markets, the following sections estimate GVAR (Global Vector Autoregressive) models and calculate the spillovers by using the variance decomposition. To the extent that spillovers are one-directional and have no further propagation, a single equation would be enough to capture the financial spillovers. However, shocks are propagated through a feedback loop; shocks occurred in the USA affect Asia, the affected Asian economy has a further impact on the US economy, and the feedback loop continues for a few days. A GVAR is a useful econometric framework when such a loop exists because it can capture multilateral financial spillovers with various feedbacks across regions.

In the analysis, we use principal component analysis (PCA) to capture total (common) financial shocks in Asia. PCA is a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called "principal components". By using a linear combination, we calculate the first principal component to account for as much of the variability in the data as possible. We then remove this variance and seek a second linear combination which explains the maximum proportion of the remaining variance. In the PCA, we use financial variables in five emerging Asian economies (South Korea, China, Hong Kong, Taiwan, and Singapore) and those in their subsamples. This is because these economies have more developed financial markets than the other emerging Asian economies.

Using the first and second principal components in the Asian economies, we estimate the following GVAR:

$$(1) \quad Y_t = \alpha + \sum_{j=1}^{p} \beta_j Y_{t-j} + \sum_{j=1}^{p} \gamma x_{t-j} + u_t,$$

where Y_t is a vector of endogenous variables and x_t is an exogenous variable. The vector of endogenous variables are composed of six financial variables: a variable in Japan, the first and

second principal components in the Asian economies, two European variables (variables in the UK and Germany), and a variable in the USA. The exogenous variable is daily log-difference of VIX. We use VIX as an exogenous variable to account for common/systematic global factors. The estimation of the GVAR model is done recursively, with the number of lags set to two.[3]

The order of the Cholesky decomposition is a variable in Japan, the first principal component in Asia, the second principal component in Asia, a variable in the UK, a variable in Germany, and a variable in the USA. We chose the order because Asian financial markets are open when European and New York markets are closed. For example, Figure 1 shows the time zones of each stock market in Asia, Europe, and New York. Putting aside overlaps of a few hours, London and Frankfurt markets are open after the Asian financial markets are close, and the New York market is open after the European markets are closed. Thus, the use of daily data allows us to identify spillover effects without simultaneous biases.[4]

Strictly speaking, the identified spillover effects do not necessarily mean causality from Asian financial shocks to European and US markets because financial variables move in anticipation of future shocks. For example, if some events are expected to happen in the USA when Asian stock markets are open, stock prices in Asia would respond earlier in anticipation of the shocks in the New York market. However, noting that most of the country-specific financial shocks occur when its local market is open, it is less likely that large events are expected to happen in the USA when the New York market is closed. In contrast, country-specific financial shocks in Asia usually occur before those in Europe and the USA will occur in each business day. In the following analysis, we thus suppose that the identified spillover effects in our GVARs suggest causality from Asian financial shocks to European and US markets.

To the extent that the data is available, the sample period starts in January 2003 and ends in April 2018. We split the sample periods into three subsample periods: January 3, 2003 to June 29, 2007 (i.e. pre-GFC period), July 1, 2009 to May 20, 2013 (i.e. post-GFC and pre-tapering period), and May 21, 2013 to April 27, 2018 (i.e. tapering period). The subsample periods did not include July 1, 2007 to June 30, 2009 to exclude the effects of the GFC. We split the post-GFC into the two to allow different monetary policy regimes in the USA. The break point is the date when Federal Reserve

[3] Schwarz SC chose either one or two lags in all cases, and so did AIC. Our essential results were robust even if we set the number of lags to be one.

[4] To circumvent simultaneous biases, a number of previous studies used two-day average returns in literature (Forbes and Rigobon [2002]). But, we did not need such transformation because simultaneous biases are less likely.

Chairman Ben Bernanke first mentioned the idea of gradually reducing or "tapering" the Federal Reserve Board's monetary expansion. Unless explained otherwise, the data were downloaded from *Datastream*.

3. Empirical results: Stock Price Spillovers

In this section, we explore stock price spillovers between Asian and advanced financial markets. We take log-difference of daily main stock market indexes and use them as endogenous variables. The main stock market indexes in Asia are Nikkei 225, Shanghai SSEC, Hang Seng Stock Index, Seoul Composite Index, Singapore (SES) Strait Times Index, Taiwan Weighted Price, and Thailand SET-Index. Those in Europe and the USA are FTSE 100, DAX 30, and Dow Jones Industrials.

Table 1 reports the correlation of the first, second, and third principal components in Asia with the stock market index returns in each Asian economy for three alternative subsample periods. It shows that the first principal component is positively correlated with the stock market returns in all Asian economies. The correlation with China's stock market returns is small for the first subsample period. But the correlation lies almost between 0.3 and 0.5 for the other Asian returns. This implies that the first principal component is a weighted average of all Asian stock market returns. In contrast, the second principal component has large positive correlation only with China's stock market returns. The degree of the correlation is over 0.8 for all subsample periods, which implies that the second principal component reflects mainly China-specific returns. Similarly, the third principal component has large positive correlation only with Thai stock market returns. The degree of the correlation is over 0.7, which implies that the third principal component reflects mainly Thai-specific returns.

Using the first and second principal components in Asian economies, we estimate the GVAR formulated in the last section for three alternative sample periods. Table 2 reports the variance decomposition over 10 business days. It shows how many percentages of the fluctuations were explained by the other stock price shocks over 10 business days. Our main interest is to see spillover effects between Asian stock markets and those in advanced economies. Thus, Table 2-(1) reports how many percentages of the first and second principal components in Asia were explained by shocks in Japan, the two European countries, and the USA, while Table 2-(2) reports how many percentages of stock prices in Japan, the two European countries, and the USA were explained by the first and second principal components in Asia.

Table 2-(1) indicates that the first principal component of Asia was largely explained by stock price shocks in advanced economies throughout the three subsample periods. More than 40% of the first principal component was explained by shocks in advanced economies in the first and second subsample periods and more than 30% in the third subsample periods. This implies that there have been large positive spillovers from stock markets in advanced economies to Asian stock markets before and after the GFC, although the spillover effects declined in the tapering period. Among the advanced economies, shocks in Japan explained most in the first and the third subsample periods, while so did shocks in the UK in the second subsample period. Shocks in the USA also explained more than 8% in the first and the third subsample periods. The only exception was shocks in Germany which only explained 1.55% in the second subsample period and 0.35% in the third subsample period. This may have happened because of the Euro crisis in these periods.

However, Table 2-(1) suggests that the second principal component of Asia was little explained by stock price shocks in advanced economies. Except for shocks in the UK in the second subsample period, no shocks in the advanced economies explained more than 1%. Even shocks in the UK explained 1.22% in the second subsample period. This does not mean that there has been no positive spillover to China because the first principal component is correlated with the China's returns. But this implies that there has been no positive spillover from advanced economies to China-specific returns which were independent of stock prices in the other emerging economies. This may reflect the fact that substantial part of the China's remarkable economic growth occurred independently.

In contrast, Table 2-(2) shows that only limited percentages of the stock price fluctuations in advanced economies were explained by the first and second principal components of Asia throughout the subsample periods. In particular, stock price fluctuations in Japan were little explained in the first and the second subsample periods. This implies that the stock price spillovers are asymmetric between Asia and advanced economies. That is, spillovers from advanced economies to Asian markets have been much larger than those from Asian markets to advanced economies.

However, Table 2-(2) also indicates that after the GFC, the first principal component of Asia came to explain significant percentages of stock price fluctuations in the two European countries and the USA. In the second subsample period (i.e. post-GFC and pre-tapering period), it explained 14.77% in the UK, 11.18% in Germany, and 7.46% in the USA. In the third subsample period (i.e. tapering period), it explained 12.00% in the UK, 9.79% in Germany, and 6.01% in the USA. These percentages were much larger than those in the first subsample period (i.e. pre-GFC period). This

implies that spillovers from emerging Asian stock markets to the stock markets in Europe and the USA, which were small before the GFC, became significantly positive after the GFC. The spillovers from Asia to advanced economies became far from negligible even though they were still smaller than those from advanced economies to Asia,

4. Estimation results based on industry-level stock returns

In the last section, we found that spillovers from stock markets in emerging Asia to those in Europe and the USA, which had been small before the GFC, became significant in the post GFC period. The result indicates that even in the financial markets, shocks in emerging Asia came to have substantial impacts on advanced countries after the GFC. But it does not necessarily suggest that financial linkages from emerging Asia to advanced countries were tightened after the GFC. This is because the significant impacts could have happened when real linkages such as trade linkages or FDI linkages increased in the post-GFC period.

The purpose of this section is to explore whether the significant spillovers in the post-GFC period were originated in Asian financial sector or in Asian manufacturing sector. Specifically, using daily log-difference of industry-level stock price data, we compare spillovers from Asian manufacturing sector with those from Asian financial sector and investigate which sector's shocks had larger impacts on the stock markets in advanced countries. Except that we use the two industry-level stock price returns, that is, stock price returns in the manufacturing sector and those in the financial sector, the estimated equations are essentially the same as those in the last two sections. In the analysis, we use PCA to capture total (common) stock price shocks of the manufacturing sector and those of the financial sector in five emerging Asian economies (South Korea, China, Hong Kong, Taiwan, and Singapore) for the three subsample periods.

Table 3 reports the correlation of the first, second, and third principal components with each industry-level stock price in each Asian economy. It shows that both in the manufacturing sector and in the financial sector, the first principal component is positively correlated with the industry-level stock market returns in all Asian economies. The correlation is relatively small in Thailand. But except for a couple of cases in Thailand, the correlation lies between 0.3 and 0.5 for each industry-level Asian returns. This implies that the first principal component is a weighted average of all Asian industry-level stock market returns. Unlike the aggregate stock price shock, the second and

third principal components do not have dominant positive correlation with stock market returns in China. Instead, in the manufacturing sector, the second principal component has large positive correlation only with stock market returns in Thailand. Even in the financial sector, so does the second principal component in the second subsample period and the third principal component in the first and third subsample periods. This implies that either second or the third principal component reflects mainly Thai stock market returns when using industry-level stock prices.

Except for the use of the first and second principal components in the manufacturing and financial sectors for emerging Asia, the set of endogenous variables, the exogenous variable, and their order are the same as those in the last section. As in the last section, we estimate GVARs for three alternative subsample periods: January 3, 2003 to June 29, 2007, July 1, 2009 to May 20, 2013, and May 21, 2013 to April 27, 2018. When estimating GVARs, we ordered the first and second principal components of the manufacturing sector prior to those of the financial sector in emerging Asian economies.

Table 4 reports the variance decomposition over 10 business days. For three alternative subsample periods, Table 4-(1) reports how many percentages of the first and second principal components in Asian manufacturing and financial sectors were explained by stock price shocks in Japan, the two European countries, and the USA, while Table 4-(2) reports how many percentages of stock prices in Japan, the two European countries, and the USA were explained by the first and second principal components in Asian manufacturing and financial sectors. In both of the tables, we find no significant spillover from advanced countries to the second principal component in Asia throughout the subsample periods.

But as in the last section, we find large spillovers from advanced countries to the first principal component in Asia throughout the subsample periods. Table 4-(1) shows that in both the manufacturing and financial sectors, more than 30% of the first principal component was explained by advanced economies in the first and third subsample periods and more than 40% in the second subsample periods. Before and after the GFC, there have been large positive spillovers from stock markets in advanced economies to Asian stock markets in both of the sectors. However, in the manufacturing sector, nearly 60% of the first principal component's fluctuations were explained by its own shocks. In contrast, in the financial sector, substantial part of the first principal component's fluctuations was explained by the first principal component's shocks in the manufacturing sector. This implies that there have been large positive spillovers not only from advanced economies but

also from the manufacturing sector in Asia to the financial sector in Asia.

As in the last section, we can confirm that the spillovers are asymmetric between Asia and advanced economies. Table 4-(2) shows that only limited percentages of the stock price fluctuations in advanced economies were explained by the first principal components of Asian stock prices in the manufacturing and financial sectors. However, regarding spillovers from Asia to advanced economies, we see one noteworthy feature which we could not observe in the last section.

Throughout the subsample periods, the first principal component of Asian financial sector never had significant spillover effects on advanced countries. Throughout the subsample periods, it never explained more than 2% of stock price fluctuations in each advanced country. In contrast, the first principal component of Asian manufacturing sector had significant spillover effects on stock prices in advanced countries after the GFC. Both in the second and third subsample periods, it explained more than 10% of UK stock price fluctuations, about 10% of German stock price fluctuations, and more than 5% of US stock price fluctuations. These features suggest that spillovers from emerging Asian stock markets to those in Europe and the United States increased in the post GFC period mainly because manufacturing sector's shocks in emerging Asia had significant impacts on macro fundamentals in advanced economies.

It is noteworthy that the share of emerging Asia in the global trading network has progressed steadily over the last decade.[5] Because the financial market in emerging Asia had developed at a slower pace, the increased real linkage had little impact on financial linkage until the post GFC-period. However, once it had reached some threshold level, real linkage between emerging Asia and advanced economies came to have significant impact on financial linkage between the two regions. As a result, the increased real linkage has tightened financial linkage significantly even though direct financial linkages from emerging Asia to advanced countries were, if any, small even after the GFC.

5. Interest Rate Spillovers

In previous sections, we explored spillovers between Asian stock markets and those in advanced economies. In the following sections, we will examine spillovers of short-term and long-term interest rates. As in the previous sections, we calculate the variance decomposition of GVARs and

[5] See also Helble and Ngiang (2016).

investigate how many percentages of the fluctuations were explained by the other interest rate shocks over 10 business days. Variables in the GVARs are composed of six endogenous variables and one exogenous variable (that is, daily log-difference of VIX). The endogenous variables include the first and second principal components of daily difference of interest rates in five Asian economies (that is, South Korea, China, Hong Kong, Taiwan, and Singapore) and daily difference of interest rates in Japan, the UK, Germany, and the USA. The estimation of the GVAR model is done recursively, with the number of lags set to two, for the three subsample periods: January 3, 2003 to June 29, 2007 (i.e. pre-GFC period), July 1, 2009 to May 20, 2013 (i.e. post-GFC and pre-tapering period), and May 21, 2013 to April 27, 2018 (i.e. tapering period). But, because of missing data, pre-GFC period is from January 6, 2006 to June 29, 2007 for short-term interest rates. Since Asian financial markets are open when European and New York markets are closed, the order of the Cholesky decomposition is a variable in Japan, the first principal component in Asia, the second principal component in Asia, a variable in the UK, a variable in Germany, and a variable in the USA.

We first explore spillovers of short-term interest rates. In the following analysis, we use overnight rates as the short-term interest rates for five Asian economies and calculate their principal components.[6] The data of these interest rates were downloaded from *Datastream*. However, because of the zero lower bound, we use the estimated shadow rates for the short-term interest rates in advanced economies. All of the shadow rate estimates are obtained using the Leo Krippner's shadow/lower bound framework with two factors (see Krippner (2015)).[7]

Table 5 summarizes the correlation of the first, second, and third principal components with each short-term rate in Asia for three alternative periods. Unlike in the stock prices, we cannot observe a feature that the first principal component is a weighted average of all Asian economies in the short-term rates. The 2nd and 3rd PCs also have large correlations only with specific economies. This happened not only because short-term rates were still regulated by the government in emerging Asia but also because each central bank could control its policy rate without being affected by external policy rates.

Table 6 reports the variance decomposition over 10 business days. For three alternative subsample periods, Table 5-(1) reports how many percentages of the first and second principal components in

[6] Specifically, we use Korea overnight call rate, Singapore repo O/N, Thailand Interbank O/N, Taiwan Interbank swap overnight, China Interbank O/N, and Hong Kong Interbank 1D.
[7] The two factors are the K-ANSM(2), a fixed 12.5 basis point lower bound, and yield curve data with maturities from 0.25 to 30 years with the sample beginning in 1995.

Asian short-term rates were explained by the short-term rates in Japan, the two European countries, and the USA, while Table 5-(2) reports how many percentages of short-term rates in Japan, the two European countries, and the USA were explained by the first and second principal components in Asian short-term rates. In both of the tables, we find no significant spillover in either direction throughout the subsample periods. This indicates that there was no significant spillover either from advanced economies to emerging Asia or from emerging Asia to advanced economies. This was true even after the GFC when central banks in advanced economies adopted unconventional monetary expansion.

In case of the two European countries and the USA, the variance decomposition shows that there were some spillovers among them. But in Asian economies including Japan, except for the second principal component in the second period, it shows that more than 90% of the short-term rate fluctuations were explained by their own shocks. This indicates that the short-term rates in emerging Asia not only show no synchronization within the region but also are independent of those in the other regions.

6. Spillovers of Long-term Interest Rates

In the last section, we found that there was no significant spillover of short-term interest rates either from advanced economies to emerging Asia or from emerging Asia to advanced economies. The purpose of this section is to explore whether there were any significant spillovers of long-term interest rates between emerging Asia and advanced economies. Specifically, using daily difference of 5-year or 10-year government bond yields, we explore spillover effects of long-term rates between emerging Asia and advanced economies. Unlike short-term rates, long-term rates are difficult to control without being affected by external shocks for each central bank. It is thus likely that long-term interest rates have different spillovers across the regions. Except that we use the long-term interest rates for the endogenous variables, the estimated equations are essentially the same as those in previous sections. We use daily difference of long-term interest rates as endogenous variables and estimate GVARs for three alternative subsample periods.

In the analysis, we use PCA to capture total (common) long-term interest rates in five emerging Asian economies. Table 7 reports the correlation of the first, second, and third principal components with the 5-year and 10-year government bond yields in each Asian economy. It shows

that in both the 5-year and 10-year government bond yields, the first principal component is positively correlated with the Asian long-term interest rates except with Thai long-term rate. The correlation with Taiwan's long-term rate is relatively small in the first and second subsample periods. But, putting aside these outliers, the other correlations lie between 0.37 and 0.6 in 10-year government bond yields. They also tend to exceed 0.4 in 5-year government bond yields. This implies that the first principal component is a weighted average of Asian long-term interest rates.

In contrast, the second principal component has large positive correlation only with Thai long-term interest rates. The degree of the correlation is over 0.8 except for 5-year government bond yields in the first subsample period, which implies that the second principal component reflects mainly Thai long-term interest rates. It is likely that long-term bond markets in Thailand were still less developed and were little affected by external shocks.

Table 8 reports the variance decomposition over 10 business days for three alternative subsample periods. Table 8-(1) reports how many percentages of the first and second principal components in Asian long-term rates were explained by shocks in the four advanced countries, while Table 8-(2) reports how many percentages of long-term rates in the four advanced countries were explained by the first and second principal components in Asia.

Table 8-(1) indicates that in both 10-year and 5-year yields, there were significant spillovers from the advanced economies to the first principal component of Asia throughout the subsample periods. The spillovers were smaller than stock price spillovers. But in the first subsample period, long-term rates in the four advanced economies explained more than 40% of the first principal component. In particular, US long-term rates explained about one-fourth of the first principal component in the first subsample period. In the second and third subsample periods, the explanatory power of long-term rates in the advanced economies declined because the first principal component was more explained by its own shocks. This indicates that intraregional spillovers increased in Asian bond markets after the GFC. However, even in these subsample periods, advanced economies' shocks explained significant part of the first principal component's fluctuations in 10-year and 5-year yields. After the GFC, spillovers from advanced economies were slightly larger in 5-year yields than in 10-year yields. This may have happened because unconventional monetary policy in advance economies had some spillovers to Asia in 5-year yields.

Unlike in the first principal component, we do not necessarily observe large spillovers from the advanced economies to Asia in the second principal component. In case of 5-year yields, most of the

second principal component's fluctuations were explained by its own shocks throughout the subsample periods. Noting that China's long-term interest rates have no correlation with the first principal component but have large correlation with the second principal component, this implies that China's 5-year interest rates have been determined independently. However, in case of 10-year yields, shocks in the four advanced economies explained more than 20% of the second principal component in the second and third subsample periods. This suggests that China's 10-year yields had significant spillovers from the advanced economies after the GFC even though China's 5-year yields were still controlled by the government.

In contrast, Table 5-(2) shows that only limited percentages of the long-term rate fluctuations in advanced economies were explained by the first and second principal components of Asia throughout the subsample periods. This implies that the spillovers of long-term rates are asymmetric between Asia and advanced economies. That is, as in the stock markets, spillover effects from advanced economies to Asian markets have been much larger than those from Asian markets to advanced economies in the long-term bond markets.

Among the advanced economies, long-term rate fluctuations in Japan were explained mainly by their own shocks and were little explained by external shocks throughout the subsample periods. This happened because unconventional monetary policy by the Bank of Japan induced extremely low long-term rates throughout the sample periods. Even long-term rates in the other advanced economies, whose fluctuations were sometimes explained by external shocks, were little explained by Asian shocks in the first and the second subsample periods. This is in marked contrast with stock price spillovers in which the first principal component of Asia came to explain significant percentages of stock price fluctuations in the two European countries and the USA after the GFC.

In case of 10-year yields, the first principal component of Asia explained about 4.47% in the UK, 3.17% in Germany, and 5.09% in the USA in the third subsample period. This implies that in the tapering period, spillovers from emerging Asia to Europe and the USA came to have some significance in 10-year bond markets. But the spillovers were much smaller than the stock price spillovers in the magnitude. Noting that stock price spillovers from emerging Asia to Europe and the United States increased mainly because manufacturing sector's shocks in emerging Asia had significant impacts on advanced economies, this result also supports the view that direct financial linkages from emerging Asia to advanced countries were, if any, small even after the GFC.

7. Concluding Remarks

In this paper, we explored how financial market spillovers between emerging Asia and advanced economies have changed during the past decade. In both stock and bond markets, financial market spillovers from advanced economies to emerging Asia were much larger than those from emerging Asia to advanced economies. Stock market spillover effects from emerging Asia became far from negligible in the post GFC period. However, the spillover effects in the stock markets were mostly from shocks in the manufacturing sector rather than from those in the financial sector. This implies that the spillover effects increased in the post GFC period because of increased manufacturing sector's shocks in emerging Asia.

Over the past two decades, the role of Asian emerging market economies has risen substantially in global economy. As a result, macro fundamental shocks in emerging market economies came to have substantial spillover effects on advanced economies. Our empirical results support the view that even though the financial market in emerging Asia has developed at a slower pace, the impact of emerging Asia has been rising in the global financial markets.

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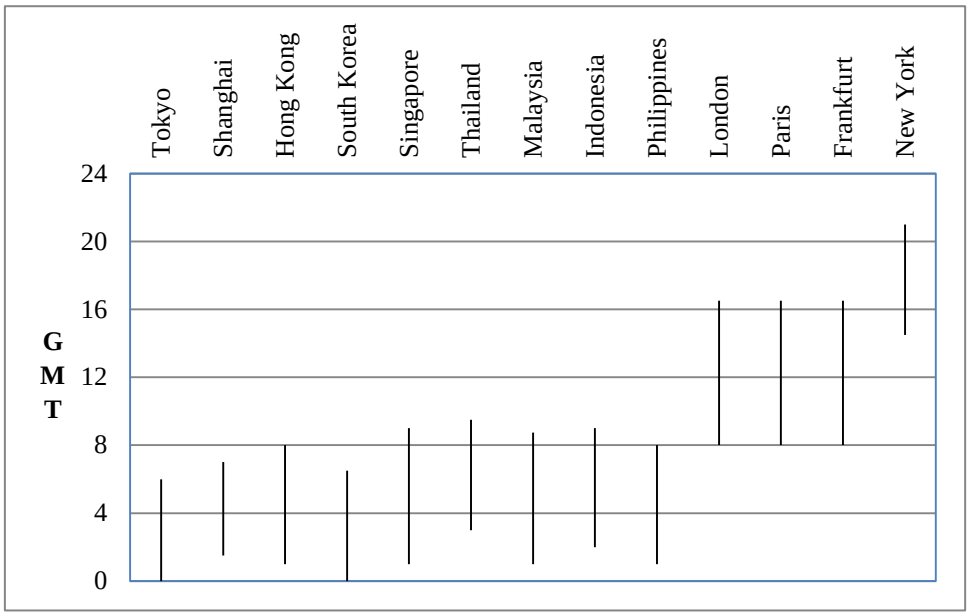
Figure 1. The Time Zones for which Each Stock Market is Open



Note) The time zone is based on winter time. Asian financial markets are open when European and New York markets are closed and European and New York markets are open when Asian financial markets are closed.

Table 1. The correlation of the principal components with each stock market index returns

(1) Pre-GFC period			
	1st PC	2nd PC	3rd PC
Korea	0.476	−0.059	−0.205
Hong Kong	0.489	0.030	−0.127
China	0.109	0.982	0.090
Taiwan	0.445	−0.109	−0.265
Singapore	0.475	−0.004	−0.052
Thailand	0.315	−0.136	0.928
(2) Post-GFC and pre-tapering period			
	1st PC	2nd PC	3rd PC
Korea	0.430	−0.158	−0.436
Hong Kong	0.466	0.073	0.076
China	0.310	0.897	0.166
Taiwan	0.425	−0.120	−0.472
Singapore	0.441	−0.150	0.089
Thailand	0.354	−0.360	0.739
(3) Tapering period			
	1st PC	2nd PC	3rd PC
Korea	0.431	−0.199	−0.413
Hong Kong	0.483	0.197	−0.038
China	0.300	0.849	0.215
Taiwan	0.432	−0.169	−0.379
Singapore	0.440	−0.140	0.073
Thailand	0.331	−0.390	0.796

Note: “PC” denotes “principal component”.

Table 2-(1). The variance decomposition of the principal components

(a) The decomposition of the 1st principal component

	1st PC shock	Advanced Economies				
		Total	Japan	UK	Germany	USA
Pre-GFC period	57.09	41.62	24.39	6.03	3.03	8.17
Pre-tapering period	56.17	43.02	15.33	19.49	1.55	6.65
Tapering period	64.26	33.33	14.80	8.05	0.84	9.65

(b) The decomposition of the 2nd principal component

	2nd PC shock	Advanced Economies				
		Total	Japan	UK	Germany	USA
Pre-GFC period	98.59	0.99	0.15	0.08	0.33	0.43
Pre-tapering period	97.09	2.08	0.03	1.22	0.03	0.79
Tapering period	97.95	1.46	0.77	0.17	0.01	0.50

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 2-(2). The variance decomposition in advanced economies

	Japan's stock prices			
	Japan shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	82.64	15.87	1.29	0.19
Pre-tapering period	70.99	27.87	0.25	0.89
Tapering period	74.84	22.18	2.38	0.61
	UK stock prices			
	UK shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	80.45	14.83	4.53	0.19
Pre-tapering period	74.59	9.47	14.77	1.17
Tapering period	71.09	16.00	12.00	0.92
	Germany stock prices			
	Germany shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	37.19	56.53	6.03	0.25
Pre-tapering period	22.37	64.92	11.18	1.52
Tapering period	35.87	53.03	9.79	1.32
	US stock prices			
	US shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	62.42	34.76	2.60	0.22
Pre-tapering period	40.92	50.14	7.46	1.47
Tapering period	65.17	28.42	6.01	0.41

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 3. The correlation of the principal components with each industry-level returns

(1) Pre-GFC period

	manufacturing sector			financial sector		
	1st PC	2nd PC	3rd PC	1st PC	2nd PC	3rd PC
Korea	0.461	0.006	−0.302	0.435	−0.239	0.092
Hong Kong	0.485	−0.151	−0.021	0.491	−0.037	−0.203
China	0.316	−0.591	0.650	0.348	0.551	−0.620
Taiwan	0.434	0.160	−0.393	0.379	−0.549	0.126
Singapore	0.441	−0.038	−0.081	0.453	−0.094	−0.015
Thailand	0.264	0.775	0.570	0.316	0.572	0.741

(2) Post-GFC and pre-tapering period

	manufacturing sector			financial sector		
	1st PC	2nd PC	3rd PC	1st PC	2nd PC	3rd PC
Korea	0.410	−0.337	0.201	0.385	−0.415	0.439
Hong Kong	0.448	0.060	−0.398	0.460	0.076	−0.396
China	0.463	0.013	−0.260	0.454	0.047	−0.373
Taiwan	0.374	−0.462	0.601	0.383	−0.472	0.350
Singapore	0.425	0.060	−0.373	0.420	0.064	−0.314
Thailand	0.310	0.816	0.484	0.334	0.770	0.539

(3) Tapering period

	manufacturing sector			financial sector		
	1st PC	2nd PC	3rd PC	1st PC	2nd PC	3rd PC
Korea	0.389	−0.248	0.584	0.314	0.679	0.495
Hong Kong	0.464	−0.127	−0.396	0.489	−0.143	−0.358
China	0.457	−0.189	−0.301	0.477	−0.110	−0.344
Taiwan	0.401	−0.159	0.502	0.392	0.325	0.039
Singapore	0.410	0.045	−0.372	0.439	−0.070	−0.093
Thailand	0.310	0.927	0.145	0.297	−0.630	0.706

Table 4-(1). The variance decomposition of the principal components

(a) The decomposition of the 1st principal component

		1st PC	Advanced Economies				
		shock	Total	Japan	UK	Germany	USA
mfg.	Pre-GFC period	60.62	37.20	22.19	5.66	2.88	6.47
sector	Pre-tapering period	57.88	41.24	13.45	19.69	1.72	6.38
	Tapering period	68.25	30.48	13.75	7.64	1.18	7.91
financial	Pre-GFC period	25.19	35.40	20.46	4.89	2.96	7.09
sector	Pre-tapering period	12.98	41.12	14.38	18.09	1.98	6.67
	Tapering period	22.92	31.16	13.73	8.35	1.01	8.07

(b) The decomposition of the 2nd principal component

		2nd PC	Advanced Economies				
		shock	Total	Japan	UK	Germany	USA
mfg.	Pre-GFC period	97.36	0.53	0.02	0.08	0.14	0.29
sector	Pre-tapering period	96.98	1.76	0.82	0.41	0.15	0.37
	Tapering period	97.12	1.83	0.81	0.96	0.03	0.02
financial	Pre-GFC period	90.86	2.86	1.84	0.04	0.71	0.28
sector	Pre-tapering period	73.55	2.41	0.83	0.67	0.42	0.49
	Tapering period	80.53	2.40	0.99	0.90	0.38	0.13

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 4-(2). The variance decomposition in advanced economies

The variance decomposition of Japan's stock prices						
	Japan	Other	mfg. sector		financial sector	
	shock	adv. econ.	1st PC	2nd PC	1st PC	2nd PC
			shock	shock	shock	shock
Pre-GFC period	82.17	15.68	1.15	0.11	0.75	0.13
Pre-tapering period	71.28	27.32	0.56	0.08	0.36	0.40
Tapering period	74.64	22.27	2.18	0.70	0.17	0.04
The variance decomposition of UK stock prices						
	UK	Other	mfg. sector		financial sector	
	shock	adv. econ.	1st PC	2nd PC	1st PC	2nd PC
			shock	shock	shock	shock
Pre-GFC period	79.97	14.90	2.92	0.10	1.28	0.83
Pre-tapering period	73.69	9.83	14.77	0.44	0.58	0.68
Tapering period	71.14	16.00	11.33	0.36	1.00	0.17
The variance decomposition of Germany stock prices						
	Germany	Other	mfg. sector		financial sector	
	shock	adv. econ.	1st PC	2nd PC	1st PC	2nd PC
			shock	shock	shock	shock
Pre-GFC period	37.04	56.63	4.04	0.34	1.67	0.27
Pre-tapering period	22.37	64.62	10.92	0.42	1.03	0.63
Tapering period	35.61	53.09	9.41	0.41	1.12	0.35
The variance decomposition of US stock prices						
	US	Other	mfg. sector		financial sector	
	shock	adv. econ.	1st PC	2nd PC	1st PC	2nd PC
			shock	shock	shock	shock
Pre-GFC period	62.29	34.89	1.52	0.01	1.04	0.26
Pre-tapering period	41.04	50.32	7.55	0.19	0.61	0.29
Tapering period	64.85	29.32	5.04	0.30	0.37	0.12

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 5. The correlation of the principal components with each short-term rate

(1) Pre-GFC period

	1st PC	2nd PC	3rd PC
Korea	−0.342	−0.367	0.294
Hong Kong	0.042	−0.615	−0.103
China	0.703	−0.156	0.246
Taiwan	0.114	0.353	0.800
Singapore	−0.481	0.396	−0.020
Thailand	0.376	0.425	−0.451

(2) Post-GFC and pre-tapering period

	1st PC	2nd PC	3rd PC
Korea	−0.312	−0.505	0.478
Hong Kong	0.292	0.283	0.410
China	0.666	0.195	0.283
Taiwan	−0.200	0.459	0.515
Singapore	0.258	−0.599	0.402
Thailand	−0.517	0.239	0.310

(3) Tapering period

	1st PC	2nd PC	3rd PC
Korea	0.242	−0.126	−0.547
Hong Kong	0.672	0.019	0.131
China	0.636	0.058	−0.014
Taiwan	0.178	0.696	−0.152
Singapore	0.212	−0.702	0.021
Thailand	0.094	0.062	0.812

Table 6-(1). The variance decomposition of the principal components

(a) The decomposition of the 1st principal component

	1st PC	Advanced Economies				
	shock	Total	Japan	UK	Euro	USA
Pre-GFC period	97.28	1.21	0.68	0.07	0.35	0.11
Pre-tapering period	98.41	1.46	1.05	0.27	0.13	0.02
Tapering period	98.90	0.56	0.35	0.06	0.12	0.04

(b) The decomposition of the 2nd principal component

	2nd PC	Advanced Economies				
	shock	Total	Japan	UK	Euro	USA
Pre-GFC period	95.74	2.05	1.32	0.35	0.30	0.09
Pre-tapering period	99.12	0.37	0.06	0.13	0.16	0.02
Tapering period	98.78	1.15	0.17	0.26	0.10	0.61

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 6-(2). The variance decomposition in advanced economies

Japan's short-term shadow rates				
	Japan shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	98.38	0.62	0.49	0.51
Pre-tapering period	90.18	9.61	0.17	0.04
Tapering period	94.53	5.23	0.14	0.10
UK short-term shadow rates				
	UK shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	89.65	7.34	1.75	1.26
Pre-tapering period	93.07	6.86	0.06	0.01
Tapering period	91.83	1.86	0.15	6.16
Euro short-term shadow rates				
	Euro shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	72.50	25.48	0.13	1.90
Pre-tapering period	70.58	28.69	0.14	0.60
Tapering period	75.92	17.90	0.95	5.24
US short-term shadow rates				
	US shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	71.53	27.31	0.98	0.18
Pre-tapering period	71.09	28.06	0.53	0.31
Tapering period	68.42	30.10	0.27	1.21

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 7. The correlation of the principal components with each long-term rate

(1) Pre-GFC period

	10-year bond yields			5-year bond yields		
	1st PC	2nd PC	3rd PC	1st PC	2nd PC	3rd PC
Korea	0.375	0.165	0.089	0.446	−0.304	−0.117
Hong Kong	0.569	0.007	−0.083	0.606	0.027	−0.137
China	0.419	−0.120	−0.099	0.158	0.745	0.194
Taiwan	0.129	0.101	0.971	0.165	0.167	0.794
Singapore	0.583	0.042	−0.131	0.614	0.018	−0.100
Thailand	−0.054	0.973	−0.122	0.066	−0.569	0.538

(2) Post-GFC and pre-tapering period

	10-year bond yields			5-year bond yields		
	1st PC	2nd PC	3rd PC	1st PC	2nd PC	3rd PC
Korea	0.439	−0.077	−0.224	0.476	−0.005	0.010
Hong Kong	0.532	−0.065	0.267	0.474	−0.149	−0.121
China	0.442	−0.116	−0.048	0.408	−0.149	−0.173
Taiwan	0.265	0.546	−0.723	0.299	0.304	0.887
Singapore	0.503	−0.163	0.260	0.521	−0.172	−0.167
Thailand	0.071	0.807	0.535	0.145	0.913	−0.374

(3) Tapering period

	10-year bond yields			5-year bond yields		
	1st PC	2nd PC	3rd PC	1st PC	2nd PC	3rd PC
Korea	0.457	−0.121	0.225	0.462	−0.030	0.207
Hong Kong	0.488	−0.048	−0.214	0.463	0.077	−0.352
China	0.390	0.013	0.677	0.398	−0.131	0.746
Taiwan	0.394	0.063	−0.665	0.416	0.059	−0.498
Singapore	0.493	−0.015	−0.008	0.490	0.000	−0.049
Thailand	0.057	0.989	0.051	0.006	0.986	0.163

Table 8-(1). The variance decomposition of the principal components

(a) The decomposition of the 1st principal component

		1st PC	Advanced Economies				
		shock	Total	Japan	UK	Germany	USA
10-year	Pre-GFC period	52.31	47.37	3.30	15.04	4.33	24.69
yields	Pre-tapering period	81.82	15.43	2.59	3.92	1.75	7.17
	Tapering period	77.88	19.84	2.25	5.56	0.89	11.13
5-year	Pre-GFC period	56.23	43.53	2.94	12.27	2.00	26.32
yields	Pre-tapering period	72.74	22.06	2.75	6.89	1.29	11.14
	Tapering period	68.73	24.42	2.48	9.02	0.70	12.22

(b) The decomposition of the 2nd principal component

		2nd PC	Advanced Economies				
		shock	Total	Japan	UK	Germany	USA
10-year	Pre-GFC period	56.23	43.53	2.94	12.27	2.00	26.32
yields	Pre-tapering period	70.15	29.24	3.89	6.50	4.92	13.94
	Tapering period	60.76	37.21	3.34	9.71	1.72	22.45
5-year	Pre-GFC period	96.58	2.42	0.47	1.11	0.36	0.49
yields	Pre-tapering period	95.95	3.39	0.79	0.35	0.08	2.18
	Tapering period	97.16	2.01	0.10	0.38	0.10	1.43

Note: Table reports the variance decomposition over 10 business days after a shock.

Table 8-(2). The variance decomposition in advanced economies

The variance decomposition of Japan's long-term rates

	10-year yields				5-year yields			
	Japan shock	Other adv. econ.	1st PC shock	2nd PC shock	Japan shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	92.45	7.28	0.08	0.20	93.59	6.28	0.05	0.07
Pre-tapering period	82.42	17.10	0.16	0.32	83.32	16.44	0.21	0.04
Tapering period	86.71	11.96	0.96	0.36	93.40	6.33	0.25	0.03

The variance decomposition of UK stock prices

	10-year yields				5-year yields			
	UK shock	Other adv. econ.	1st PC shock	2nd PC shock	UK shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	91.59	6.21	2.14	0.06	91.37	5.05	3.07	0.50
Pre-tapering period	87.75	7.14	2.62	2.49	91.62	4.87	3.32	0.19
Tapering period	86.30	7.74	2.19	3.77	91.60	3.72	4.47	0.22

The variance decomposition of Germany stock prices

	10-year yields				5-year yields			
	Germany shock	Other adv. econ.	1st PC shock	2nd PC shock	Germany shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	37.80	59.22	2.81	0.17	59.60	37.76	2.05	0.60
Pre-tapering period	39.92	54.38	2.28	3.42	55.88	40.88	1.49	1.75
Tapering period	41.63	53.00	2.32	3.05	51.80	41.72	2.89	3.60

The variance decomposition of US stock prices

	10-year yields				5-year yields			
	US shock	Other adv. econ.	1st PC shock	2nd PC shock	US shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	38.42	57.30	3.81	0.47	69.81	28.14	1.84	0.22
Pre-tapering period	60.31	37.88	1.80	0.01	60.67	36.56	2.41	0.36
Tapering period	61.53	34.83	3.17	0.46	64.10	30.76	5.09	0.05

Note: Table reports the variance decomposition over 10 business days after a shock.