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Dynamic Connectedness in Emerging Asian Equity Markets

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February 2018

Discussion Paper

No. 82

Dynamic Connectedness in Emerging Asian Equity Markets*

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Abstract

Abstract: This paper examines dynamic connectedness among emerging Asian equity markets as well as explores their linkages vis-à-vis other major global markets. We find that international equity markets are tightly integrated. Measuring connectedness based on a generalized Vector Autoregressive model, more than half of all total forecast error variance in equity return and volatility shocks come from other markets as opposed to country own shocks. When examining the degree of connectedness over time, we find that international stock markets have become increasingly connected, with a gentle upward trend since the Asian financial crisis but with a rapid burst during the global financial crisis. Despite the growing importance of Asian emerging markets in the world economy, we find that their influence on advanced economies is still relatively small, with no significant increase over time. During the past decade, advanced markets have been consistently net transmitters of shocks while emerging Asian markets act as net receivers. Based on the nature of equity shock spillovers, we also find that advanced countries are still tightly connected amongst themselves while intraregional connectedness within Asia remains strong. By investigating whether uncertainty plays an important role in explaining the degree of stock market connectedness, we find that economic policy uncertainty from the US is an important source of financial shock spillover for the majority of international equity markets. In contrast, US financial market uncertainty as proxied by the VIX index drives equity market spillovers only among advanced economies.

Keywords: emerging Asia financial integration, financial spillovers, generalized VAR, stock market, uncertainty

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1. Introduction

One of the most striking global developments over the past two decades has been the rapid trade and financial integration of emerging Asia into the world economy and financial system. Emerging Asia exports now account for more than a third of world trade flows, up sharply from about 20 percent since the early 1990s. During the same time, intraregional trade within Asia also grew at twice the pace as those seen in other regions. Capital markets in emerging Asia have also deepened. On top of significant foreign direct investments, portfolio inflows to the region have surged over past decades, particularly due to lower interest rates and declining asset investment returns in advanced economies. More recently, capital outflows from emerging Asia have also been substantial, increasing by tenfold since the mid 1990s to over $500 billion US dollars in 2007.

As trade and financial linkages are known to be important determinants of stock market interdependence (see Chen and Zhang, 1997; Johnson and Soenen, 2002; Forbes and Chinn, 2004; IMF, 2016), this paper joins a growing literature in examining dynamic connectedness for international equity markets with a focus on emerging Asia. While a voluminous body of research finds that global equity markets are integrated (see Sharma, 2012 for a comprehensive review), most studies focus on examining interconnectedness among developed markets. For studies that examine cross-border linkages between mature and emerging markets in Asia, their focus has mostly been on the East Asian financial crisis (AFC) in 1997 and the global financial crisis (GFC) in 2007 (Yang, Kolari and Min, 2002; Chiang, Jeon and Li, 2007; Yoshida, 2010; Huyghebaert and Wang, 2010)[4]. However, the recent plunge in world stock markets after the announcement of a change in the Renminbi exchange rate regime on August 24, 2015, or how equity markets reacted to the Brexit vote on June 23, 2016 makes it evident that spillover of financial shocks to and from the emerging Asia region can be triggered by events that occur during non-crises periods as well.

Against this backdrop, this paper addresses two main questions. First, how have equity market spillovers to and from emerging market economies in Asia evolved over the past two decades? Are there any upward or downward trends, or any bursts during crisis periods? To study connectedness of emerging Asia equity markets vis-à-vis other major equity markets, we utilize the Diebold and Yilmaz (2009, 2012) approach which is based on generalized variance decompositions of a Vector Autoregressive (VAR) model to construct spillover indices for weekly returns and volatilities in 15 international equity markets. Other major approaches used to examine connectedness include cross-market correlation coefficients (Lee and Kim, 1993; King and Wadhwani, 1994; Forbes and Rigobon, 2002), multivariate ARCH and GARCH models (Hamao, Masulis and Ng, 1990; Berben and Jansen, 2005; Bartram, Taylor and Wang, 2007), and cointegration techniques (Kasa, 1992; Longin and Solnik 1995). However, the pairwise correlation approach has limited value in

[4] Studies that focus on crises periods mostly analyze contagion. While there is still disagreement about the terminology, contagion in this paper is defined as a significant increase in cross-market linkages after a shock occurs to a country or a region. If the two markets exhibited strong linkages before the crisis and continue to show strong ties afterwards, this situation is referred to as interconnectedness or interdependence.

financial market contexts where spillovers should be analyzed as a system, multivariate ARCH and GARCH models require many parameters for estimation, and the cointegration method is a long-run approach that fails to capture the fluid nature of stock market dynamics. Not only does the Diebold and Yilmaz approach overcome these challenges, but it also provides information about the *direction* of spillover from one market to another, which is particularly useful towards analyzing the source of equity market spillovers.

The second question that we examine in this paper pertains to the underlying determinants of stock market connectedness. During recent years, it has become increasingly apparent that discussions over fiscal challenges, trade agreement annulments and re-negotiations, as well as the impact of major elections in the US has delivered strong synchronized movements across equity markets worldwide. The financial market collapse in 2007 that originated from the US also caused ripple effects across global equity markets. We therefore examine the extent in which the intensity of stock market spillover *received* by international equity markets can be explained by US financial as well as economic policy uncertainty (EPU) shocks. To measure broad financial market uncertainty, we employ the VIX index, while we utilize the EPU index as constructed from newspaper coverage frequency by Baker, Bloom and Davis (2016) to measure the level of EPU in the US[5].

Related to our research is a large literature that studies the influence of uncertainty on general stock market movements. However, the majority of past studies restrict their analysis to the US (Fleming, Ostdiek and Whaley, 1995; Connolly, Stivers and Sun, 2005; Giot, 2005 for the VIX and Sum and Fanta, 2012; Antonakakis et al., 2013; Kang and Ratti, 2013; Liu and Zhang, 2015 for the EPU). Limited attention has been attributed to analyzing the relationship between uncertainty and the nature of equity market spillover across countries. Exceptions are Beirne, Caporale, Schulze-Ghattas and Spagnolo (2009), whom find that conditional correlations and financial spillovers from mature to developing markets rise when the VIX index level is high during turbulent periods. Tsai (2017) analyzes the influence of the EPU originating from China, Japan, Europe and the US on the dynamic correlation and conditional volatility of 22 global stock markets. He finds that apart from the EPU effect from China, there is limited evidence that EPU shocks from the US, Europe and Japan influences equity market spillovers in global markets.[6] However, one drawback is that their analysis is based on monthly data. In our study,

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[5] Based on this measure, many studies have found the EPU to be an important determinant of domestic economic activity such as output, unemployment, consumption and investment (Baker et al. 2016; Gulen and Ion, 2016; Arbatli, Davis, Ito, Miake and Saito, 2017).

[6] Many studies also examine the cross-country implications of EPU on stock market returns. Lam and Zhang (2014) show that global policy uncertainty in general has a significant effect on equity market returns in a sample of 49 countries during 1995 to 2006. Sum (2012a, b) find that US EPU shocks do not significantly affect stock returns in China, Brazil and India, while it negatively affects Japan and Russia. Momin and Masih (2015) find limited evidence that policy uncertainty from the US impacts BRICS equity markets. Christou, Cunado, Gupta and Hassapis (2017) finds a significant negative relationship between US EPU shocks and stock market returns in Canada, China, Japan and Korea.

we base our analysis on weekly data which should be able to better capture the fluid and fast response of financial shock spillovers to changes in uncertainty conditions.

As a preview of our empirical findings, we find that first, international equity markets are tightly integrated. Based on the generalized VAR framework, more than half of all total forecast error variance in equity return and volatility shocks come from other markets as opposed to country own shocks. Second, international stock markets have become more connected over time, with a slowly increasing trend since the AFC and a rapid burst during the GFC. Third, advanced countries have been consistently net transmitters of shocks while emerging Asian markets act as net receivers, with no major shift in terms of net shock givers and receivers over time. Fourth, despite the growing importance of emerging market economies, particularly China, we find that the influence of financial shocks from emerging Asia on advanced economies is still relatively small. Advanced countries tend to be more connected among themselves, while the degree of intraregional connectedness within Asia is particularly strong. Finally, by investigating whether uncertainty plays an important role in explaining the degree of stock market spillovers, we find that EPU from the US has a significant impact on market connectedness for the majority of countries. On the other hand, financial market uncertainty in the US as measured by the VIX index only drives shock spillovers among advanced economies.

This paper is organized as follows. Section 2 explains the empirical methodology, data and findings on dynamic connectedness for international equity markets. Section 3 outlines the model to explore whether uncertainty that originates from the US is a key determinant of financial shock spillovers received by international equity markets and discusses the empirical results. Section 4 concludes.

2. Equity Market Returns and Volatility Spillovers

2.1 Measuring Connectedness

Connectedness across international equity markets is measured based on the spillover index of Diebold and Yilmaz (2009, 2012). The original measure in the authors' earlier work is based on variance decompositions of forecast errors associated with VAR models. In particular, for each asset i, connectedness is measured as the sum of the shares of asset $i's$ forecast error variance coming from shocks to asset j, for all $j \neq i$. In this paper, we use the improved spillover index in the authors' latter study which measures connectedness based on the generalized VAR framework of Koop, Pesaran and Potter (1996) and Pesaran and Shin (1998). Unlike the original measure, the forecast error variance decompositions used to calculate the spillover index is invariant to different orderings of the variables in the Cholesky decomposition. Moreover, the generalized VAR approach allows for correlated shocks.

To gain insight on the spillover index, consider the following covariance stationary N-variable VAR with p lags:

$$X_t = \Phi_1 X_{t-1} + \cdots + \Phi_p X_{t-p} + \varepsilon_t$$

where $X_t = \{X_{1,t}, X_{2,t}, \ldots, X_{N,t}\}$ is a matrix of endogenous variables and $\varepsilon_t \sim (0, \sum)$ is a vector of disturbance terms with Σ as a variance matrix of error terms that are assumed to have contemporaneous correlation with each other but are independently and identically distributed over time. When the variances in the VAR system are covariance stationary, one can rewrite the system into a moving average representation as:

$$X_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i}$$

where A_i is the N x N coefficient matrix that obeys the recursion $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} \ldots + \Phi_p A_{i-p}$. Then, based on the generalized VAR framework, the *H*-step ahead forecast error variance decomposition can be calculated as:

$$\theta_{ij}(H) = \frac{\sigma_{ii}{}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}$$

where σ_{ii} is the standard deviation of the error term for the i^{th} equation and e_i is the *Nx1* selection vector with one as the *i-th* element and zeros elsewhere. Accordingly, $\theta_{ij}(H)$ can be interpreted as the contribution of the H-step-ahead error variance in forecasting X_i that comes from a one-standard deviation shock to X_j for each *i,j=1,2,…,N,* where $\forall i \neq j$.

Finally, Diebold and Yilmaz (2012) normalize each entry of the variance decomposition matrix by the row sum as follows:

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{j=1}^{N} \theta_{ij}(H)}$$

which allows VAR innovations to be contemporaneously correlated while ensuring that the sum of the contributions to the variance of the forecast error sums to one, i.e. $\sum_{j=1}^{N} \tilde{\theta}_{ij}(H) = 1,\ \sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H) = N$.

Based on the volatility contributions from the above variance decompositions, the various spillover indices can be calculated as follows:

Total Spillovers: measures the contribution of spillovers across the *N* variables to the total forecast error variance:

$$TS(H) = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\theta}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H)} \times 100 = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\theta}_{ij}(H)}{N} \times 100.$$

Directional Spillovers: measures volatility spillovers transmitted by *i* to all other markets *j* ($DS_{i\to\cdot}(H)$), and volatility spillovers received by *i* from all other markets *j* ($DS_{\cdot\to i}(H)$):

$$DS_{i\to\cdot}(H) = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\theta}_{ji}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}(H)} \times 100 = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\theta}_{ji}(H)}{N} \times 100,$$

$$DS_{\cdot\to i}(H) = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\theta}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H)} \times 100 = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\theta}_{ij}(H)}{N} \times 100.$$

Note that directional spillovers are calculated by decomposing total spillovers into those coming from, or spread to, a particular source. Directional spillovers can only be computed within the generalized VAR framework because the variance decompositions are invariant to the ordering of variables.

Net Spillovers: is the difference between volatility shocks that are transmitted to and received from all other markets, defined as:

$$NS(H) = DS_{i\to\cdot}(H) - DS_{i\to\cdot}(H).$$

2.2 Equity Market Return and Volatility Data

To study dynamic connectedness between emerging Asia and other major global equity markets, spillover indices are calculated for the following 15 countries, which are categorized into three groups according to their region and level of development: (1) Emerging Asia: China (CHN), India (IND), Indonesia (IDN), Malaysia (MYS), Philippines (PHL), and Thailand (THA); (2) Advanced Asia: Australia (AUS), Hong Kong (HKG), Japan (JPN), South Korea (KOR) and Taiwan (TAI); and (3) Other advanced economies: France (FRA), Germany (GER), the United States (US), and the United Kingdom (UK). For ease of reference, we list the corresponding country abbreviations in parentheses.

The underlying data used to compute stock market returns are daily nominal local-currency stock market indexes taken from Datastream. Following Yilmaz (2010), we compute weekly returns as the change in Friday-to-Friday log prices, where Thursday data is used if Friday is a holiday[7]. Weekly returns for market i are then annualized as $r_{it} = 52 \times 100 \times (\Delta lnP_{it})$. Based on the assumption that volatility is fixed within the week period, the weekly variance for stock market i is estimated as:

$$\tilde{\sigma}_{it}^2 = 0.511(H_{it} - L_{it})^2 - 0.019[(C_{it} - O_{it})(H_{it} + L_{it} - 2O_{it}) - 2(H_{it} - O_{it})(L_{it} - O_{it})] - 0.383(C_{it} - O_{it})^2$$

where H is the Monday to Friday high, L is the Monday to Friday low, O is the Monday open and C is the Friday close, all in natural logarithms. Then, the corresponding estimate of the annualized weekly volatility can be computed is $\hat{\sigma}_{it}^2 = 100\sqrt{52\,\tilde{\sigma}_{it}^2}$. Unfortunately, H and L data in Datastream for some countries in our sample are only available from April 1, 2000 through November 30, 2017. Therefore, the weekly volatility series can only be calculated for this shorter subsample, while weekly return series span the longer January 1, 1992 to November 30, 2017 period[8].

Descriptive statistics for weekly returns and volatilities are reported in Table 1. Some observations are as follows. First, based on the average annualized returns in Panel A, Indonesia has the highest weekly average return of 11.72%, followed by India at 9.33%. Japan gives the lowest return at 0.61%. The remaining equity market average returns are more or less comparable. Similarly, the standard deviation of weekly returns for all markets is within the same range, with the exception of China. Thus, the variance of weekly returns in developed equity markets are not necessarily lower when compared to those in emerging market ones. The return distribution of all equity markets is negatively skewed, except for the Chinese and Malaysian stock

[7] With higher frequency data such as daily data, it becomes difficult to interpret the directional and causal relationships of the movement of markets with different trading periods due to time zone differences. To avoid this issue, studies often use two-day averaging of daily returns or weekly returns.

[8] High and low data for Singapore is even shorter and is only available from January 2008 onwards. For this reason, we exclude Singapore from our analysis.

markets. Kurtosis is in general high, particularly for China, displaying evidence of non-normal distribution for stock returns. Last, turning to analyze Panel B, the German, Chinese and French stock markets are the most volatile, while the Malaysian and the Philippines markets are the least. Thus, while high volatility tends to be thought of as a distinguishing feature of emerging economy equity markets and Harvey, 1997), it is not the case for our particular dataset and time period of study.

2.3 Full Sample Analysis: Spillover Tables

To examine overall connectedness of international equity markets, we begin by analyzing the intensity of stock returns and volatility spillovers over the full sample. In doing so, we estimate the generalized VAR with 4 lags and calculate the spillover index based on 8-day-ahead forecast errors in the generalized variance decomposition[9]. The results are reported in Tables 2 and 3, where the contents of the table is to be read as follows. First, the *ij*-th entry represents the estimated contribution to the forecast error variance of country *i*, coming from innovations to country *j*. Therefore, the off diagonal column sums (contribution to others) or row sums (contribution from others) are the "to" and "from" directional spillovers and the "from minus to" differences are the net volatility spillovers. The total volatility spillover index is reported in the lower right corner of the spillover table, calculated as the sum of all off-diagonal column sums (or row sums) relative to the sum of all column sums including diagonals, expressed in percent.

According to Tables 2 and 3, the total spillover index is 67 and 71 percent over the full sample for equity market returns and volatility respectively. This finding suggests that for our sample of 15 countries, more than half of all total forecast error variance are shocks from other markets as opposed to country own shocks. Our finding of high spillover intensity among markets is similar to Guimarães-Filho and Hong (2016), whom for a slightly larger set of countries report total return and volatility spillover indices of 81 and 78 percent respectively during 1996-2015. However, based on a similar selection of countries to these authors, Diebold and Yilmaz (2009) find that the return and volatility spillover indices are lower at only 36 and 40 percent respectively. However, their analysis excludes the GFC period, suggesting that international equity market connectedness measures may have increased significantly during that period.

Next, the directional spillovers figures in the second to last row and the last column suggest that the intensity of return and volatility spillovers *to* others are much higher for advanced countries than emerging market ones. The contribution of spillovers *from* others on the other hand, are more or less comparable for all countries, whether it be for return or volatility spillovers. Then, examining the magnitude of the off diagonal elements, advanced economies also appear to be much more connected among themselves. For countries within emerging Asia, intraregional connectedness also appears to be strong, especially for equity returns, consistent with findings of Masih and Masih (1999) and Dekker, Sen and Young (2001). We also do not find that financial shocks from the US for emerging Asia markets necessarily dominate those from other advanced economies such as from Hong Kong, which is known to be a market leader in the region. Furthermore, similar to Yang et al. (2002), but in contrast to Ghosh, Saidi and Johnson (1999) and Masih and Masih (2001), the influence of

[9] Results are robust to different lags and forecasting horizon specifications.

financial shocks from Japan on emerging Asia does not appear to be particularly substantial.

In general, the full sample analysis suggests that the stock markets of all countries display strong linkages with the rest of the world. This contrasts with some studies that have identified certain emerging Asian markets as isolated markets, such as Indonesia (Janakiramanan and Lamba, 1998), the Philippines (Dekker, Sen and Young, 2001), Taiwan and Thailand (Ghosh et al., 1999; Dekker et al., 2001). The only isolated market in our analysis is China, which displays exceptionally low contribution of shocks both *to* and *from* others. Therefore, despite the growing presence of China in the world economy alongside the large size of its stock market, our initial results here suggest that China's tight capital controls still insulate their markets from the rest of the world. However, the growing importance of China's economy for world growth as well as its ongoing liberalization efforts may have increased its integration with world equity markets during recent periods. To further examine this issue, we move from a static full-sample analysis to a time-varying rolling-sample one.

2.4 Rolling-sample Analysis: Spillover Plots

To examine the time-varying intensity of return and volatility spillovers, we follow Diebold and Yilmaz (2009) and calculate spillover indices over a 200-week rolling window. As shown in Figure 1, there has been significant time variation in both total equity return and volatility connectedness. Over the duration of the sample, both indices rose from approximately 50 to 70 percent, reflecting stronger cross-country linkages over time.

Next, examining the behavior of connectedness during crises periods, we observe different characteristics during the AFC and GFC. Similar to Diebold and Yilmaz (2009), we find that there is a gentle increase in the trend for equity returns prior to the GFC, indicating a steady rise in the degree of financial market integration over time. However, consistent with Guimarães-Filho and Hong (2016), both connectedness measures peaked during the GFC, with sharp rises and falls, especially for dynamic volatility. This evidence of clear bursts are consistent with the sizeable shocks during the crisis and also indicate that the spread in volatility transmits much more rapidly across financial markets.

Turning to examine the directional spillover of equity market returns, Figure 2 plots the rolling net return spillovers averaged across the three country groups. Focusing on the first half of the sample, the group of other advanced economies increasingly became net transmitters of shocks, while emerging Asia increasingly became net receiver of shocks. The importance of other advanced economies as net givers peaked in the early 2000s, which corresponded to a period of low interest rates in those economies as well as the introduction of the Euro. Countries in the advanced Asia group were mildly net receivers, most likely because during that time the Korean and Taiwanese stock markets were relatively less mature when compared to other advanced economies.

During the second part of the sample, advanced economies have been consistently net givers while emerging economies have been net receivers of shocks. In other words, since the GFC, there have been no substantial changes in the role of net givers or receivers of shocks. This finding contrasts with those of Guimarães-Filho and Hong (2016), whom show via a similar analysis but with a shorter dataset that during past decades, emerging Asia markets have moved from a net receiver to a net transmitter of shocks due to its growing importance in global markets. They also find that net connectedness of returns in advanced economies are declining over time while it is increasing for emerging Asia. Finally, turning to examine the behavior of net volatility connectedness, Figure 3 suggests that similar to the behavior of net returns, the group of other advanced economies is consistently net givers of shocks while emerging Asian markets are net receivers. Advanced Asia is on average mild net givers of financial shocks.

So far, we have analyzed total and net dynamic connectedness based on country groups. To ensure that we are not drawing any broad generalizations, we plot the net and directional spillover indices for individual equity market returns and volatilities in Appendix A. Overall, net return and volatility connectedness behavior on a country-by-country basis more or less fits with the overall description for its corresponding group. Nevertheless, the country analysis reveals the following interesting insights.

First, financial shocks both to and from China intensified significantly since the GFC, consistent with the findings of Glick and Hutchinson (2013) whom find that as China increasingly liberalizes its financial markets, the Chinese stock market has become more integrated with international equity markets. However, China is still a receiver of return and volatility shocks because while the spillover of shocks from China approximately doubled, shocks to the country increased by even more. In fact, its role as a net receiver of shocks rose by more than threefold since the global financial crisis. In the post crisis period however, we observe China’s role as a net receiver of shocks to be gradually declining. Based on similar spillover indices, Guimarães-Filho and Hong (2016) also advocates the growing importance of China as the net source of financial shocks, although they find that this substantial increase started later, that is, only from the year 2015 onwards.

A second observation that emerges from the country-by-country analysis is that unlike other major advanced economies, Japan became a net receiver of volatility shocks around the year 2012, which corresponded to the period in which Prime Minister Shinzo Abe started to conduct various monetary and fiscal stimuli to boost the economy. His policies, also known as Abenomics, spurred a 20 percent decline in the yen and record growth in its domestic stock market, which may have attracted volatility spillovers from abroad especially as other advanced economies were experiencing tepid growth during their recovery from the global financial crisis.

Last, it can be observed that Indonesia was the only net giver of volatility shocks among all emerging Asia markets. This occurred during the 2013 to 2015 period, which corresponded to a time when the value of rupiah weakened by approximately 40 percent against the US dollar. This is because as the Federal Reserve started its quantitative tapering program in 2013, the dollar strengthened against many currencies in emerging Asia, but the weakened rupiah subsequently caused the most severe capital outflows out of Indonesia given its wide current deficit, high inflation, and slowing economic growth. Overall, these findings highlight the importance of country fundamentals as well as financial, economic and political uncertainty as major driving factors for equity market return and volatility spillover dynamics.

3. The Role of Uncertainty on Dynamic Connectedness

Identification of the underlying determinants of international stock market connectedness is important, not only for making sense of important issues such as the equity home bias puzzle (French and Poterba, 1991; Lewis, 1999), but also for practical concerns such as the development of proper market monitoring measures. A large literature explores this issue and finds that the main determinants of cross-country financial interdependence include trade intensity (Chinn and Forbes, 2004; Shinagawa, 2014), the degree of financial liberalization and globalization (Beine and Candelon, 2011; IMF, 2016), the level of financial development (Dellas and Hess, 2005), and geographical variables (Flavin, Hurley and Rousseau, 2002). Other macroeconomic determinants that have been found to influence stock market spillovers include interest rate and inflation differentials, exchange rate risk, and various global risk factors (Pretorius, 2002; Sun and Psalida, 2009; Syllignakis and Kourestas, 2011; Hwang, Kim and Kim, 2013; Narayan, Sriananthakumar and Islam, 2014).

Since the GFC, it has become increasingly apparent that the degree of uncertainty in advanced economies has led to synchronized movements in equity markets worldwide. For example, global stock markets plunged following the Lehman Brothers Collapse in 2007, the Eurozone debt crisis in 2009, the United States debt-celling crisis of 2011, as well as the Brexit vote in 2016. Therefore, in this section, we aim to explore how the degree of spillovers *received* by international equity markets are driven by uncertainty in the US, which is inarguably one of the main exporters of international uncertainty shocks to the world economy (Yin and Han, 2014; Klößner and Sekkel, 2015)[10]. Since different types of uncertainty can deliver varied effects, we differentiate between broad financial market uncertainty and economic policy uncertainty (EPU) and focus on examining their implications for the nature of spillovers received by international markets, especially those of emerging Asia.

3.1 Empirical Model and Data

We measure the impact of uncertainty on the return spillovers *received* in each of the countries by estimating the following VAR for each country *i*:

$$Y_{it} = \Phi_1 Y_{i,t-1} + \cdots + \Phi_p Y_{i,t-p} + \varepsilon_t,$$

where Y_{it} is a matrix of endogenous variables that includes the estimated time-varying total return spillover index for country *i* that is received from all other markets, and measures of financial market and policy uncertainty in the US[11]. The lags in the VAR are chosen based on minimizing the Akaike Information Criterion (AIC) during estimation. Note that due to the short sample, we only focus on analyzing return but not volatility spillovers.

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[10] Note that while we would like to study the spillover effects due to uncertainty originating in other major economies, we only focus on the US due to data limitations that will be described later. However, we believe that the US case study in itself can offer interesting insights given that it is one of the foremost trading partners and major suppliers of capital to the majority of countries in the world.

[11] Based on Augmented Dickey-Fuller tests, we cannot reject the null hypothesis of a unit root for each of the country's total time-varying return spillover index while we reject the null hypothesis that the uncertainty measures have a unit root. Therefore, in the empirical VAR, the return spillover indices enter as first differences while the uncertainty measures enter in levels.

To measure the degree of broad financial market uncertainty, we use the weekly Chicago Board Options Exchange Market Volatility (VIX) index available from Bloomberg, calculated as the 30-day period implied volatility in the S&P 500 index. To measure US EPU, we take the weekly average of the US daily EPU index as constructed by Baker et al. (2016). The series is developed based on newspaper coverage frequency of terms that reflect economic policy uncertainty (the relative frequency of newspaper articles that refer to "uncertainty", "economy", and "policy"), available from the website www.policyuncertainty.com for the January 1, 1992 to November 30, 2017 sample period. Note that while the website contains EPU indices for other countries as well, they are only available at the monthly frequency, which we believe is at a frequency too low to adequately capture the dynamic relationship between EPU shocks and stock market spillovers.

As an initial exploration of the data, Figure 4 contains plots of the weekly VIX and EPU. As shown, the two indices generally move together, but also contain distinct variation. The VIX reacts more strongly to events that have strong financial associations such as the AFC, the Worldcom Fraud and the Lehman Brothers collapse. The EPU index on the other hand, responds stronger to events that involve major policy concerns with implications on stock market volatility such as the election of a new president, political battles over taxes and government spending. It can be observed that the EPU measure increased sharply after several events such as the 9/11 attack, the 2nd Gulf War, and the 2011 debt-ceiling dispute. Other discrepancies between the two series as highlighted by Baker et al. (2016) is that the VIX reflects implied volatility over a 30-day look ahead period while the EPU index has no explicit horizon; the VIX pertains to uncertainty about equity returns for only publicly traded firms while the EPU index is more broad and reflects general *policy* uncertainty, and is therefore not only limited to equity returns.

Next, Table 4 reports the pairwise correlations between the spillovers of shocks received for each country and the EPU and VIX indices. As shown, EPU is positively correlated with the country measures of stock market connectedness, implying that US EPU is potentially an important determinant of stock market return spillovers. The correlations with the VIX, on the other hand, are not as strong. However, even if the VIX has low or no implications for the degree of financial market spillovers, we view that including the VIX in the VAR framework is important. Over the sample, the correlation between the VIX and EPU indices is 0.50, and therefore the VIX can be treated as a control variable to ensure that the EPU will only capture the influence of *policy* uncertainty and not *financial* market uncertainty.

3.2 Empirical Findings

To examine whether US uncertainty shocks are important determinants of stock market interdependence, we calculate the Granger Causality or block exogeneity Wald test with the corresponding null hypothesis that all lags of the VIX and EPU variables can be excluded from each equation in the VAR system. Table 5 reports the corresponding Chi-square test statistics and p-values in parentheses. Two key findings emerge as discussed below.

First, US EPU can explain spillovers received for the majority of equity markets in our sample. This finding implies that policy uncertainty in the US causes increasing spillovers across international stock markets. The Chinese and Indian stock markets are exceptions because the influence of the EPU on their estimated spillover indices are statistically insignificant. This result however, is not surprising given that most studies find these countries to have rather isolated stock markets (Shachmurove, 2006). Overall, our findings contrast with those of Tsai (2017) who finds that US EPU is a significant determinant of dynamic spillovers only among developed markets. These authors however, use monthly instead of weekly data for the empirical analysis, which in our view may be partly responsible for the difference in findings.

Our empirical results related to the EPU are indeed part of a growing literature that provides strong evidence that EPU shocks from advanced economies, in particular the US, can significantly influence real activity variables of other countries. IMF (2013) finds that EPU shocks in the US and Europe suppresses economic activity in a sample of 43 countries. Gauvin, McLoughlin and Reinhardt (2014) show that there are notable differences in the spillover effects of policy shocks from the EU versus the US on emerging market economies via portfolio capital flows. Colombo (2016) shows that an unexpected increase in US EPU impacts macroeconomic aggregates such as industrial production and inflation in the Euro area. Biljanovska, Grigoli and Hengge (2017) find that spillovers from the United States, Europe and China reduces growth in real output, private consumption and private investment in the rest of the world and these spillovers account for about two-thirds of the negative effect.

Second, Table 5 shows that the influence of the VIX index is only prominent for time-varying return spillovers received by Japan, Hong Kong, Germany France, the UK and the US. Given that these are all advanced economies, this finding implies that while US EPU shocks are quick to transmit to emerging markets, US financial market shocks as proxied by the VIX index are still contained within the group of developed markets. Therefore, based on the VIX measure, emerging Asia stock markets may still not be fully integrated with developed ones. To investigate this issue further, we plot the time-varying return spillovers received by each country from emerging Asia, advanced Asia and the other advanced country groups. As shown, for all emerging Asian markets, the contributions of spillovers received from both emerging and developed Asian markets are higher than those coming from the group of other advanced economies. A similar observation can be made about advanced Asia equity markets, suggesting tight regional integration in Asia. Similarly, equity markets in the other advanced economy group are also tightly integrated, although since the GFC, contributions of financial shocks received from advanced Asia have become more prominent while within group shocks have declined. Nevertheless, shock contributions from emerging Asia to the group of other advanced economies are still lagging behind, with no clear signs of upward or downward trends.

Overall, our findings are related to an ongoing debate as to whether emerging Asia's equity markets should be treated as a separate asset class from developed ones when making portfolio allocation decisions. On the one hand, Saunders and Walter (2002) provide empirical evidence that emerging markets are now tightly integrated with developed ones and there is no need to treat them as separate asset classes. In contrast, Bekaert, Harvey, Lundblad and Siegel (2011) argue that while financial markets have become increasingly integrated during past decades, emerging markets are still segmented due to factors such as capital controls, trade regulations, as well as its political risk profile and level of stock market development. Similarly, Bekaert and

Harvey (2014) agree that despite dramatic globalization, the progress of integration of developed markets into world markets is still incomplete. Based on our estimated spillover measures, we view that Asian markets are highly integrated with global equity markets, but the influence of intraregional shocks appear to be more prominent when compared to interregional ones. Also, while the influence of shocks from advanced economies matter for emerging Asia equity markets, such as those transmitted via US political uncertainty, compared to the US and other advanced economies in Europe, equity markets in emerging Asia may still not be fully integrated with global markets due to the limited impact of the VIX on financial shock spillovers received.

4. Conclusion

In this paper, we apply the spillover index as developed by Diebold and Yilmaz (2009, 2012) to examine how financial shocks are transmitted across global equity markets and how uncertainty may play an important role in explaining the degree of dynamic connectedness across markets. We find that overall, global stock market connectedness is strong, and has also been increasing steadily since the Asian financial crisis in 1997. Over the course of the global financial crisis however, the comovement of international stock market returns and volatility peaked and declined rapidly, but has remained stable during the past few years. We also find that over past decades, advanced countries have been consistently net transmitters of shocks while emerging Asian markets act as net receivers.

Despite the growing importance of emerging Asian markets in the global trade and financial system, we find that that their influence in terms of financial shocks spillovers is still well contained within Asia. The contribution of shocks that are transmitted to the US and Europe from emerging Asia, including China, are still relatively small when compared to within group shocks and those coming from advanced Asia. In other words, equity markets of advanced countries tend to be more connected amongst themselves, while intraregional connectedness within Asia is particularly strong. Based on uncertainty measures, political uncertainty shocks transmit widely to both advanced economies and emerging markets in Asia while US financial market uncertainty shocks only explains stock market spillovers in advanced economies. This finding suggests that only some uncertainty shocks from advanced countries matter for explaining the intensity of spillover received by equity markets in emerging Asia, implying that emerging Asia while connected to global markets are still not fully integrated.

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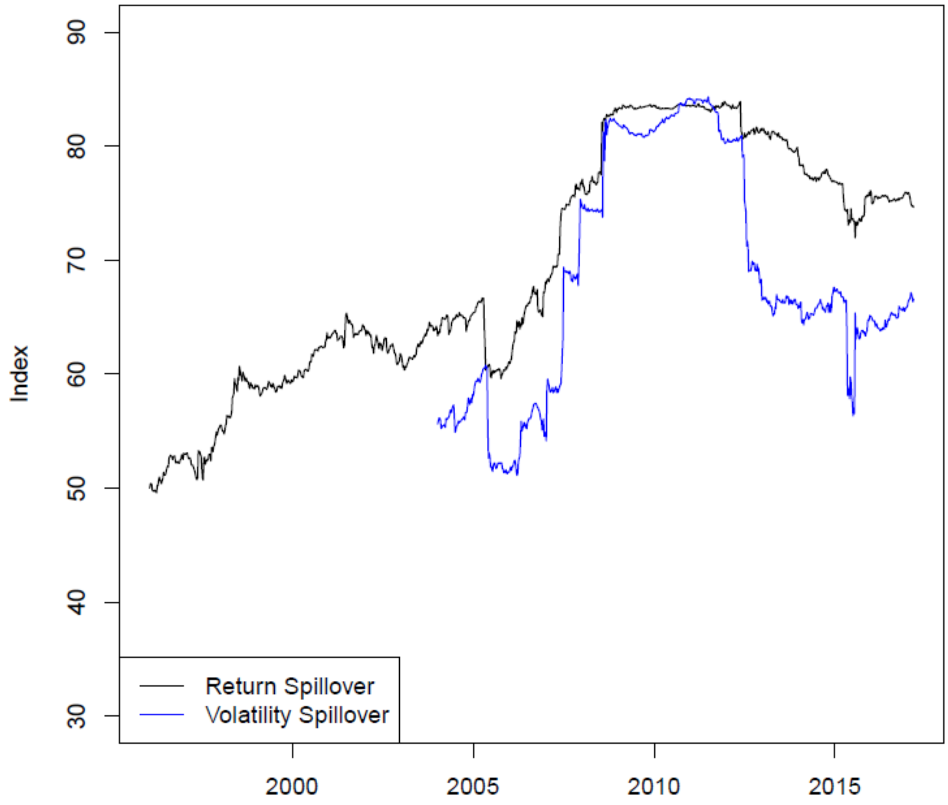
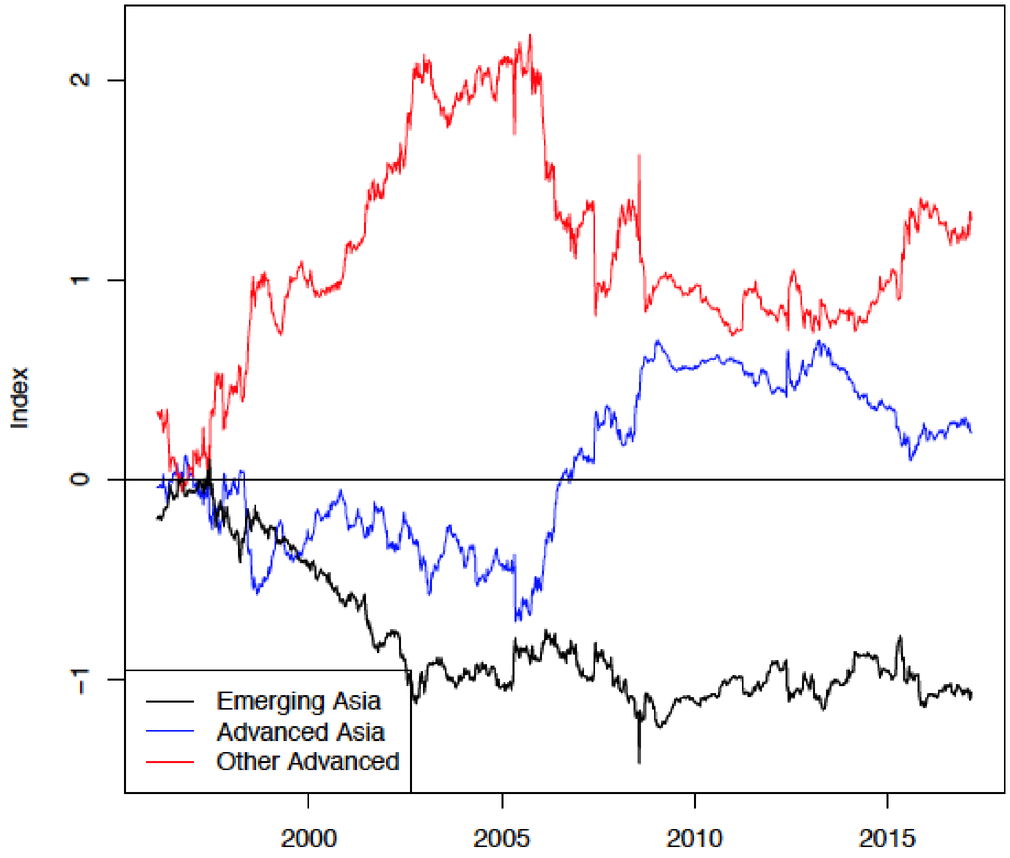
Figure 1. Time-varying Connectedness of Equity Return and Volatility Spillovers



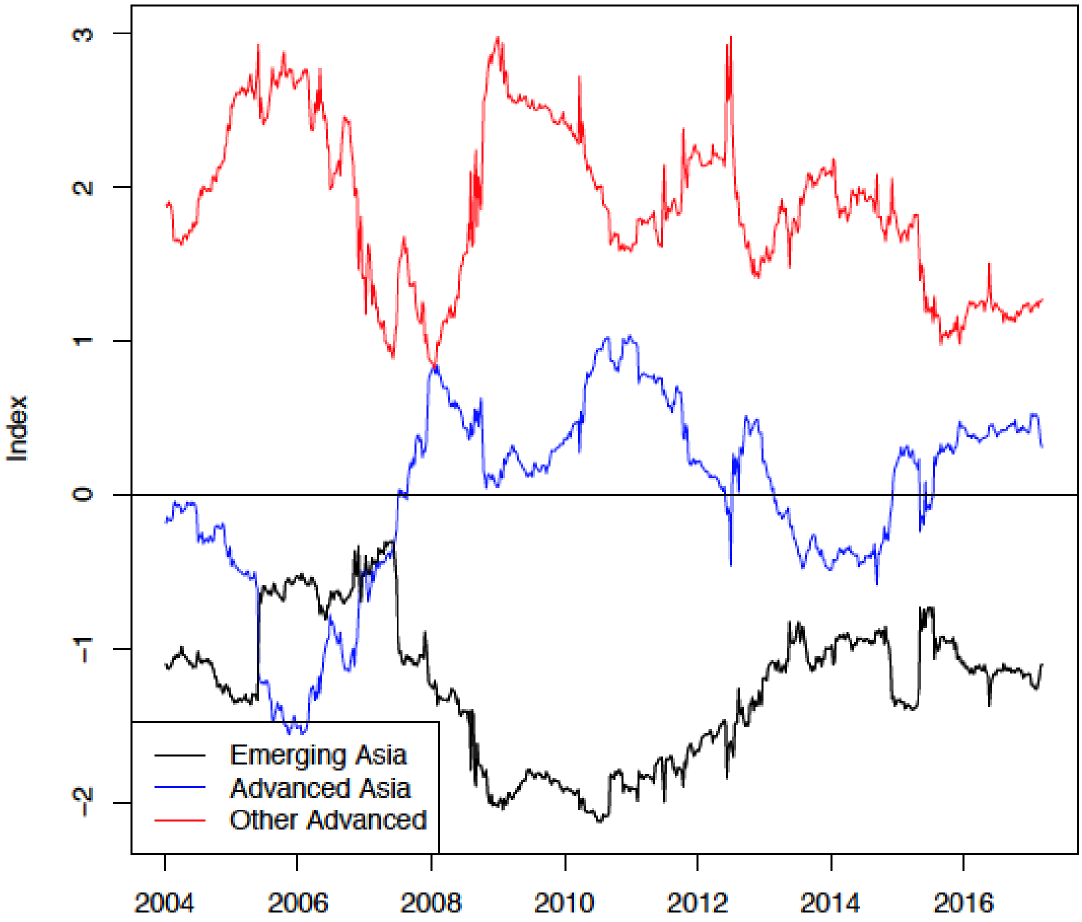
Note: Plotted are total return and volatility spillover indices based on a 200-week rolling estimation window. The corresponding date in the plot denotes the end of the rolling estimation window.

Figure 2. Average Net Return Spillovers by Group



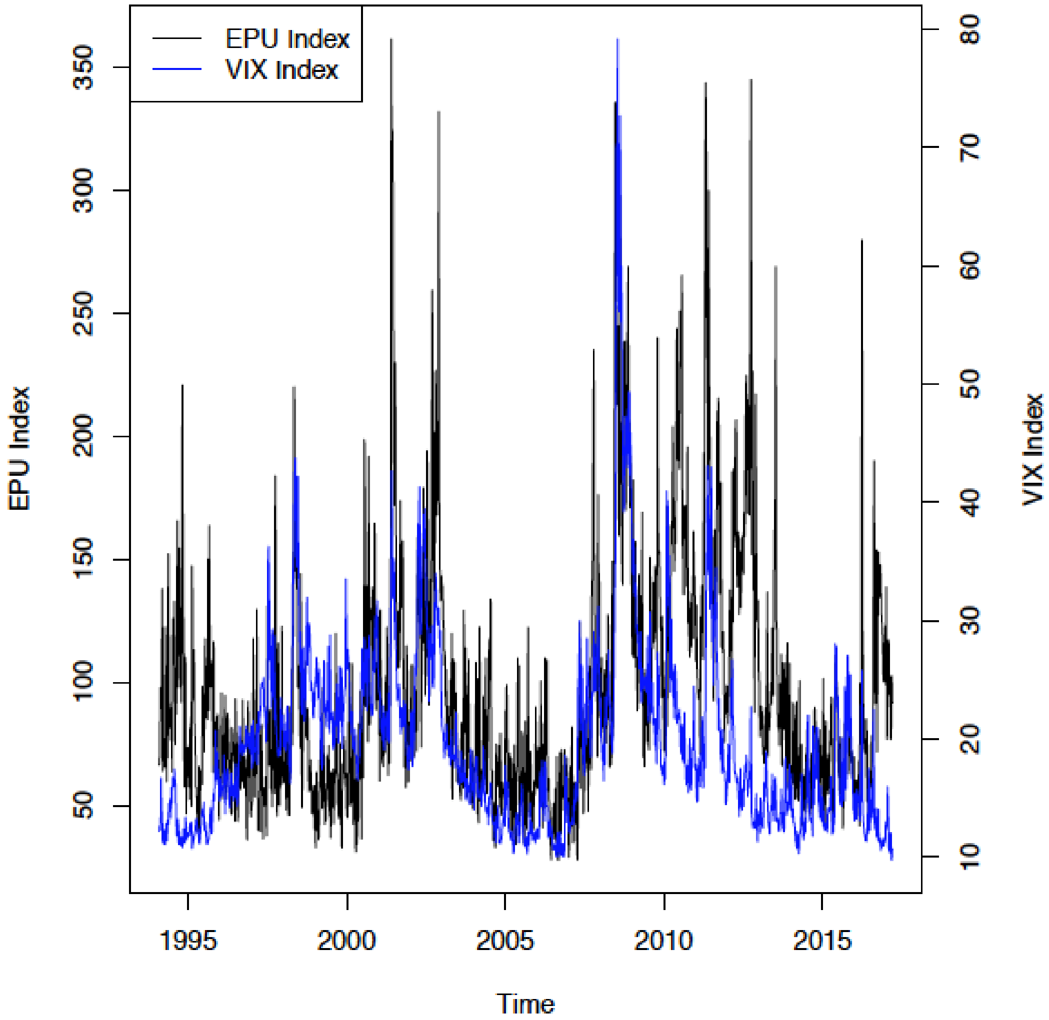
Note: Plotted are the average net return spillover indices based on a 200-week rolling estimation window. The corresponding date in the plot denotes the end of the rolling estimation window.

Figure 3. Average Net Volatility Spillovers by Group



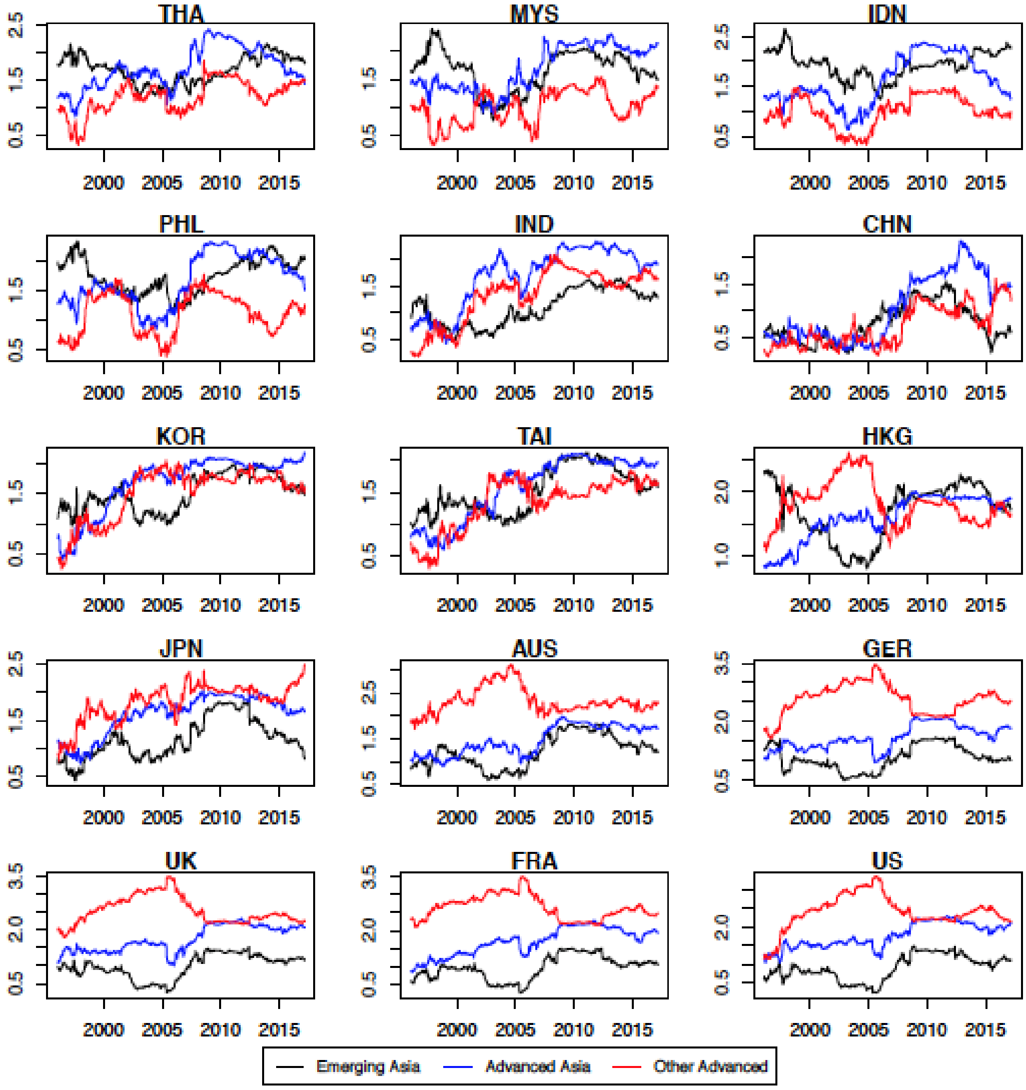
Note: Plotted are the average net volatility spillover indices based on a 200-week rolling estimation window. The corresponding date in the plot denotes the end of the rolling estimation window.

Figure 4. EPU and VIX Indices



Source: Bloomberg and www.policyuncertainty.com

Figure 5. Contributions of Return Spillover Shocks by Country Group



Note: Plotted is the sum of directional shocks received by each country, classified by country group.

Table 1. Descriptive Statistics of International Equity Markets

Panel A. Weekly Returns

	THA	MYS	IDN	PHL	HKG	KOR	IND	JPN	CHN	TAI	AUS	GER	UK	FRA	US
Mean	3.53	4.25	11.72	7.04	6.06	5.78	9.33	0.61	3.92	3.39	4.88	7.75	4.01	4.54	7.16
Med	15.48	7.19	16.13	11.34	13.52	13.76	20.85	8.90	0.00	12.54	11.76	20.90	12.02	13.96	12.36
Max	1135.60	1278.09	977.75	841.60	723.68	906.67	878.29	595.38	3932.79	952.54	473.91	776.99	654.39	633.35	590.51
Min	-1386.39	-989.39	-1211.45	-1143.25	-1035.90	-1192.30	-905.11	-1449.99	-1205.81	-743.18	-884.85	-1266.04	-1228.85	-1291.36	-1044.36
Std.D	182.54	142.40	182.58	169.06	174.86	194.35	176.77	157.30	264.06	167.71	103.59	160.46	120.46	145.09	118.68
Skew	-0.26	0.12	-0.42	-0.48	-0.37	-0.46	-0.48	-0.73	3.66	-0.10	-0.77	-0.64	-0.90	-0.79	-0.80
Kur	8.15	13.80	8.83	8.22	6.02	8.16	5.60	9.15	53.21	5.65	8.34	7.96	13.52	9.06	10.26

Panel B. Weekly Volatilities

	THA	MYS	IDN	PHL	HKG	KOR	IND	JPN	CHN	TAI	AUS	GER	UK	FRA	US
Mean	16.03	9.85	16.63	9.14	16.84	17.74	17.91	17.42	18.89	16.35	11.85	18.97	14.77	18.13	13.77
Med	13.94	8.21	14.19	7.04	14.02	14.55	14.56	15.45	16.13	13.40	9.88	15.77	12.10	15.54	10.99
Max	110.65	55.87	94.62	53.99	140.21	108.53	128.64	117.59	97.51	86.92	67.33	95.42	88.07	96.70	102.36
Min	2.87	1.44	1.48	0.44	2.84	1.58	3.72	3.13	2.23	1.78	2.68	2.56	2.02	1.65	2.46
Std.D	10.18	6.51	10.89	6.76	10.92	11.98	12.70	10.34	11.97	10.38	7.43	12.18	9.83	11.19	9.89
Skew	2.97	2.40	2.44	2.05	3.70	2.51	2.96	3.36	1.92	1.89	2.82	2.31	2.57	2.19	3.15
Kur	18.66	11.79	12.43	9.76	28.81	13.45	17.21	23.47	8.90	9.06	15.39	10.79	13.27	10.89	20.01

Sources: Datastream and authors' calculations.

Table 2. Spillover Table for International Equity Market Returns

To	From															
	THA	**MYS**	**IDN**	**PHL**	**HKG**	**KOR**	**IND**	**JPN**	**CHN**	**TAI**	**AUS**	**GER**	**UK**	**FRA**	**US**	**Contribution from others**
THA	33.9	6.0	7.9	7.8	6.7	6.4	2.7	3.1	0.2	3.7	4.6	4.4	4.7	4.3	3.8	66
MYS	7.7	40.1	8.2	6.7	7.4	3.7	2.3	2.9	0.1	4.0	3.9	3.7	3.4	3.1	2.9	60
IDN	8.3	7.0	34.4	8.2	6.3	4.8	3.7	3.7	0.4	3.0	4.9	4.0	3.8	4.0	3.3	66
PHL	8.5	5.9	8.4	34.3	7.4	3.5	2.4	3.0	0.1	4.1	5.7	4.0	4.6	4.1	4.0	66
HKG	4.9	4.5	4.4	5.0	25.0	5.7	3.4	5.1	0.2	4.9	7.7	7.1	8.1	7.3	6.7	75
KOR	6.3	2.9	4.0	2.8	7.4	33.0	4.1	6.0	0.2	5.3	5.6	5.8	5.6	5.6	5.1	67
IND	3.3	2.3	4.0	2.9	5.8	5.1	39.1	4.8	0.9	3.7	5.2	6.2	5.8	6.2	4.8	61
JPN	2.7	2.1	3.1	2.7	6.1	5.5	3.6	29.7	0.3	4.0	8.4	7.6	7.7	8.4	8.0	70
CHN	0.6	0.7	1.2	0.5	1.4	0.5	1.9	0.9	84.8	1.4	1.4	1.4	1.0	1.2	1.0	15
TAI	4.1	3.8	3.0	4.3	7.5	5.9	3.3	5.0	0.4	37.7	4.8	5.7	4.6	5.4	4.6	62
AUS	3.3	2.4	3.3	3.8	7.5	4.3	3.2	6.9	0.2	3.2	24.5	8.2	10.1	9.5	9.6	75
GER	2.6	1.7	2.4	2.3	5.9	3.8	3.2	5.3	0.1	3.0	6.9	21.2	13.4	16.4	11.9	79
UK	2.8	1.6	2.2	2.7	6.6	3.5	2.9	5.4	0.1	2.4	8.5	13.2	20.9	14.9	12.4	79
FRA	2.5	1.4	2.3	2.4	5.8	3.5	3.1	5.7	0.1	2.6	7.8	15.8	14.6	20.5	11.7	80
US	2.3	1.4	2.1	2.5	5.8	3.6	2.6	5.9	0.1	2.5	8.6	12.8	13.6	13.1	23.0	77
Contribution to others	60	44	56	54	88	60	43	64	4	48	84	100	101	104	90	998
																Spillover index
Contribution including own	94	84	91	89	113	93	82	93	88	86	109	121	122	124	113	**66.5%**

Table 3. Spillover Table for International Equity Market Volatility

To	From															
	THA	**MYS**	**IDN**	**PHL**	**HKG**	**KOR**	**IND**	**JPN**	**CHN**	**TAI**	**AUS**	**GER**	**UK**	**FRA**	**US**	**Contribution from others**
THA	34.2	4.3	5.6	3.9	7.1	6.4	6.6	4.1	0.6	5.0	2.7	4.1	5.3	4.4	5.6	66
MYS	3.8	29.7	4.1	2.9	8.4	5.9	6.1	3.7	1.3	6.9	3.1	5.1	7.2	5.7	6.2	70
IDN	3.6	3.7	36.7	2.5	7.3	6.0	5.8	3.6	1.4	5.0	3.6	3.8	5.7	3.8	7.5	63
PHL	4.5	4.1	3.9	44.6	5.2	3.9	2.8	3.1	2.5	4.5	4.3	2.6	4.4	3.8	5.7	55
HKG	3.3	4.4	4.5	2.0	19.5	7.9	6.0	5.6	1.6	7.4	6.8	6.2	9.2	6.8	8.9	80
KOR	3.0	3.3	3.6	1.7	9.1	23.1	4.9	5.1	0.8	8.9	3.7	7.8	8.0	7.3	9.8	77
IND	3.2	4.1	6.4	2.2	10.4	7.9	31.6	4.9	0.5	6.7	3.9	3.6	5.0	3.5	6.0	68
JPN	2.8	2.4	3.1	1.6	8.5	6.5	4.1	24.2	0.6	4.3	5.7	8.4	9.4	8.3	10.1	76
CHN	1.5	2.6	5.3	3.3	7.1	2.0	1.7	1.3	57.6	3.4	5.5	1.8	2.2	1.6	3.2	42
TAI	2.4	4.7	3.6	2.1	9.3	12.2	4.9	3.8	1.1	26.0	3.5	6.2	6.4	6.0	7.9	74
AUS	1.9	2.7	3.6	2.3	8.4	4.2	3.4	4.5	1.7	4.0	24.3	7.0	11.4	9.2	11.4	76
GER	1.8	1.6	1.9	1.0	4.9	5.3	1.6	4.6	0.7	4.2	5.2	20.8	16.0	18.2	12.2	79
UK	1.9	2.3	2.5	1.4	6.2	5.2	2.3	4.5	0.7	4.4	6.7	13.4	20.0	15.9	12.5	80
FRA	2.1	1.8	1.9	1.3	4.8	4.6	1.5	4.1	0.7	4.0	6.2	16.4	16.9	20.7	13.1	79
US	2.5	2.0	3.1	2.0	6.5	6.8	2.3	4.8	0.9	5.5	6.8	10.7	13.2	12.7	20.4	80
Contribution to others	38	44	53	30	103	85	54	58	15	74	68	97	120	107	120	1067
Contribution including own	73	74	90	75	123	108	86	82	73	100	92	118	141	128	140	**Spillover index** **71.1%**

Table 4. Correlation Table

Correlation	Country														
	THA	**MYS**	**IDN**	**PHL**	**HKG**	**KOR**	**IND**	**JPN**	**CHN**	**TAI**	**AUS**	**GER**	**UK**	**FRA**	**US**
VIX	0.140	0.112	0.175	0.251	-0.068	-0.008	-0.116	-0.072	0.027	0.103	0.082	0.068	0.024	0.053	0.019
EPU	0.453	0.368	0.291	0.354	0.351	0.370	0.307	0.317	0.398	0.459	0.433	0.406	0.348	0.398	0.342

Note: Reported are the pairwise correlation coefficients between the time-varying spillover of stock returns received by each country and the VIX and EPU indices.

Table 5. Granger Causality Tests Results

Country	**VIX**	**EPU**
THA	7.512 (0.482)	18.403*** (0.018)
MYS	1.609 (0.900)	10.920** (0.053)
IDN	1.117 (0.891)	7.018 (0.134)
PHL	2.813 (0.589)	8.765* (0.067)
IND	6.642 (0.355)	2.392 (0.880)
CHN	3.396 (0.493)	1.799 (0.772)
TAI	5.622 (0.584)	13.277* (0.065)
KOR	8.267 (0.689)	15.780 (0.149)
JPN	14.327** (0.026)	13.137** (0.0409)
HKG	9.816* (0.080)	15.816*** (0.007)
AUS	4.549 (0.473)	9.613* (0.087)
GER	10.067* (0.073)	11.983** (0.035)
FRA	14.077*** (0.015)	16.248*** (0.006)
UK	11.924** (0.035)	11.929** (0.035)
US	10.238* (0.068)	8.906 (0.112)

Note: Reported are the Chi-square test statistics associated with the Block exogeneity Wald test with the corresponding null hypothesis that all lags of the EPU and VIX can be excluded from each equation in the VAR system. The corresponding p-values are reported in parentheses and *,**,*** denotes statistical significance at the 10, 5, and 1 percent levels respectively.

Appendix A

Figure A1. Net Return Spillovers By Country

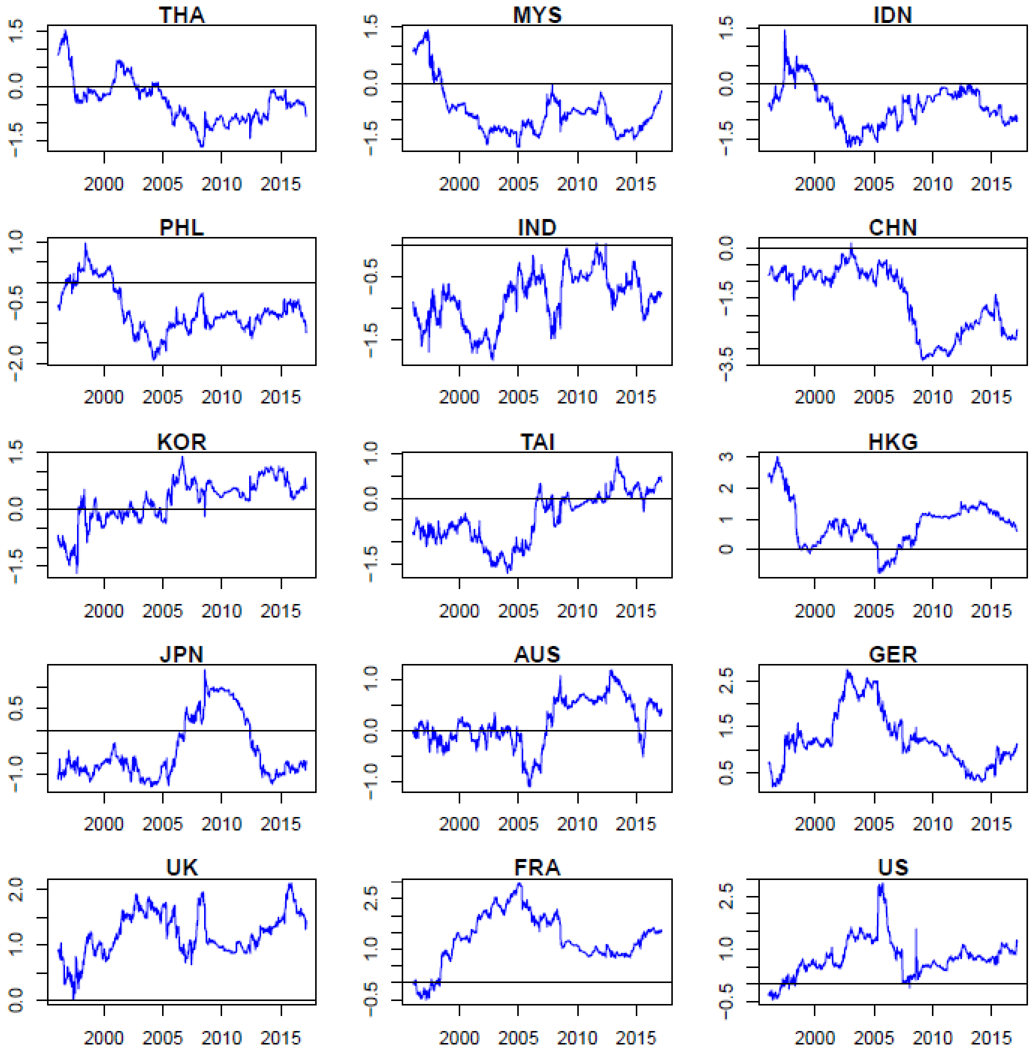


Figure A2. Net Volatility Spillovers By Country

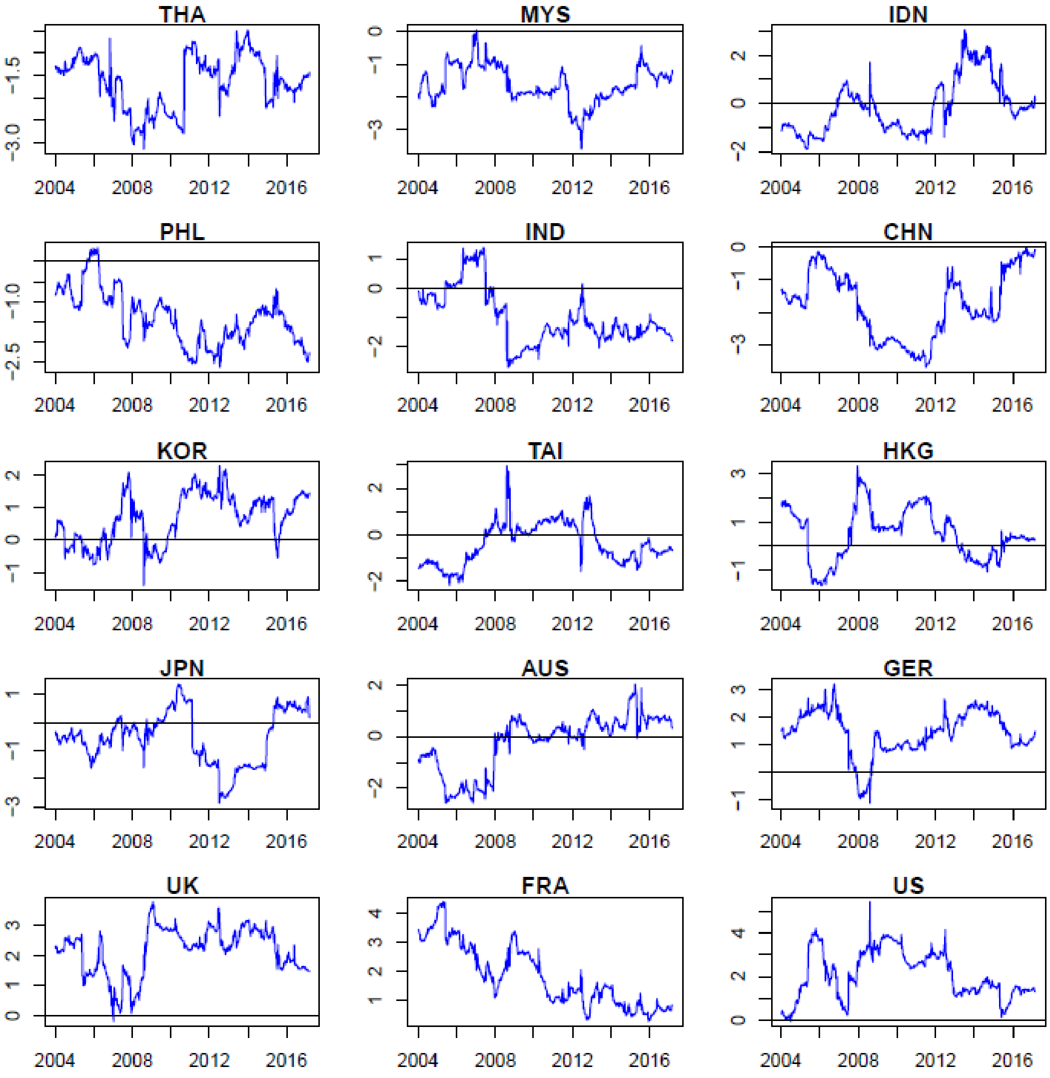


Figure A3. Directional Return Spillovers Received by Country

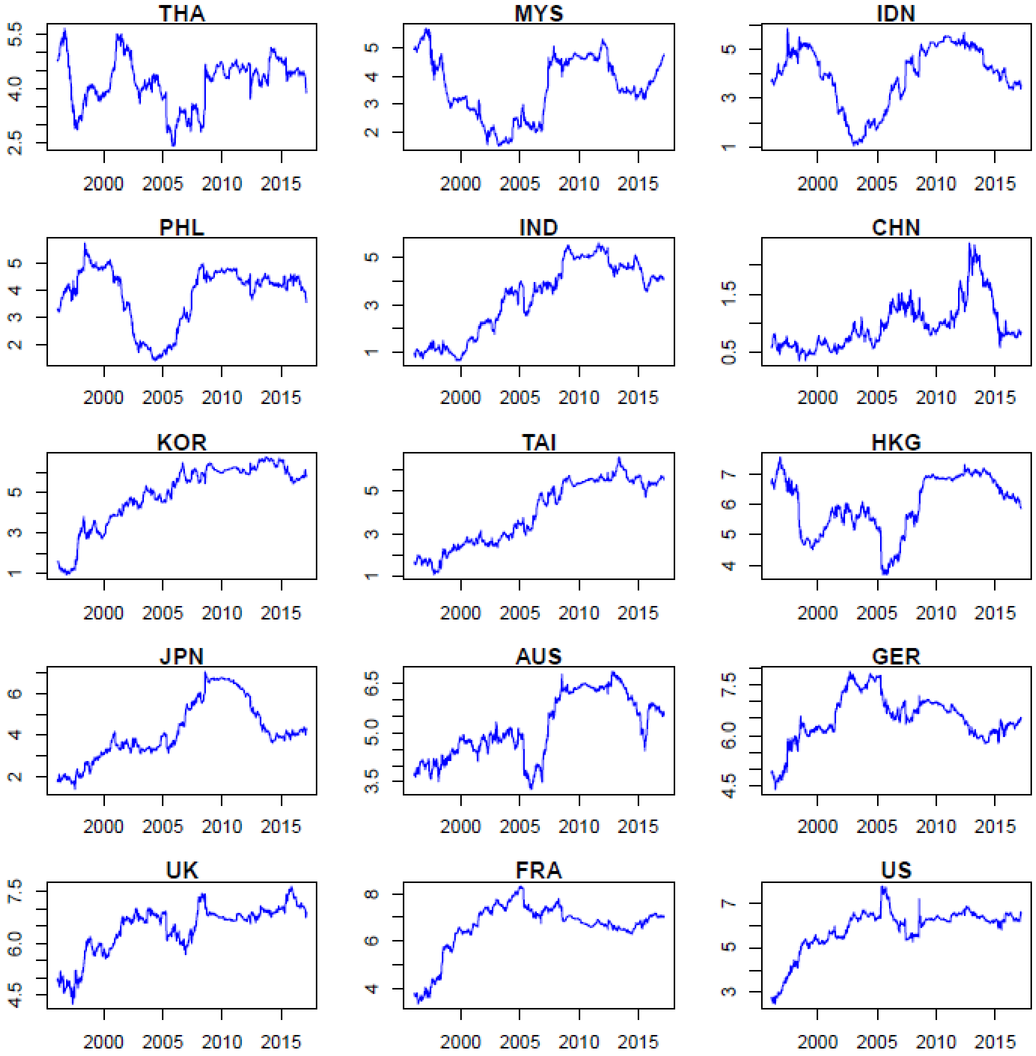


Figure A4. Directional Return Spillovers Transmitted by Country

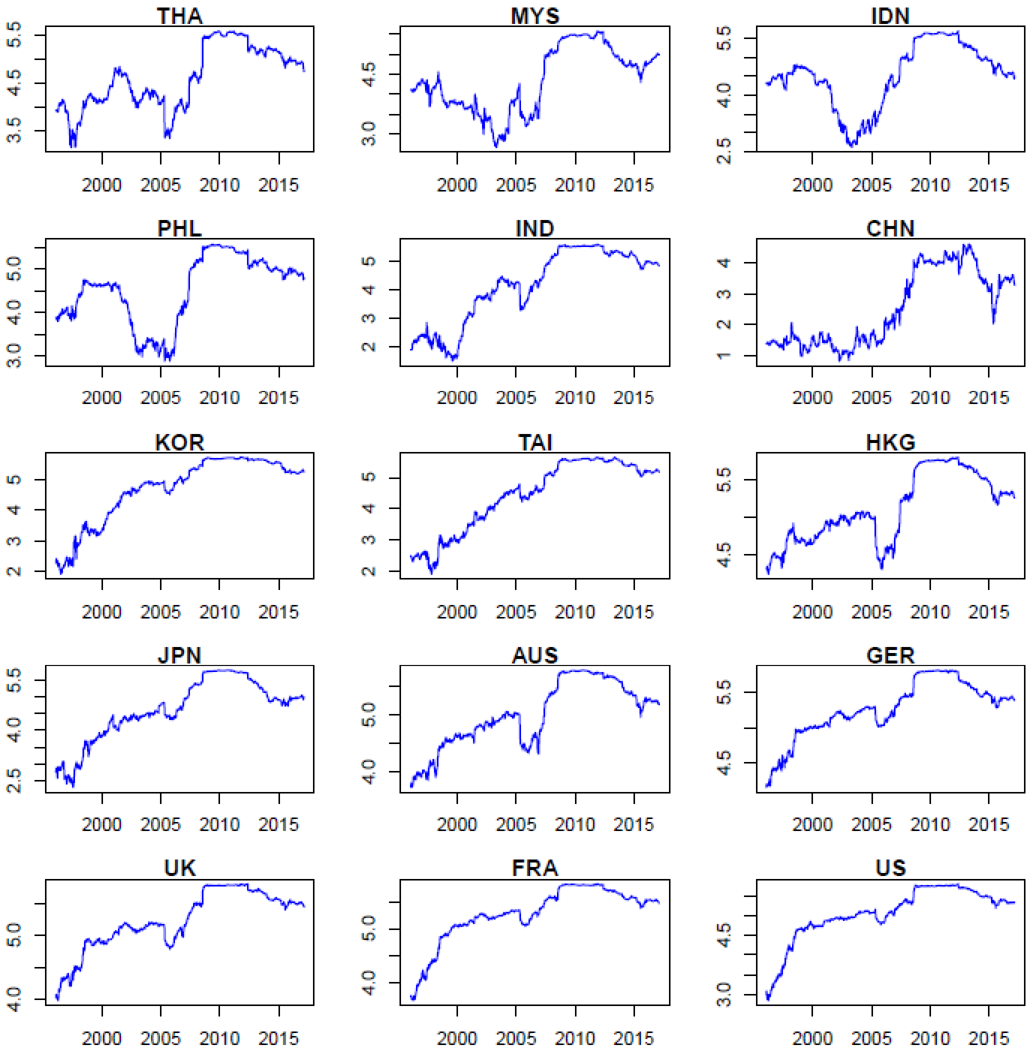


Figure A5. Directional Volatility Spillovers Received by Country

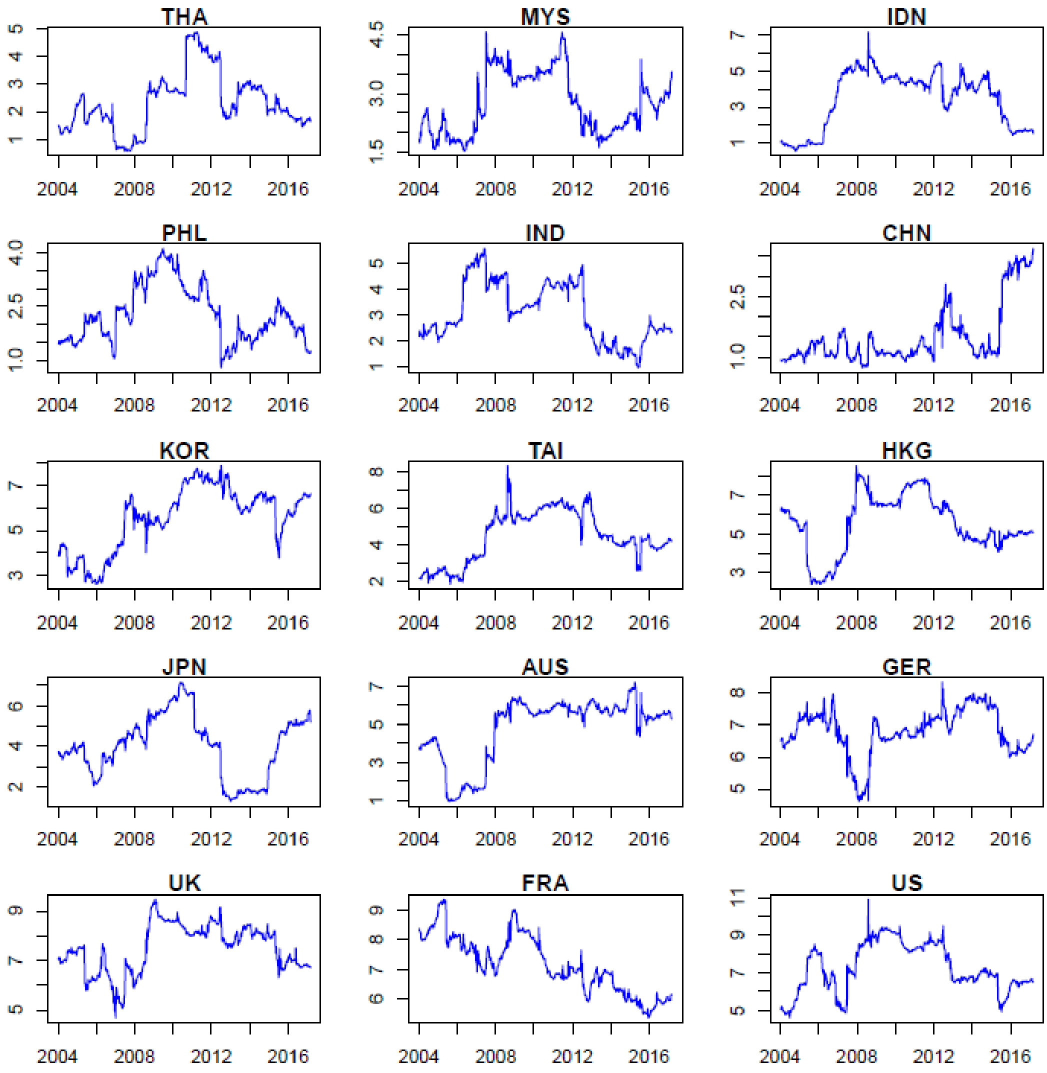


Figure A6. Directional Volatility Spillovers Transmitted by Country