Financial Spillovers in Asian Emerging Economies*

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Abstract

This paper explores financial spillovers between emerging Asia and advanced economies using principal component analysis (PCA) to extract common shocks in Asia. We first investigate stock market spillovers across the regions and find that the spillovers from emerging Asia became significant in the post GFC (Global Financial Crisis) period. However, the industry-level analysis showed that the increased spillovers were attributable to the first principal component (PC) in manufacturing sector rather than to the first PC in financial sector. This implies that a rise of Asian manufacturing sector in the global market played a key role for enhancing the stock market spillovers. We next examine bilateral spillovers in short-term and long-term rates. In the tapering period, we find significant spillovers from the first PC in emerging Asia to Europe and the United States in long-term rates. However, the spillovers were much smaller than the stock market spillovers in the magnitude.

I. Introduction

In the 2000s, emerging economies increased their share in global GDP substantially. IMF's World Economic Outlook (October 2018) suggested that based on Purchasing Power Parity (PPP), the share of emerging and developing economies in world total GDP, which was 43.2% in 2000, would be 62.7% in 2023 (Figure 1). In integrated global production networks, emerging economies are increasingly more connected with the rest of the world. However, despite a large increase in their disposable income, many of them have not been able to sell in advance rights over their output, i.e. to create financial assets, owing to their financial underdevelopment. Therefore, despite the dramatic output growth, there still exists a view that financial markets in emerging economies have a limited role in the global financial market.

In this paper, we explore how financial spillovers between emerging East Asia and advanced economies have evolved in the 2000s. To investigate financial spillovers between emerging and advanced economies, East Asia has the following three notable features. First, emerging East Asian economies have undergone rapid industrialization and maintained exceptionally high growth rates called the "East Asian Miracle". According to IMF's World Economic Outlook (October 2018), the share of emerging and developing Asia in world total GDP, which was 16.7% in 2000, would be 37.8% in 2023 based on PPP. East Asia now plays a central role in global production networks (see, for example, Ito and Vézina 2016, Helble and Ngiang 2016, Aizenman and Fukuda 2017, and Shepherd 2018). Second, despite the dramatic output and trade growth, financial markets in emerging East Asia have developed at a slower pace and from a lower base until recently. In the 2000s, some Asian emerging economies started a process of financial "catching up" towards mature economies. However, various indicators suggest that the scope for financial catching up is still substantial in most of the Asian emerging economies (see, for example, Fukuda 2013). Third, since Asian financial markets are open when European and New York markets are closed, we may identify causality from Asian financial market shocks to Europe and the United States without serious simultaneous biases. If the financial markets were open at the same time, it would be difficult to identify from which financial markets the shocks were originated. But because of substantial time differences across the regions, the use of daily data in each region may allow us to identify direction of spillover effects without serious simultaneous biases.

In the analysis, we use principal component analysis (PCA) to capture common financial shocks in Asia and estimate GVAR (Global Vector Autoregressive) models to see bilateral spillovers across the

regions. In the first part, we investigate bilateral stock market spillovers across the regions. We find that while spillovers from Asian stock markets to those in Europe and the United States had been small, stock market spillovers from the first PC in emerging Asia became significant in the post GFC (Global Financial Crisis) period. However, we also find that the increased spillovers were attributable to the first PC in manufacturing sector rather than to the first PC in financial sector. This implies that a rise of Asian manufacturing sector in the global market played a key role for enhancing stock market spillovers from emerging Asia in the post GFC period.

In the second part, we examine bilateral spillovers in short-term and long-term rates. In short-term rates, there was a significant spillover neither from advanced economies to Asia nor from Asia to advanced economies. In contrast, in long-term rates, we find large spillovers from advanced economies to Asia. We also find some significant spillovers from Asia to Europe and the United States in long-term rates. However, spillovers from emerging Asia were much smaller in the bond markets than in the stock markets. This supports the view that bond market linkages from emerging Asia to advanced countries were, if any, small even after the GFC.

In literature, a number of studies investigated financial spillovers from advanced economies. They found that financial market shocks in advanced countries had large spillover effects on emerging market economies (EMEs) although the responses of EMEs were heterogeneous (see, for example, Gauvin, McLoughlin, and Reinhardt 2014, Engel 2016, and Aizenman, Chinn, and Ito 2017). In particular, an extensive literature suggested that US unconventional monetary policy had enormous spillover effects on EMEs after the GFC, especially on those with fragile macro fundamentals (e.g., Rogers et al. 2014, Neely 2015, Eichengreen and Gupta 2015, Rey 2016, and Tillmann 2016). Several regional studies also found that financial shocks in advanced economies had various spillover effects on emerging Asian economies (see, for example, Morgan 2011, Park and Um 2016, and Fukuda 2019). However, spillovers originating from the emerging markets have received relatively scant attention in most of the previous studies. Gelos and Surti (2016) and Huidrom, Kose, and Ohnsorge (2016) are exceptional studies that showed the growing importance of financial spillovers from emerging economies in the 2000s especially after the GFC. However, few studies investigated spillovers from Asian financial markets to advanced markets. It is thus important to understand how large spillovers Asian financial markets have had in the 2000s and to what extent they have risen after the GFC.

This paper is a straightforward extension of Fukuda and Tanaka (2017) in that we explore the

degree of financial spillovers from emerging Asia in the 2000s. However, it has two critical differences. First, this paper uses principal component analysis (PCA) to extract common financial shocks in Asia. The extracted financial shocks in Asia allow us to investigate how large regional spillovers Asian common financial shocks had before and after the GFC. A number of studies suggested growing regional integration in Asian financial markets (see, for example, Yu, Fung, and Tam 2010, Boubakri and Guillaumin 2015, Komatsubara, Okimoto, and Tatsumi 2017, Mensah and Premaratne 2017, Didier, Llovet, and Schmukler 2017, and Sugimoto and Matsuki 2018). Given financial integration in Asia, it is important to estimate regional spillovers excluding spillovers from country-specific shocks. Second, this paper investigates bond market spillovers in addition to stock market spillovers. Regarding the degree of financial development, bond markets have been less developed than stock markets in Asia.[1] Thus, comparing spillovers in the two types of financial markets, we may see whether bond market linkages from emerging Asia to advanced countries were smaller owing to their financial underdevelopment.

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 significant spillovers from Asian stock market to advanced economies in the post GFC period. The industry-level stock market spillovers indicate that this happened because of increased manufacturing sector's shocks in emerging Asia. The impact of fundamental shocks in emerging Asia has been rising in global financial markets. This has considerably increased stock market spillovers from Asia to global financial markets even if financial markets remained less developed in Asia. However, direct financial linkages from emerging Asia to advanced countries were, if any, limited even after the GFC. Structural reforms of financial markets are still important policy agenda in emerging Asia.

The paper proceeds as follows. After explaining our empirical methodology in section 2, section 3 provides empirical results on stock market spillovers. Section 4 extends the analysis by using industry-level stock returns. Section 5 and section 6 investigate spillovers of short-term and long-term rates respectively. Section 7 summarizes our results and refers to their implications.

II. Empirical Methodology

To investigate bilateral spillovers between Asian and advanced financial markets, the following

[1] See *AsianBondsOnline*, https://asianbondsonline.adb.org/.

sections estimate GVAR (Global Vector Autoregressive) models and investigate the degree of financial market spillovers by using the variance decomposition. Unless the spillovers are one-directional and have no further propagation, a single equation would not be enough to capture financial spillovers across the regions. In the globalized economies, a financial shock has complicated international propagation mechanism. It not only has direct and indirect spillover effects on the other financial markets. The affected financial markets also have further spillover effects on the financial market where the shocks were originated. The feedback loop sometimes continues for a few days. A GVAR is a useful econometric framework to capture such 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 (PC) 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 (Republic of Korea, People's Republic of China, Hong Kong, China, Taipei,China, and Singapore). These economies have more developed financial markets than the other emerging Asian economies.

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

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

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 financial variable in Japan, the first and second PCs in the Asian economies, two European financial variables (variables in the UK and Europe), and a financial variable in the United States. 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.[2]

The order of the Cholesky decomposition is the variable in Japan, the first PC in Asia, the second

[2] 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.

PC in Asia, the variable in the UK, the variable in Europe, and the variable in the United States. We chose the order because Asian financial markets are open when European and New York markets are closed. 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 may allow us to identify spillover effects across the regions without serious simultaneous biases.

Because causality identified by GVAR is "Granger causality", our identified spillovers do not necessarily mean "true" causality. This is because financial variables can move in anticipation of future shocks. For example, if some event is expected to happen in the UK when Asian stock markets are open, stock prices in Asia would respond earlier in anticipation of the shock in the UK. In this case, the identified Granger causality is from Asia to the UK, although the true causality is from the UK to Asia. However, noting that most of the country-specific shocks tend to occur when its local market is open, large EU or US specific events are less likely to happen when Asian markets are open. In the following analysis, we thus suppose that our GVARs approximately identify true spillovers from Asian financial shocks to European and US markets.

In addition to the above limitation, our identified spillovers may not mean "true" spillovers when important news is announced after closing their stock markets. In this case, our order of the Cholesky decomposition may identify some European shocks as US shocks and some US shocks as Japanese shocks. However, given the order of the Cholesky decomposition, it is unlikely that we identify shocks in Europe and the United States as emerging Asian market shocks. In Appendix, we show that our results are essentially the same, even if we control spillover effects of the shocks after the New York market is closed.

Unless explained otherwise, we downloaded the data from *Datastream*. 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 United States. The break point is the date when Federal Reserve Chairman Ben Bernanke first mentioned the idea of gradually reducing or "tapering" the Federal Reserve Board's monetary expansion.

III. Empirical Results: Stock market spillovers

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

Table 1 reports the correlation of the first, second, and third PCs in Asia with each stock market returns in Asia for the three alternative subsample periods. It shows that the first PC is positively correlated with the stock market returns in all Asian economies. The correlation with People's Republic of 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 PC is a weighted average of all Asian stock market returns. In contrast, the second PC has large positive correlation only with People's Republic of China's stock market returns. The degree of the correlation is over 0.8 for all subsample periods, which implies that the second PC reflects mainly People's Republic of China-specific returns. Similarly, the third PC has large positive correlation only with Thai stock market returns. The degree of the correlation is over 0.7, which implies that the third PC reflects mainly Thai-specific returns.

Using the first and the second PCs in Asia, we estimate the GVAR formulated in the last section for the 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 their own and the other stock market 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 PCs in Asia were explained by shocks in Japan, the two European countries, and the United States, while Table 2-(2) reports how many percentages of stock prices in Japan, the two European countries, and the United States were explained by the first and second PCs in Asia.

Table 2-(1) indicates that the first PC of Asia was largely explained by stock price shocks in the advanced economies throughout the three subsample periods. More than 40% of the first PC was explained by shocks in the 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 significantly 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 United States 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 PC of Asia was little explained by stock price shocks in the advanced economies. Except for the UK shocks in the second subsample period, any shocks in the advanced economies explained less than 1% of the second PC. Even the UK shocks in the second subsample period explained only 1.22%. This does not mean that there has been no positive spillover to People's Republic of China because the first PC is correlated with the People's Republic of China's returns. But, this implies that there has been no positive spillover from advanced economies to People's Republic of China--specific returns which were independent of stock prices in the other emerging Asia. This may happen partly because of various financial regulations in People's Republic of China and partly because of independent remarkable economic growth in People's Republic of China.

In contrast, Table 2-(2) shows that the first and second PCs of Asia explained only limited percentages of the stock price fluctuations in the advanced economies throughout the subsample periods. In particular, they little explained stock price fluctuations in Japan 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 PC of Asia came to explain significant percentages of stock price fluctuations in the two European countries and the United States. 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 United States. 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 United States. These percentages were much larger than those in the first subsample period (i.e. pre-GFC period). This implies that stock market spillovers from emerging Asia to Europe and the United States, 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.

IV. Industry-level Estimation Results

In the last section, we found that stock market spillovers from the first PC in emerging Asia to those in Europe and the United States became significant in the post GFC period. The result indicates that even in the stock markets, common shocks in emerging Asia came to have substantial impacts on advanced countries after the GFC. However, stock market spillovers could increase because emerging Asia were increasingly more connected with the rest of the world in integrated global production networks. If this is the case, the spillovers do not necessarily suggest direct financial linkages from emerging Asia to advanced countries in the post-GFC period.

In this section, we investigate whether the stock market spillovers from emerging Asia in the post-GFC period were originated from financial sector or from manufacturing sector. In the analysis, we use daily industry-level stock market returns in emerging Asia and explore which sector's shocks had larger impacts on the stock prices in advanced countries. In the analysis, we use PCA to extract common stock price shocks of the manufacturing sector and those of the financial sector in the five emerging Asian economies for the three subsample periods. Except for the use of PCs in the manufacturing sector and those in the financial sector, the estimated equations are essentially the same as those in the last two sections.

Table 3 reports the correlation of the first, second, and third PCs with each industry-level stock market returns in Asia. It shows that both in the manufacturing sector and in the financial sector, the first PC 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 PC is a weighted average of all Asian industry-level stock market returns. Unlike in the aggregated returns, the second and third PCs in the industry-level returns do not have dominant positive correlation with stock market returns in People's Republic of China. Instead, in the manufacturing sector, the second PC has large positive correlation only with stock market returns in Thailand. Even in the financial sector, so does the second PC in the second subsample period and the third PC in the first and third subsample periods. This implies that either the second or the third PC reflects mainly

Thai returns when using industry-level stock prices.

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. Except for the use of the first and second PCs 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. When estimating GVARs, we ordered the first and second PCs of the manufacturing sector prior to those of the financial sector in Asia.

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

But, as in the last section, we find large spillovers from advanced countries to the first PC in Asia throughout the subsample periods. Table 4-(1) shows that in both the manufacturing and financial sectors, shocks in advanced economies explained more than 30% of the first PC 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 PC's fluctuations were explained by its own shocks. In contrast, in the financial sector, substantial part of the first PC's fluctuations was explained by the first PC's shocks in the manufacturing sector. This implies that the financial sector in Asia has experienced large positive stock market spillovers not only from advanced economies but also from the manufacturing 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 the first PCs of Asian stock prices in the manufacturing and financial sectors explained only limited percentages of the stock price fluctuations in advanced economies. However, regarding spillovers from Asia to advanced economies, we see one noteworthy feature which we did not observe in the last section.

Throughout the subsample periods, the first PC 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 PC 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 stock market spillovers from emerging Asia increased in the post GFC period mainly because common manufacturing sector's shocks in emerging Asia had significant impacts on advanced economies.

The share of emerging Asia in the global output and trading network has progressed steadily in the 2000s. Before the GFC, the increased real linkage did not intensify financial linkage much. However, in the post-GFC period, it came to have significant impact on stock market linkage between the two regions. As a result, stock market spillovers from emerging Asia to advanced economies increased significantly even though direct financial linkages were, if any, small even after the GFC.

V. 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 across the regions. As in the previous sections, we calculate the variance decomposition of GVARs and 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 PCs of daily difference of interest rates in five Asian economies (that is, Republic of Korea, People's Republic of China, Hong Kong, China, Taipei,China, and Singapore) and daily difference of interest rates in Japan, the UK, Europe, and the United States. The estimation of the GVAR model is done recursively, with the number of lags set to two, for the three subsample periods. The subsample periods are the same as those in the last section. However, 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 an interest rate in Japan, the first PC in Asia, the second PC in Asia, an interest rate in the UK, an interest in Europe, and an interest rate in the United States.

We first explore spillovers of short-term interest rates. For short-term interest rates of the five

Asian economies, we use overnight rates (that is, Republic of Korea overnight call rate, Singapore repo O/N, Thailand Interbank O/N, Taipei,China Interbank swap overnight, People's Republic of China Interbank O/N, and Hong Kong, China Interbank 1D) and calculate the PCs of their daily changes. For those of the advanced economies, we use daily changes of uncollateralized overnight call rate in Japan, UK bank rate, ECB MRO or deposit rate, and Federal Funds target rate respectively. 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).[3]

Table 5 summarizes the correlation of the first, second, and third PCs with daily change of each Asian short-term rate for the three alternative periods. Unlike in the stock returns, we cannot observe a feature that the first PC 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 the three subsample periods. Table 6-(1) reports how many percentages of the first and second PCs in Asian short-term rates were explained by the short-term rates in the advanced economies, while Table 6-(2) reports how many percentages of short-term rates in the advanced economies were explained by the first and second PCs 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 Asia or from 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 United States, the variance decomposition shows that some spillovers existed among them. However, in case of Asian economies including Japan, except for the second PC in the second period, it shows that their own shocks explained more than 90% of the short-term rate fluctuations. This indicates that the short-term rates in emerging Asia are not only independent of those in the other regions but also show no synchronization within the region.

[3] 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.

VI. 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 Asia or from 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 differences of 5-year or 10-year government bond yields, we explore their spillover effects between emerging Asia and advanced economies (that is, Japan, UK. Germany, and the United States). 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 daily differences of the long-term interest rates as the endogenous variables, the estimated equations are essentially the same as those in previous sections. We estimate GVARs for the three subsample periods.

In the analysis, we use PCA to extract common changes of the long-term interest rate in the five Asian economies. Table 7 reports the correlation of the first, second, and third PCs with the change of 5-year or 10-year government bond yields in each Asian economy. It shows that in both of the government bond yields, the first PC is positively correlated with each Asian long-term interest rate except with the Thai long-term rates. The correlations with Taipei,China's long-term rates are 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 PC is a weighted average of Asian long-term interest rates.

In contrast, the second PC has large positive correlation only with the 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 PC reflects mainly the 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 the three subsample periods. Table 8-(1) reports how many percentages of the first and second PCs 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 PCs in Asia.

Table 8-(1) indicates that in both 5-year and 10-year yields, there were significant spillovers from the advanced economies to the first PC of Asia throughout the subsample periods. The spillovers were smaller than stock market spillovers. But in the first subsample period, the long-term rates in the four advanced economies explained more than 40% of the first PC. In particular, US long-term rates explained about one-fourth of the first PC in the first subsample period. In the second and third subsample periods, the explanatory power of the long-term rates in the advanced economies declined because the first PC 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 PC's fluctuations in 5-year and 10-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 increased spillovers to Asia in 5-year yields.

In case of the second PC, we could not observe significant spillovers from the advanced economies to Asia in 5-year yields. In 5-year yields, its own shocks explained most of the second PC's fluctuations throughout the subsample periods. Noting that People's Republic of China's long-term interest rates have no correlation with the first PC but have large correlation with the second PC, this implies that People's Republic of 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 PC in the second and third subsample periods. This suggests that People's Republic of China's 10-year yields experienced significant spillovers from the advanced economies after the GFC even though People's Republic of China's 5-year yields were still controlled by the government.

In contrast, Table 8-(2) shows that the first and second PCs of Asia explained only limited percentages of the long-term rate fluctuations in the advanced economies throughout the subsample periods. That is, as in the stock markets, spillover effects from advanced economies to Asia have been much larger than those from Asia 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 the long-term rate fluctuations in the other advanced economies were mostly explained by their own shocks or by shocks in the other advanced

economies. This is in marked contrast with stock market spillovers in which the first PC of Asia came to explain significant percentages of stock returns fluctuations in the two European countries and the United States after the GFC.

After the GFC, the first and the second PCs of Asia came to explain about 5% of long-term rate fluctuations in the UK, Germany, and the United States. For example, in the UK, the two components in Asia explained 5.11% of 10-year yields and 3.51% of 5-year yields in the second subsample period and 5.96% of 10-year yields and 4.68% of 5-year yields in the third subsample period. This implies that after the GFC, spillovers from emerging Asia to Europe and the United States came to have some significance even in the bond markets. But the spillovers were much smaller than the stock market spillovers in the magnitude. Noting that stock market spillovers from Asia to Europe and the United States increased mainly because manufacturing sector's shocks in 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.

VII. Concluding Remarks

In this paper, we explored how financial market spillovers between emerging Asia and advanced economies have changed in the 2000s. Stock market spillovers from emerging Asia became significant in the post GFC period. Even in long-term rates, we found significant spillovers from emerging Asia to Europe and the United States in the tapering period. However, the bond market spillovers were much smaller than the stock market spillovers in the magnitude. More importantly, the industry-level analysis showed that the stock market spillovers were originated mostly from common shocks in the manufacturing sector rather than from those in the financial sector. The financial spillovers from emerging Asia increased in the post GFC period because emerging Asia were increasingly more connected with the rest of the world in integrated global production networks. This supports the view that direct financial market linkages from emerging Asia to advanced countries were, if any, limited even after the GFC.

In the 2000s, emerging Asia underwent rapid industrialization in integrated global production networks and their real fundamental shocks came to have substantial spillover effects on advanced economies. Our empirical results are consistent with the view that even though the financial market in emerging Asia has been less developed, the increased role of Asian economies in integrated global production networks raised spillovers from emerging Asia in the global financial markets. However,

limited direct financial linkages from emerging Asia to advanced countries are still important policy agenda even after the GFC. This is particularly true in Asian bond markets. In emerging Asia, we probably need further structural reforms of financial markets, which may contribute to solving persistent external imbalances in the global financial markets.

Appendix. Shocks after the New York Market was Closed

In the main text, the order of the Cholesky decomposition in GVARs was set to be the variable in Japan, the first and the second PCs in Asia, the variable in the UK, the variable in Europe, and the variable in the United States. We chose the order because Asian financial markets are open before European and New York markets are open. However, in the United States, some important news is announced after the New York market was closed. One may have concern that our order of the Cholesky decomposition would identify some shocks in the United States as Japanese market shocks. The purpose of this Appendix is to show that our results are essentially the same even if we control spillover effects of the shocks after the New York market was closed.

In the analysis, we split daily changes of Japan's stock price index into "daytime change" and "nighttime change". The "daytime change" in date *t* is the change of Nikkei 225 from 9:15am to 3:30pm in date *t*. The "nighttime change" in date *t* is the change of Nikkei 225 from 3:30pm in date *t*-1 to 9:15am in date *t*. In the GVARs, the order of the Cholesky decomposition was set to be the daytime change in Japan, the first and the second PCs in Asia, the variable in the UK, the variable in Europe, the variable in the United States, and the nighttime change in Japan. Given the order of the Cholesky decomposition, it is natural to suppose that the "daytime change" would reflect shocks in Japan, while the "nighttime change" would reflect shocks after the New York market was closed but before Asian markets are open.

By using the new order of the Cholesky decomposition, we examine stock market spillovers between Asian and advanced financial markets. Except that we use the "daytime change" and the "nighttime change", the estimated equations are the same as those in Section 3. Using the first and the second PCs in Asia, we estimate the GVARs for the three subsample periods. Table A1 summarizes the results of the variance decompositions. Table A1-(1) reports how many percentages of the first and second PCs in Asia were explained by shocks in the advanced economies, while Table A1-(2) reports how many percentages of stock prices in the advanced economies were explained by the first and second PCs in Asia.

In both of the tables, the contributions of the "daytime change" in Table A1 are very similar to those of Japan's daily stock returns in Table 2. More importantly, the first and second PCs in Asia and the stock returns in the other advanced countries have very similar contributions in Table A1 to those in Table 2. This implies that our results are essentially the same as those in section 3 even if we split daily changes of Japan's stock price index into the "daytime change" and the "nighttime change".

This happened because spillovers of the "nighttime change" are, if any, very small in our estimated GVARs. For example, in Table A1-(1), the contributions of the "nighttime change" are less than 0.1% in explaining the first and second PCs in Asia. This implies that even if some important news might have been announced after the New York market was closed, they had negligible spillover effects on Asian stock returns. As a result, even if we control their spillover effects, we still find that stock market spillovers from emerging Asia became far from negligible in the post GFC period, although financial market spillovers from advanced economies to Asia were much larger than those from Asia to advanced economies.

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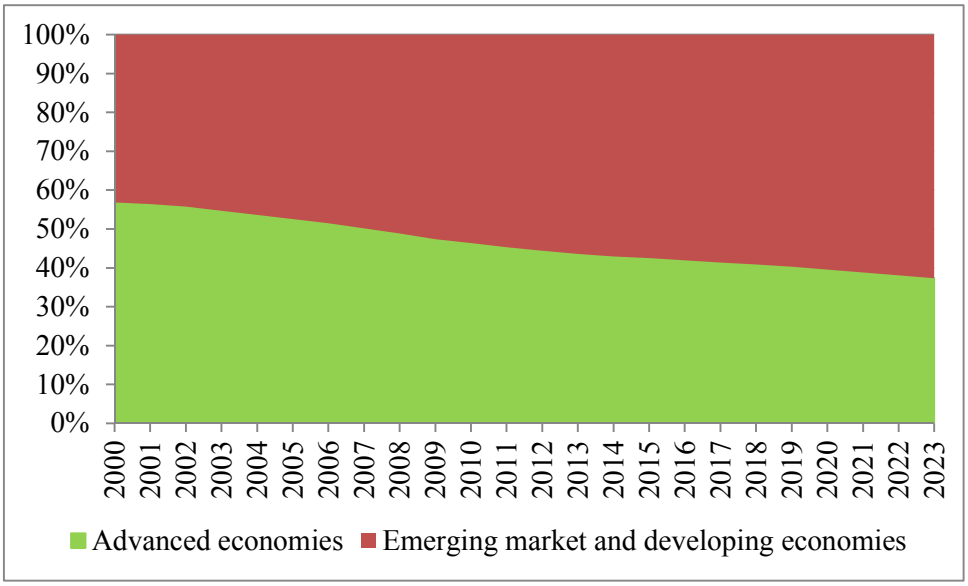
Figure 1. The Share of World Total GDP



Note: The share of world total GDP is based on Purchasing Power Parity (PPP).

Source: IMF's World Economic Outlook (October 2018) ~~suggested that~~

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

(1) Pre-GFC period

	1st PC	2nd PC	3rd PC
Republic of Korea	0.476	−0.059	−0.205
Hong Kong, China	0.489	0.030	−0.127
People's Republic of China	0.109	0.982	0.090
Taipei,China	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
Republic of Korea	0.430	−0.158	−0.436
Hong Kong, China	0.466	0.073	0.076
People's Republic of China	0.310	0.897	0.166
Taipei,China	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
Republic of Korea	0.431	−0.199	−0.413
Hong Kong, China	0.483	0.197	−0.038
People's Republic of China	0.300	0.849	0.215
Taipei,China	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 PCs in Asian stock returns

(a) The decomposition of the 1st principal component

	1st PC	Advanced Economies				
	shock	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	Advanced Economies				
	shock	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 of stock returns 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's stock prices			
	German 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 PCs 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
Republic of Korea	0.461	0.006	−0.302	0.435	−0.239	0.092
Hong Kong, China	0.485	−0.151	−0.021	0.491	−0.037	−0.203
People's Republic of China	0.316	−0.591	0.650	0.348	0.551	−0.620
Taipei,China	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
Republic of Korea	0.410	−0.337	0.201	0.385	−0.415	0.439
Hong Kong, China	0.448	0.060	−0.398	0.460	0.076	−0.396
People's Republic of China	0.463	0.013	−0.260	0.454	0.047	−0.373
Taipei,China	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
Republic of Korea	0.389	−0.248	0.584	0.314	0.679	0.495
Hong Kong, China	0.464	−0.127	−0.396	0.489	−0.143	−0.358
People's Republic of China	0.457	−0.189	−0.301	0.477	−0.110	−0.344
Taipei,China	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 PCs: industry-level returns

(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: industry-level

The variance decomposition of Japan's stock prices

	Japan shock	Other adv. econ.	mfg. sector 1st PC shock	mfg. sector 2nd PC shock	financial sector 1st PC shock	financial sector 2nd PC 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 shock	Other adv. econ.	mfg. sector 1st PC shock	mfg. sector 2nd PC shock	financial sector 1st PC shock	financial sector 2nd PC 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's stock prices

	German shock	Other adv. econ.	mfg. sector 1st PC shock	mfg. sector 2nd PC shock	financial sector 1st PC shock	financial sector 2nd PC 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 shock	Other adv. econ.	mfg. sector 1st PC shock	mfg. sector 2nd PC shock	financial sector 1st PC shock	financial sector 2nd PC 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 PCs with each short-term rate

(1) Pre-GFC period

	1st PC	2nd PC	3rd PC
Republic of Korea	−0.342	−0.367	0.294
Hong Kong, China	0.042	−0.615	−0.103
People's Republic of China	0.703	−0.156	0.246
Taipei,China	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
Republic of Korea	−0.312	−0.505	0.478
Hong Kong, China	0.292	0.283	0.410
People's Republic of China	0.666	0.195	0.283
Taipei,China	−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
Republic of Korea	0.242	−0.126	−0.547
Hong Kong, China	0.672	0.019	0.131
People's Republic of China	0.636	0.058	−0.014
Taipei,China	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 PCs: short-term rates

(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: short-term rates

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 PCs 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
Republic of Korea	0.375	0.165	0.089	0.446	−0.304	−0.117
Hong Kong, China	0.569	0.007	−0.083	0.606	0.027	−0.137
People's Republic of China	0.419	−0.120	−0.099	0.158	0.745	0.194
Taipei,China	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
Republic of Korea	0.439	−0.077	−0.224	0.476	−0.005	0.010
Hong Kong, China	0.532	−0.065	0.267	0.474	−0.149	−0.121
People's Republic of China	0.442	−0.116	−0.048	0.408	−0.149	−0.173
Taipei,China	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
Republic of Korea	0.457	−0.121	0.225	0.462	−0.030	0.207
Hong Kong, China	0.488	−0.048	−0.214	0.463	0.077	−0.352
People's Republic of China	0.390	0.013	0.677	0.398	−0.131	0.746
Taipei,China	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 PCs: long-term rates

(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: long-term rates

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 long-term rates

	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's long-term rates

	10-year yields				5-year yields			
	German shock	Other adv. econ.	1st PC shock	2nd PC shock	German 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 long-term rates

	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.

Table A1-(1). The variance decomposition of the PCs: stock returns

(a) The decomposition of the 1st principal component

	1st PC	Advanced Economies					
	shock	Total	Japan	UK	Germany	USA	Nighttime
Pre-GFC period	62.59	36.02	18.39	6.08	2.93	8.57	0.05
Pre-tapering period	55.94	43.26	14.80	19.70	1.61	7.03	0.12
Tapering period	63.64	34.10	14.92	8.32	0.77	9.96	0.14

(b) The decomposition of the 2nd principal component

	2nd PC	Advanced Economies					
	shock	Total	Japan	UK	Germany	USA	Nighttime
Pre-GFC period	98.36	1.20	0.30	0.07	0.33	0.42	0.08
Pre-tapering period	96.95	2.27	0.09	1.24	0.03	0.84	0.07
Tapering period	98.16	1.33	0.56	0.16	0.01	0.51	0.08

Table A1-(2). The variance decomposition in advanced economies: stock returns

	Japan's stock prices			
	Japan shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	97.40	2.04	0.23	0.33
Pre-tapering period	95.66	3.76	0.48	0.09
Tapering period	97.84	1.23	0.38	0.55
	UK stock prices			
	UK shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	79.92	15.11	4.76	0.21
Pre-tapering period	74.40	10.94	13.49	1.17
Tapering period	41.59	46.21	10.81	1.39
	Germany's stock prices			
	German shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	37.24	55.43	7.05	0.28
Pre-tapering period	22.33	66.38	9.79	1.50
Tapering period	35.91	51.89	10.81	1.39
	US stock prices			
	US shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	62.36	35.00	2.43	0.21
Pre-tapering period	40.81	51.40	6.30	1.49
Tapering period	64.96	28.75	5.88	0.42
	Nighttime stock prices			
	Nighttime shock	Other adv. econ.	1st PC shock	2nd PC shock
Pre-GFC period	47.83	46.17	5.91	0.09
Pre-tapering period	49.14	46.05	3.33	1.48
Tapering period	49.08	46.51	4.12	0.29