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ASEAN+3 Financial Interconnectedness

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Abstract

This paper examines financial interconnectedness in ASEAN+3 using BIS Locational Banking Statistics to map the cross-border claims and liabilities of ASEAN+3 banks and analyze contagion risks via daily market and financial asset prices, based on the Diebold and Yilmaz (2012, 2014) methodology. The findings indicate that even as intraregional interconnectedness is rising, the region remains vulnerable to shocks from major advanced economies. ASEAN+3 economies also generate outward spillovers both within and beyond the region. This interconnectedness highlights the need for stronger regional surveillance, enhanced cross-border data sharing, regional stress testing, improved supervision, and robust liquidity support.

JEL classification: G15, E44

Keywords: ASEAN+3, financial interconnectedness, cross-border contagion, systemic risk, spillover effects

Abbreviations

AMRO	ASEAN+3 Macroeconomic Research Office
ABIF	ASEAN Banking Integration Framework
ASEAN	Association of South-East Asian Nations (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam)
ASEAN+3	ASEAN plus China (including Hong Kong), Japan, Korea
BIS	Bank for International Settlements
CBS	Consolidated Banking Statistics
CBOE	Chicago Board Options Exchange
CMIM	Chiang Mai Initiative Multilateralisation (CMIM)
COVID-19	Coronavirus disease 2019
DS	Datastream
DSIB	Domestic Systemically Important Bank
GFC	Global Financial Crisis
ICIO	Inter-Country Input-Output
IMF	International Monetary Fund
LBS	Locational Banking Statistics
MES	Marginal Expected Shortfall
OECD	Organisation for Economic Co-operation and Development
RFA	Regional Financial Arrangement
VAR	vector autoregression
VIX	Volatility Index

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I.   Introduction

The Global Financial Crisis (GFC) exposed the flaws in assessing financial institutions in isolation, and revealed the deep interconnectedness of global financial systems. Even countries with strong fundamentals were affected by cascading shocks from abroad, underscoring the need to understand how these linkages can amplify shocks and trigger widespread financial turmoil. This highlighted the importance of understanding contagion channels among financial institutions.

Intraregional cross-border financial intermediation in the ASEAN+3 region has surged in recent decades, increasing interconnectedness and contagion risks. This shift has reduced the dominance of U.S., U.K., and European financial firms, amid growing regional financial market integration. Hong Kong and Singapore have emerged as key financial hubs, facilitating cross-border flows and promoting an intraregional financing pattern. Regional frameworks, such as the ASEAN Banking Integration Framework (ABIF), have further supported cross-border financing. While these changes boost efficiency, competition, and market development, they also increase spillover and contagion risks (Remolona and Shim 2015).

This study examines cross-border contagion and financial interconnectedness in the ASEAN+3 region. While several studies have explored financial contagion following the GFC, most have focused on advanced economies such as the U.S. (see, for example, Diebold and Yilmaz 2012, 2014) and European countries (see, for example, IMF 2017 on Finland and 2015 on Norway), with relatively less attention placed specifically on the ASEAN+3 region.[3] This paper bridges this gap in the research by considering the following questions:

- Global vs regional spillovers: Are global risk factors—like the VIX, commodity price shocks, and spillovers from advanced economies—still primary sources of spillover, or have intra-ASEAN+3 cross-border factors become more significant? To what extent do developments in other emerging markets affect stability in ASEAN+3?
- Sectoral interconnectedness: How substantial are spillovers within economies (for example, from the real estate to the financial sector) and across borders (for example, real estate sector impacts across economies in the region)?
- Potential shock scenarios: Which stress scenarios require priority attention? Are triggers more likely from within or outside the region, and which sectors (banking,

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[3] While there has been some prior research focusing on Asia, these studies differ from ours in methodology, scope, and focus. For instance, Mensah and Premaratne (2017) analyzed interconnectedness among 83 Asian banking institutions using Conditional Value-at-Risk (CoVaR) and Granger causality methods, emphasizing the relationship between bank size and systemic risk. Rosenkranz and Melchor (2022) employed probit and logit models to examine the link between crisis probabilities and financial connections, while Dogah and Premaratne (2020) investigated the influence of intraday and overnight trading information on financial market risk behavior. Guimaraes-Filho and Hong (2016), an earlier study, focused on China as a source of economic shocks.

In contrast, this study is distinct in multiple aspects. First, it focuses specifically on the ASEAN+3 economies, leveraging the most recent data to reflect the dynamic nature of spillovers and evolving economic structures. Methodologically, it combines BIS cross-border claims and liabilities with market-based approaches and incorporates input-output analysis as a robustness check. More importantly, the focus of our analysis is different in that we examine the relative importance of global factors, advanced economies (outside ASEAN), and intra-ASEAN spillovers on the ASEAN+3 region, as well as outward spillovers originating from ASEAN+3 economies. Sectoral interconnections, such as insurer-to-insurer, banking-to-banking, and real estate-to-real estate linkages, are also analyzed. Most critically, we differ by conducting a risk scenario impact analysis, which evaluates the effects of banking sector shocks, U.S. dollar appreciation, commodity price shocks, and spillovers from China's real estate sector on its domestic economy and the broader ASEAN+3 region. These dimensions, which have not been explored in previous studies, position our research as a meaningful contribution to understanding financial dynamics in the region.

property, corporate) are more vulnerable? Would the impacts be uniform across ASEAN+3, or would some economies face heightened risk?

Our findings reveal that interconnectedness among ASEAN+3 economies is growing, though the region remains exposed to macro-financial shocks from major advanced economies. Singapore and Hong Kong, as global financial hubs, are highly susceptible to and can transmit cross-border spillovers. Japan's financial system is closely tied to those of developed economies, while China's is more linked to Hong Kong. ASEAN+3 economies not only receive inward spillovers but also generate outward spillovers affecting both advanced and emerging markets. This growing interconnectedness underscores the need for stronger regional surveillance and cooperation, including enhanced cross-border data sharing, regional stress testing, improved home-host supervision, and liquidity support.

II. Literature Review

Financial interconnectedness and contagion are commonly analyzed through two main types of network studies (Bricco and Xu, 2019). The first type focuses on direct financial links based on contractual exposures such as interbank lending, with data derived from balance sheets (Allen and Gale, 2000; Freixas, Parigi, and Rochet, 2000). Connections between banks and non-bank financial institutions may form through loans, deposits, and other channels. Cross-border exposures, mapped using Bank for International Settlements (BIS) data like the Locational Banking Statistics (LBS) and Consolidated Banking Statistics (CBS), help identify potential contagion and risk transmission sources by revealing key exposure destinations and origins.

The second approach is market-based, utilizing market and asset price data to capture both direct and indirect connections from shared asset exposures (Cont and Schaanning, 2017, 2019), such as losses from fire sales (Shleifer and Vishny, 1992; Cifuentes, Shin, and Ferrucci, 2005), information spillovers, or market perceptions. This approach often measures interconnectedness through correlation networks. The Diebold and Yilmaz (2012, 2014) methodology, which uses forecast error variance decomposition of daily price returns, is widely used to assess economies' and sectors' systemic shock vulnerability and contributions to systemic risk. Their method, linked to approaches such as pairwise Granger causality (Billio et al., 2012) and average pairwise correlation (Engle and Kelly, 2012), represents interconnectedness as weighted directed networks. Similar measures include the CoVaR method by Adrian and Brunnermeier (2008) and the marginal expected shortfall (MES) by Acharya, Pedersen, Philippe, and Richardson (2010).[4]

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[4] Several methodologies have been proposed to measure interconnectedness and spillovers, each with unique strengths and applications. For our study, we adopted the Diebold-Yilmaz (2012, 2014) methodology due to its widespread recognition and established linkages to other measures, such as CoVaR and MES. More importantly, we find this approach particularly well-suited to our dataset and research objectives, as it allows for a detailed analysis of dynamic relationships and directional spillovers among all 22 endogenous variables in our vector autoregressive (VAR) framework.

Alternative techniques, such as time-varying parameter vector autoregressive (TVP-VAR) models (Antonakakis, Chatziantoniou, and Gabauer, 2020), offer dynamic adaptability but are highly data-intensive and computationally demanding, often requiring state-space estimation techniques. Consequently, most TVP-VAR studies focus on systems with relatively few endogenous variables, making them impractical for our study. Similarly, dynamic conditional correlation multivariate generalized autoregressive conditional heteroskedasticity (DCC-MVGARCH) models (Engle 2002) and BEKK-GARCH models (Baba, Engle, Kraft, and Kroner 1990), primarily employed in volatility studies, are computationally intensive and less suited to the interconnectedness dynamics we aim to capture. Factor-augmented vector autoregressive (FAVAR) models (Bernanke, Boivin, and Eliasz 2005), while effective for dimensionality reduction, sacrifice granularity, making it difficult to analyze the interconnections and impacts of individual variables. In contrast, the Diebold-Yilmaz framework preserves the richness of these relationships, enabling a nuanced understanding of systemic vulnerabilities and spillover effects. Proposed "model-free" approaches (Gabauer, Chatziantoniou, and Stenfors 2023), though computationally simpler, similarly lack the depth needed to capture the complexity of interconnectedness in our study.

This paper applies both approaches to assess interconnectedness within ASEAN+3 financial systems. Section III examines ASEAN+3 banks' cross-border exposures using BIS data. Sections IV and V outline the econometric methods and data employed to analyze cross-border and sectoral networks in the ASEAN+3 region, with results presented in Section VI.

### III. Stylized Facts on ASEAN+3 Cross-border Banking Claims and Liabilities

Figure 1. Japan: Cross-border Claims and Liabilities, Q4 2005 and Q4 2023
(billions of U.S. dollars)
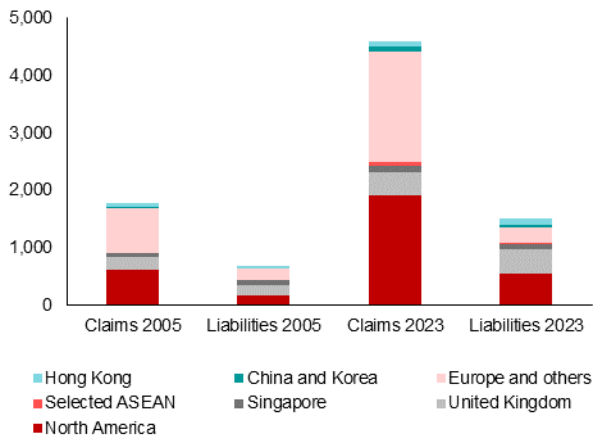
Source: BIS locational banking statistics; AMRO staff calculations.
Note: The reporting ASEAN+3 economy is Japan. North America refers to the U.S. and Canada. Selected ASEAN comprises Malaysia, Thailand, Indonesia, Philippines, Vietnam, Lao PDR, and Myanmar. Europe and others are all other banking jurisdictions not otherwise classified (mostly from Europe).

Figure 2. China: Cross-border Claims and Liabilities, Q4 2014 and Q4 2023
(billions of U.S. dollars)
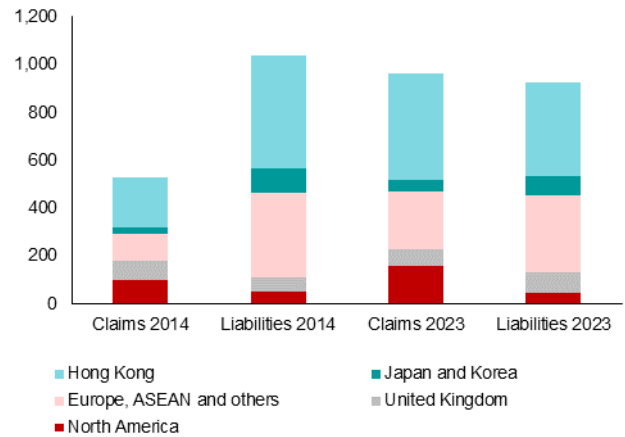
Source: BIS locational banking statistics; AMRO staff calculations.
Note: Since China does not report a breakdown of cross-border data by economy, the chart above is based on data from China's counterparty reports. Singapore also does not report a breakdown of cross-border data by economy. North America refers to the U.S. and Canada. Europe, ASEAN and others comprises all other banking jurisdictions not otherwise classified.

This section maps ASEAN+3 banks' cross-border exposures using data from BIS Locational Banking Statistics (LBS). LBS data measures claims and liabilities, including intra-group positions within reporting countries, allowing analysis of the geographic spread of international banking activities and intra-group transfers. This information highlights potential sources of risk transmission and contagion through bank lending and funding channels (Briccio and Xu 2019).

Below are some key facts on ASEAN+3 cross-border borrowing and lending based on the LBS.

- Japanese banks are closely linked to advanced economies like North America and the U.K., receiving most of their cross-border funding from and directing a substantial share of their lending to these regions. Driven by low domestic interest rates, Japanese banks pursue higher yields abroad, resulting in cross-border claims that exceed their cross-border liabilities (Figure 1).

- In contrast, China's cross-border lending and borrowing are mainly to and from banks in Hong Kong (Figure 2). Hong Kong has strong financial ties with China, directing most of its cross-border lending there and receiving most of its cross-border borrowing from China (Figure 3). International bank subsidiaries and foreign branches in Hong Kong have substantial China-related lending (IMF 2021a), positioning Hong Kong as a key conduit for foreign bank lending into China.

Figure 3. Hong Kong: Cross-border Claims and Liabilities, Q4 2014 and Q4 2023
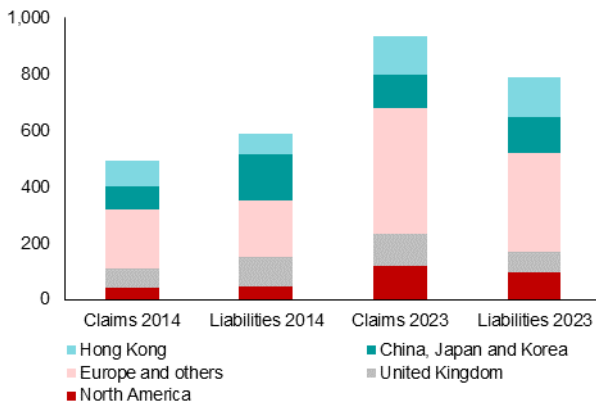(billions of U.S. dollars)
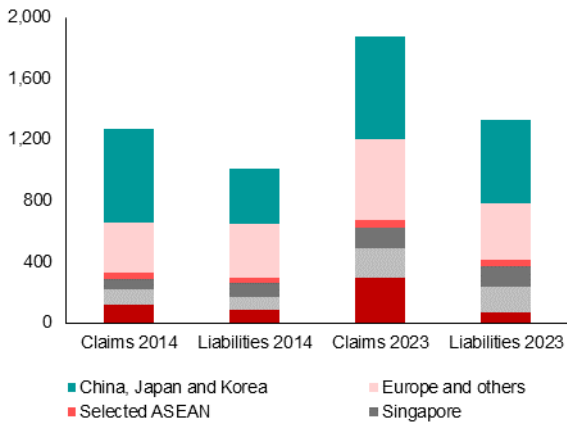
Source: BIS locational banking statistics; AMRO staff calculations.
Note: The reporting economy is Hong Kong. North America refers to the U.S. and Canada. Selected ASEAN comprises Malaysia, Thailand, Indonesia, Philippines, Vietnam, Lao PDR, and Myanmar. Europe and others comprises all other banking jurisdictions not otherwise classified (mostly from Europe).

Figure 4. Korea: Cross-border Claims and Liabilities, Q4 2005 and Q4 2023
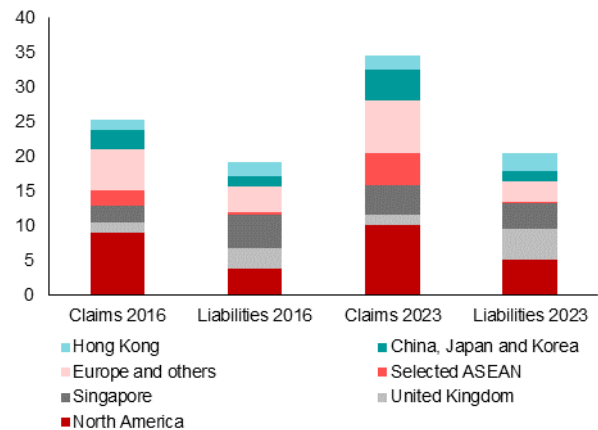(billions of U.S. dollars)
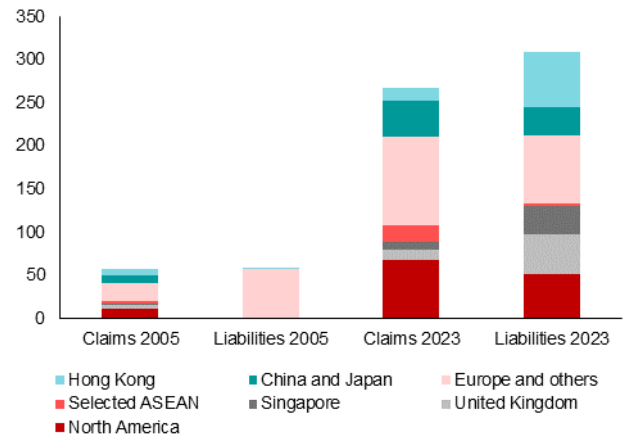
Source: BIS locational banking statistics; AMRO staff calculations.
Note: The reporting ASEAN+3 economy is Korea. North America refers to the U.S. and Canada. Selected ASEAN comprises Malaysia, Thailand, Indonesia, Philippines, Vietnam, Laos, and Myanmar. Europe and others comprises all other banking jurisdictions not otherwise classified (mostly from Europe).

Figure 5. Singapore: Cross-border Claims and Liabilities, Q4 2014 and Q4 2023
(billions of U.S. dollars)

Source: BIS locational banking statistics; AMRO staff calculations.
Note: North America refers to the U.S. and Canada. Europe and others comprises all other banking jurisdictions not otherwise classified. Since Singapore does not report a breakdown of cross-border data by economy, the chart above is based on data from Singapore's counterparties' reports. China also does not report a breakdown of cross-border data by economy, so BIS statistics do not capture bilateral flows between Singapore and China. However, the MAS had reported that 47 percent of lending by local domestic systemically important banks (DSIBs) went to China as of Q2 2018 (IMF 2019).

Figure 6. Philippines: Cross-border Claims and Liabilities, Q4 2016 and Q4 2023
(billions of U.S. dollars)

Source: BIS locational banking statistics; AMRO staff calculations.
Note: The reporting ASEAN+3 economy is the Philippines. North America refers to the U.S. and Canada. Selected ASEAN comprises Malaysia, Thailand, Indonesia, Vietnam, Lao PDR, and Myanmar. Europe and others comprise all other banking jurisdictions not otherwise classified (mostly from Europe).

- Korean banks maintain strong connections with banks in the U.S., U.K., Europe, Hong Kong, Singapore, and Japan, and provide significant lending to ASEAN economies (Figure 4). They are net debtors to banks from advanced economies, particularly the U.K., and to regional financial centers like Hong Kong and Singapore, while acting as net lenders to China and ASEAN economies, especially Indonesia, Malaysia, and Vietnam.

- Singapore's financial system is highly open, and serves as a crucial global and regional financial hub, particularly for ASEAN+3 economies. Cross-border lending

accounts for approximately 60 percent of Singapore banks' total exposure (MAS 2023). As a regional financial center, Singapore intermediates credit from advanced economies to emerging markets in Asia (Figure 5), including funding from parent banks to their foreign branches, which then extend loans to corporates from their home country (IMF 2019).

- Among ASEAN economies, only the Philippines provides detailed information on banking claims and liabilities with country-specific source and direction information to the BIS LBS. This data offers insight into ASEAN cross-border banking activities. The Philippine financial system comprises mainly banks with low direct cross-border exposure, following a traditional commercial banking model reliant on deposits and lending, primarily to large nonfinancial corporations (IMF 2021). A significant portion of Philippine banks' cross-border liabilities are from advanced economies such as the U.S. and the U.K., as well as from regional financial centers. The Philippines also holds claims on banks in these advanced economies, regional financial centers, and other regional banks (Figure 6).

- Overall, ASEAN+3 claims and liabilities have increased notably, with significant growth observed within the region itself (Figures 1 to 6).

IV. Econometric Methodology

In this paper, we adopt the definition of interconnectedness as proposed by Diebold and Yilmaz (2012, 2014). In brief, their methodology involves estimating a vector autoregression (VAR) model on price returns. This VAR model is then used to construct a generalized forecast-error variance decomposition to identify uncorrelated structural shocks to returns, following Pesaran and Shin (1998). Using this decomposition, spillover measures are calculated as the percentage contribution of entity A to the *h*-step-ahead forecast error variance of entity B, where the entities may represent banks, sectors, or economies. In this study, the forecast error variance is computed on a 10-day-ahead basis, with a rolling window length of 150 days used to capture time-varying spillovers. [5]

To provide more technical detail, interconnectedness in a multivariate framework involving multiple economies over time can be analyzed using a VAR model of order *p*:

$$y_t = \sum_{i=1}^{p} B_i y_{t-i} + u_t \tag{1}$$

where y_t is an *n*-vector of price returns and $u_t \sim N(0, \Sigma_u)$ is a vector of white noise innovation process. Assuming covariance stationarity, y_t can be expressed in its infinite-order moving-average form:

$$y_t = \sum_{i=0}^{\infty} A_i u_{t-i}, \tag{2}$$

where $A_i = 0$ for $i < 0$.

The moving-average coefficients play a crucial role in capturing the system's dynamics. Transforming these coefficients allows us to generate variance decompositions, which can then be used to measure financial interconnectedness. These decompositions help measure

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[5] This was selected to balance sensitivity to short-term dynamics and robustness in estimating spillovers across 22 endogenous variables. For robustness, we also tested a 200-day rolling window, as used by Diebold and Yilmaz (2012, 2014). The results were robust, confirming the stability of our findings.

the portion of the *H*-step-ahead forecast error variance for a particular variable attributable to shocks from others in the system.

Variance decompositions play a crucial role in analyzing interconnectedness and dynamics among variables. Table 1 provides a schematic of these interconnections. The primary *n* × *n* block in the upper-left corner displays the matrix of variance decompositions. This table extends the block by adding a rightmost column with row totals, a bottom row with column totals, and a bottom-right element representing the aggregate average, considering all cases where *i* ≠ *j*.

Table 1. Cross-market Interconnectedness Map

	y_1	y_2	$\cdots$	y_n	From others
y_1	v_{11}^H	v_{12}^H	$\cdots$	v_{1n}^H	$\sum_{j=1}^n v_{1j}^H, \quad j \neq 1$
y_2	v_{21}^H	v_{22}^H	$\cdots$	v_{2n}^H	$\sum_{j=1}^n v_{2j}^H, \quad j \neq 2$
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
y_n	v_{n1}^H	v_{n2}^H	$\cdots$	v_{nn}^H	$\sum_{j=1}^n v_{nj}^H, \quad j \neq n$
To others	$\sum_{i=1}^n v_{i1}^H$	$\sum_{i=1}^n v_{i2}^H$	$\cdots$	$\sum_{i=1}^n v_{in}^H$	$\frac{1}{n}\sum_{i,j=1}^n v_{ij}^H$
	$i \neq 1$	$i \neq 2$		$i \neq n$	$i \neq j$

The off-diagonal elements of the variance decompositions matrix are relevant to measuring interconnectedness. Specifically, the *pairwise directional interconnectedness* from variable *j* to variable *i* can be defined as:

$$I_{i \leftarrow j}^H = v_{ij}^H \tag{3}$$

which is similar to bilateral imports and exports between economies. In some cases, it is more interesting to focus on the *net pairwise directional connectedness*, defined as $I_{ij}^H = I_{j \leftarrow i}^H - I_{i \leftarrow j}^H$, comparable to bilateral trade balances.

Now, consider the sums of the off-diagonal rows or columns of the variance decomposition matrix. Take the first column, for instance. The sum of its off-diagonal elements represents the portion of the *H*-step-ahead forecast error variance of all other variables (i.e., all "non-own" or "cross" variables collectively rather than individually) that is due to shocks from the variable. Therefore, the off-diagonal column and row sums, labeled "to" and "from" in Table 1, can be used as measures of total directional interconnectedness outwardly transmitted *to others* or inwardly received *from others*. Thus, *total directional interconnectedness <u>to others</u>* from *j* is defined as

$$I_{\bullet \leftarrow j}^H = \sum_{\substack{i=1 \\ j \neq i}}^n v_{ij}^H \tag{4}$$

and *total directional interconnectedness <u>from others</u>* to *i* is defined as:

$$I_{i \leftarrow \bullet}^H = \sum_{\substack{j=1 \\ j \neq i}}^n v_{ij}^H. \tag{5}$$

Finally, we can define *net total directional interconnectedness* as $I_i^H = I_{\bullet \leftarrow i}^H - I_{i \leftarrow \bullet}^H$, similar to the total trade balances of *n* economies, and *total interconnectedness* as the overall sum of the off-diagonal elements in the variance decomposition matrix thus:

$$I^H = \frac{1}{n}\sum_{\substack{i,j=1 \\ i \neq j}}^n v_{ij}^H \tag{6}$$

Typically, variance decomposition calculations involve orthogonalizing VAR shocks, but conventional methods like the Cholesky decomposition can be sensitive to variable ordering. Thus, the generalized approach by Pesaran and Shin (1998) is used instead, which accommodates correlated shocks appropriately.

Technically speaking, the contribution of variable j to the H-step-ahead generalized forecast error variance of variable i is given by:

$$v_{ij}^{gH} = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma_u e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma_u A_h' e_j)}. \tag{7}$$

Here, e_i is a selection vector, having a value of one at its i-th position and zeros elsewhere, and σ_{jj} represents the standard deviation of the innovation process. Since the row sums of the variance decomposition matrix (where the ij-th element is given in equation (7)) do not necessarily equal one (i.e. $\sum_{j=1}^{n} v_{ij}^{gH} \neq 1$), each element is normalized by its respective row sum, resulting in

$$\tilde{v}_{ij}^{gH} = \frac{v_{ij}^{gH}}{\sum_{j=1}^{n} v_{ij}^{gH}} \tag{8}$$

Now, by construction, $\sum_{j=1}^{n} \tilde{v}_{ij}^{gH} = 1$ and $\sum_{i,j=1}^{n} \tilde{v}_{ij}^{g}(H) = n$. Thus, $\tilde{v}_{ij}^{g}(H)$ offers a straightforward measure of the pairwise directional interconnectedness from j to i at horizon H.

Diebold and Yilmaz (2014) have shown that these interconnectedness measures align closely with key concepts in network theory. The variance decomposition matrix can be viewed as the adjacency matrix representation of a weighted directed network. In this context, the asymmetric matrix elements represent pairwise directional interconnectedness, $I_{i \leftarrow j}^{H}$; their row sums (node in-degrees) correspond to total directional interconnectedness "from", $I_{i \leftarrow \bullet}^{H}$; their column sums (node out-degrees) represent total directional interconnectedness "to", $I_{\bullet \leftarrow i}^{H}$; and the mean degree of this network provides a measure of system-wide interconnectedness, I^{H}, affirming the robustness of these interconnectedness measures.

V. Data

Our dataset includes global factors and daily nominal local-currency stock market indices from Eikon Thomson-Reuters Datastream (DS). We calculated daily percent price returns from January 1, 2005 to May 31, 2024. Global factors were similarly calculated, except the VIX and macroeconomic risk indices (short- and long-term), which were standardized as z-scores. The analysis employs a VAR model with eight global factors—the VIX, energy prices, industrial metals, precious metals, agricultural prices, the U.S. nominal effective exchange rate, and short- and long-term macroeconomic risk—and stock markets from three developed economies outside ASEAN+3 (U.S., U.K., Europe), two developing regions (Latin America, Gulf Cooperation Council), and nine ASEAN+3 economies (China, Japan, Korea, Hong Kong, Singapore, Malaysia, Thailand, Indonesia, and the Philippines). Key summary statistics for each variable appear in Table 2.

More details about the data sources used in various VAR specifications are as follows.

Cross-border financial connections, various economies

- Global factors: VIX index from CBOE; commodity indices for energy, industrial and precious metals, and agriculture from GSCI; trade-weighted U.S. dollar NEER index from JPMorgan; and macroeconomic risk indices (short-term and long-term) from Citi.

- Equity indices: North America DS Market; U.K. DS Market; Europe DS Market; Developed Latin America DS Market; GCC DS Market; China DS Market; Japan DS Market; Korea DS Market; Hong Kong DS Market; Singapore DS Market; Malaysia DS Market; Thailand DS Market; Indonesia DS Market; and Philippines DS Market.

Cross-border banking and insurance linkages

- Non-ASEAN+3: North America DS banks and insurance; U.K. DS banks and insurance; Europe DS banks and insurance; Latin America DS banks and insurance; and GCC DS banks and insurance.

- ASEAN+3: China DS banks and insurance; Japan DS banks and insurance; Korea DS banks and insurance; Hong Kong DS banks and insurance; Singapore DS banks and insurance; Malaysia DS banks and insurance; Thailand DS banks; Indonesia DS banks; Philippines DS banks; and Vietnam DS banks and insurance.

Cross-border real estate linkages

- Non-ASEAN+3: North America DS real estate; U.K. DS real estate; Europe DS real estate; Latin America DS real estate; and GCC real estate.

- ASEAN+3: China DS real estate; Japan DS real estate; Hong Kong DS real estate; Singapore DS real estate; Malaysia DS real estate; Thailand DS real estate; Philippines DS real estate; and Vietnam DS real estate.

Cross-border sovereign linkages

- Non-ASEAN+3: U.S. benchmark 10-year DS government index; and U.K. benchmark 10-year DS government index.

- ASEAN+3: China benchmark 10-year DS government index; Japan benchmark 10-year DS government index; Korea benchmark 10-year DS government index; Hong Kong treasury 10+ year bond index; Singapore 10-year DS government index; Malaysia IBOXX ABF 10-15 index; Thailand 10-year DS government index; Indonesia 10-year DS government index; Philippines FTSE treasury 10+ year index; and Vietnam RF government 10-year index.

VI. Cross-border, Cross-sector and Interbank Contagion Analysis

This section assesses interconnectedness and contagion risks using daily market and financial asset price data, following the Diebold and Yilmaz (2012, 2014) methodology. While

Section III analyzed direct cross-border credit and funding risks using bank exposure data, this section's interconnectedness measure also captures indirect links, including investor perceptions and market-based linkages. This interconnectedness metric reflects direct ties (such as funding links), common exposures (to shared assets or risks), and behavioral factors like herding.[6] It utilizes forecast error variance decomposition of daily price returns, which Diebold and Yilmaz (2014) demonstrated as weighted directed networks measuring both vulnerability to systemic shocks and contributions to systemic risks.

This section examines:
- inward spillovers to the ASEAN+3 financial systems;
- outward spillovers from ASEAN+3; and
- cross-border connectivity in ASEAN+3 banking and insurance sectors.

Inward spillovers into an ASEAN+3 economy are measured by the percentage of price return variability in that economy attributable to shocks from global factors or the equity returns of advanced economies, emerging market economies, or other ASEAN+3 economies. If equity returns in an ASEAN+3 economy are not affected by shocks to a particular global factor, the spillover from that global factor to that ASEAN+3 economy is deemed to be zero. Likewise, outward spillovers from the ASEAN+3 are measured by the proportion of the variation in global factors and equity returns in other economies explained by shocks originating from ASEAN+3 equity returns. Cross-border banking and insurance connectivity, as well as domestic cross-sector spillovers, are defined analogously.

Inward Spillovers to ASEAN+3

Spillovers to ASEAN+3 are decomposed into several channels:

- global factors (such as the VIX, energy prices, metal prices, agricultural price index, U.S. dollar foreign exchange rate, and macroeconomic risk);

- advanced economies (non-ASEAN+3) spillover channels;

- emerging market economies (non-ASEAN+3) channels; and

- intra-ASEAN+3 spillovers.

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[6] The growing interconnectedness of ASEAN+3 economies and developed markets can also be partly attributed to the significant representation of these economies in major global equity and fixed income indices, which underpin passive investment vehicles such as exchange-traded funds (ETFs). These products have attracted substantial capital flows due to their efficiency and cost-effectiveness in providing market access. However, they have also introduced dynamics that amplify equity market correlations during periods of stress. For instance, large outflows from ETFs can trigger demand shocks that simultaneously affect equities in both developed and emerging markets.

Another factor driving interconnectedness is the increasing prevalence of factor investing, where systematic strategies employed by hedge funds seek to capture specific risk premiums. One prominent example is momentum-based strategies, which adjust position sizes according to the direction and intensity of asset price trends. During market sell-offs, such strategies can exacerbate downward pressure on equity prices across correlated markets, deepening declines and reinforcing financial linkages across regions.

Table 2

Summary Statistics: Global Factors and Percent Equity Market Returns, January 3, 2005 -- May 31, 2024

	VIX (z)	Energy	Industrial Metals	Precious Metals	Agriculture	US NEER	Short-term Macroeconomic Risk (z)	Long-term Macroeconomic Risk (z)
Mean	0.000	0.034	0.024	0.039	0.024	0.005	0.000	0.000
Median	-0.275	0.022	0.000	0.015	0.000	0.000	-0.113	-0.090
Maximum	6.661	22.095	7.871	9.154	7.416	1.724	2.573	2.228
Minimum	-1.207	-27.860	-7.428	-9.612	-7.351	-2.248	-2.233	-2.470
Standard deviation	1.000	2.202	1.398	1.164	1.268	0.311	1.000	1.000
Skewness	1.872	-0.275	-0.064	-0.291	-0.025	-0.008	0.309	0.310
Kurtosis	5.104	14.253	2.652	5.519	2.473	3.994	-0.659	-0.880

	North America	United Kingdom	Europe	Latin America	Gulf Cooperation Council	China	Japan	Korea
Mean	0.035	0.017	0.018	0.023	0.011	0.025	0.024	0.028
Median	0.049	0.024	0.050	0.051	0.019	0.000	0.000	0.003
Maximum	10.730	9.266	9.931	12.391	5.819	9.462	13.079	12.061
Minimum	-11.993	-10.480	-12.427	-12.909	-8.038	-8.886	-9.378	-10.455
Standard deviation	1.177	1.079	1.268	1.459	0.860	1.468	1.234	1.222
Skewness	-0.410	-0.265	-0.331	-0.611	-0.687	-0.361	-0.223	-0.128
Kurtosis	12.995	9.941	8.812	8.798	9.543	5.273	8.204	8.119

	Hong Kong	Singapore	Malaysia	Thailand	Indonesia	Philippines
Mean	0.018	0.013	0.014	0.022	0.044	0.031
Median	0.003	0.024	0.000	0.000	0.009	0.000
Maximum	11.173	7.973	6.243	12.457	12.914	8.536
Minimum	-10.933	-7.634	-9.290	-16.307	-10.967	-12.437
Standard deviation	1.354	0.908	0.672	1.231	1.283	1.080
Skewness	0.082	-0.316	-0.849	-0.683	-0.199	-0.855
Kurtosis	6.612	9.669	13.860	17.456	9.646	10.597

Global factors have significant spillover effects on ASEAN+3 financial systems. Japan and Korea, the regional financial centers of Hong Kong and Singapore, and Malaysia and the Philippines are most exposed to global factors such as the VIX, macroeconomic risk, commodity prices, and the U.S. dollar exchange rate. Figure 7 shows that among these global factors, the VIX and macroeconomic risk have the most prominent impact on ASEAN+3 equity price returns. For example, 6.3 percent of the variation in total equity returns in Japan's stock market is attributable to shocks in the VIX.

Figure 7. Selected ASEAN+3 Economies: Top Spillovers from Global Factors
(percent)
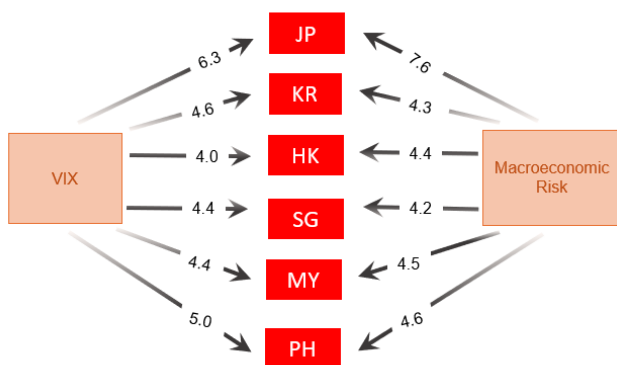
Source: AMRO staff calculations.
Note: The numbers associated with the directional arrows reflect how important a spillover transmission channel is, as calculated using the approach of Diebold and Yilmaz (2012, 2014). These numbers represent the percentage movement of equity returns in each ASEAN+3 economy that is explained by a shock from a global factor. JP = Japan; KR = Korea; HK = Hong Kong; SG = Singapore; MY = Malaysia; PH = the Philippines.

Figure 8. Selected ASEAN+3 Economies: Top Spillovers from Non-ASEAN+3 Advanced Economies
(percent)
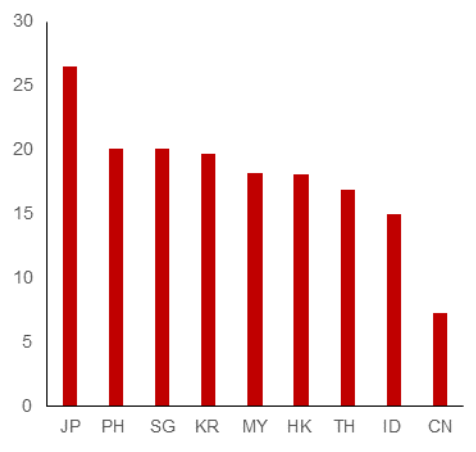
Source: AMRO staff calculations.
Note: The height of the bars reflects how important a spillover transmission channel is, as calculated using the approach of Diebold and Yilmaz (2012, 2014). The figures represent the percentage of total equity return variability in each ASEAN+3 economy that is explained by a shock from advanced economies outside the ASEAN+3 region. JP = Japan; PH = the Philippines; SG = Singapore; KR = Korea; MY = Malaysia; HK = Hong Kong; TH = Thailand; ID = Indonesia; CN = China.

The financial markets of developed economies (North America, the U.K., and Europe) have strong contagion effects on ASEAN+3 markets, as indicated by the percentage variation in ASEAN+3 stock market returns attributable to shocks in the stock market returns of these developed economies. All ASEAN+3 economies have significant links to financial systems in developed economies, with equity returns in Hong Kong, Japan, Korea, Malaysia, the Philippines, and Singapore particularly sensitive to shocks from developed markets (Figure 8). The impact of developed economies on ASEAN+3 is significantly stronger compared to the moderate spillover effects from emerging market economies outside the region (such as Latin American and GCC economies).

ASEAN+3 intraregional spillovers are significant, however. Regional financial centers Hong Kong and Singapore play key roles in intermediating finance within and into the region. Consequently, spillovers involving these centers are central to regional dynamics. Hong Kong, serving as a gateway to China, has the strongest bilateral links with China (Figure 9). The second strongest links are between Hong Kong and Singapore. Significant bilateral links also exist between Hong Kong and Korea, Singapore and Korea, and between Singapore and other regional economies such as Indonesia, Malaysia, and Thailand. Korea is the third major hub of financial connectivity in the region after Hong Kong and Singapore. Japan and the Philippines have the least exposure to financial spillovers from other ASEAN+3 economies, as they are more exposed to advanced economies (Figure 10).

These spillover effects are further detailed in Table 3, which presents the complete spillover table for global factors and economies, both within and outside ASEAN+3.

Figure 9. Selected ASEAN+3: Intraregional Spillovers
(percent)
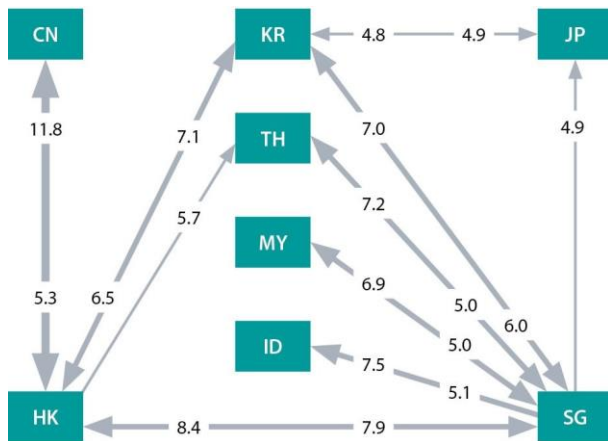
Source: AMRO staff calculations.
Note: The sizes of the directional arrows reflect the relative importance of the spillover transmission channel, as calculated using the approach of Diebold and Yilmaz (2012, 2014). The numbers displayed on the arrows represent the percentage of total equity return variability in each ASEAN+3 economy that is explained by a shock from another ASEAN+3 economy. CN = China; HK = Hong Kong; JP = Japan; KR = Korea; MY = Malaysia; SG = Singapore; TH = Thailand; ID = Indonesia.

Figure 10. Selected ASEAN+3: Inward Spillovers by Channel
(percent)
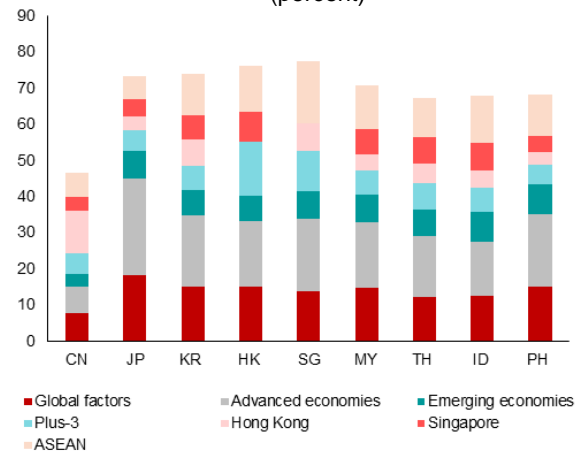
Source: AMRO staff calculations.
Note: The numbers reflect the relative importance of the spillover transmission channel, as calculated using the approach of Diebold and Yilmaz (2012, 2014). The figures represent the percentage of total equity return variability in each ASEAN+3 economy that is explained by a shock from a spillover source. CN = China; JP = Japan; KR = Korea; HK = Hong Kong; SG = Singapore; MY = Malaysia; TH = Thailand; ID = Indonesia; PH = the Philippines.

In summary, among ASEAN+3 economies, the regional financial centers (Hong Kong and Singapore) and the more developed and open financial markets of Korea, Japan, and Malaysia experience the most inward spillovers, while China remains the least affected (Figure 10).

- Global and advanced economy factors remain significant sources of spillovers, particularly for the regional financial centers, Japan, Korea, Malaysia, and the Philippines. China receives most of its inward spillovers not directly from advanced economies but through Hong Kong, which also receives significant spillovers from China.

- Among the global factor spillovers, Japan, Korea, the regional financial centers, and Malaysia and the Philippines are most affected by VIX and macroeconomic risk indicators (Figure 7).

Outward Spillovers from ASEAN+3

Individual ASEAN+3 economies not only receive inward spillovers from global factors, non-ASEAN+3 advanced and emerging market economies, and other ASEAN+3 economies, but also serve as significant sources of outside spillovers. Among the regional economies, Hong Kong and Singapore generate the most outward spillovers overall, affecting global factors, non-ASEAN+3 economies, and other ASEAN+3 economies. This is not surprising since the two are international financial hubs and Hong Kong's stock exchange ranked fifth-largest globally in terms of market capitalization at the end of 2020. Given more than 80 percent of Hong Kong's market capitalization is tied to China-related companies (IMF 2021b), a substantial portion of these outward spillovers can be attributed to them.

Figure 11. Selected ASEAN+3 and Regions: Financial Markets' Interconnectedness
(percent for both scales)
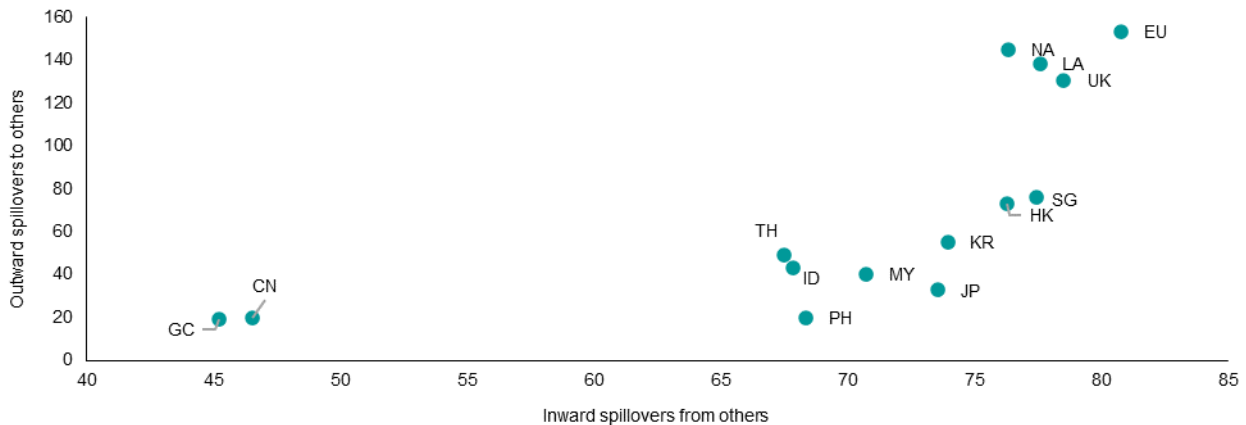
Source: AMRO staff calculations.
Note: The numbers reflect the size of outward spillovers (total spillovers given to global factors and other economies) and inward spillovers (total spillovers received from global factors and other economies) using the approach of Diebold and Yilmaz (2012, 2014). NA = North America, LA = Latin America, EU = Europe, UK = United Kingdom, GC = Gulf Cooperation Council, CN = China, JP = Japan, KR = Korea, HK = Hong Kong, SG = Singapore, MY = Malaysia, ID = Indonesia, PH = the Philippines; TH = Thailand.

Figure 11 shows that significant outward spillovers originate from within the region, particularly from the regional financial centers (Hong Kong and Singapore), Korea, and Thailand. Hong Kong exerts a significant impact on industrial metals commodity prices while both regional financial centers also exert notable influence on macroeconomic risk. For example, shocks to Hong Kong's equity returns account for 2.4 percent of the movements in industrial metal prices (Figure 12). Additionally, Singapore exerts some influence on the VIX. Meanwhile, the greatest influence on developed economies from ASEAN+3 originates from the two regional financial centers, Japan, Korea, and Thailand. For instance, shocks to Singapore's equity returns explain 4.1 percent of the variation in the U.K.'s equity returns (Figure 13). Most of the ASEAN+3 effects on emerging markets also stem from Hong Kong, Singapore, and Thailand.

By dynamically mapping spillovers over time, two general patterns emerge. Contagion and spillovers tend to escalate during periods of financial instability or stringent financial conditions. For instance, beginning from the relatively tranquil phase of 2005, the total spillover index surged during the Fed tightening in Q2 and Q3 of 2006, and again during the GFC, the European debt crisis, and the COVID-19 pandemic (Figure 14). Additionally, net spillovers from ASEAN+3—calculated as the difference between spillovers originating from ASEAN+3 and those directed towards it—have shown a tendency to increase relative to external factors, particularly evident in the trends following the GFC and the European debt crisis (Figure 15). The details of the rolling dynamic spillover analysis for each global factor and economy are further elaborated on in the Appendices – Appendix 1 presents dynamic rolling spillovers **to** others, Appendix 2 presents rolling dynamic spillovers **from** others, while **net** spillovers are detailed in Appendix 3.

Table 3

Interconnectedness Table: Global Factors and Percent Equity Market Returns, January 3, 2005 -- May 31, 2024

To \ From	VIX	ENER	INMET	PREMET	AGRI	USNEER	MA-ST	MA-LT	NA	UK	ER	LA	GC	CN	JP	KR	HK	SG	MY	TH	ID	PH	Contribution from others
VIX	30.3	2.2	1.8	0.3	0.9	2.3	5.9	6.0	13.5	9.1	9.6	6.7	1.2	0.1	1.2	1.4	1.3	2.1	0.9	2.0	0.9	0.6	69.7
ENER	3.6	45.2	5.9	2.1	4.6	3.7	2.3	1.7	5.3	5.0	5.3	6.1	1.7	0.4	0.7	0.9	1.3	1.2	0.6	1.5	0.7	0.2	54.8
INDMET	2.6	4.8	37.1	4.6	3.6	6.8	2.1	1.7	4.7	6.3	8.1	6.5	0.4	0.9	0.7	1.9	2.4	1.9	0.9	1.1	0.9	0.2	62.9
PRECMET	0.6	3.1	7.9	64.1	3.6	11.5	0.0	0.1	0.8	0.5	2.9	2.8	0.1	0.2	0.1	0.3	0.4	0.2	0.2	0.3	0.5	0.1	35.9
AGRI	1.6	6.2	5.8	3.2	59.1	4.0	1.3	1.0	2.6	2.8	3.8	4.7	0.3	0.3	0.3	0.4	0.6	0.6	0.4	0.9	0.3	0.1	40.9
USNEER	3.3	2.8	6.0	6.0	2.3	32.4	1.8	1.5	5.8	4.6	13.9	10.5	0.5	0.4	0.2	1.5	2.0	1.1	0.6	1.3	1.1	0.2	67.6
MACROST	7.5	1.9	2.3	0.0	0.7	3.0	25.4	18.4	9.7	7.1	8.5	6.8	0.4	0.4	0.8	1.3	1.7	1.7	0.7	1.2	0.5	0.2	74.6
MACROLT	7.6	1.4	1.8	0.0	0.4	2.5	20.4	29.1	8.7	6.6	7.7	6.1	0.3	0.4	0.8	1.2	1.4	1.5	0.7	1.0	0.4	0.2	70.9
NA	11.8	2.8	2.6	0.2	1.0	3.0	5.3	4.8	23.7	10.1	10.6	10.3	1.0	0.4	1.5	1.9	2.0	2.5	0.9	2.1	1.1	0.5	76.3
UK	5.9	2.4	3.6	0.2	1.0	2.9	4.1	3.7	10.3	21.5	15.7	9.2	1.1	0.6	1.8	2.5	3.0	4.1	1.6	2.8	1.6	0.6	78.5
ER	5.9	2.3	4.2	0.9	1.2	8.1	3.9	3.4	9.9	14.1	19.2	9.6	0.9	0.6	1.5	2.4	2.8	3.2	1.4	2.6	1.6	0.4	80.8
LA	5.4	3.1	3.9	1.0	1.8	6.8	3.6	3.1	10.1	9.4	10.9	22.4	1.2	0.7	1.3	2.4	3.0	3.2	1.6	2.7	2.0	0.8	77.6
GC	3.1	2.9	1.1	0.3	0.7	1.7	3.6	3.1	5.0	4.3	4.4	4.8	54.8	0.8	1.7	1.2	2.3	2.5	1.6	2.0	2.0	0.8	45.2
CN	1.5	0.7	1.7	0.2	0.4	1.0	3.9	3.5	2.5	2.3	2.5	2.8	0.8	53.5	2.0	3.7	11.8	3.9	2.1	1.8	1.9	0.8	46.5
JP	6.3	1.5	1.7	0.0	0.6	0.8	4.1	3.5	10.6	8.2	7.7	6.5	1.2	1.0	26.5	4.9	3.7	4.9	1.6	2.2	1.7	1.0	73.6
KR	4.6	1.1	2.1	0.3	0.5	2.2	2.3	2.0	7.0	6.1	6.6	6.5	0.7	1.9	4.8	26.1	7.1	7.0	3.3	3.1	3.2	1.6	73.9
HK	4.0	1.1	2.2	0.5	0.6	2.4	2.4	2.0	6.4	5.6	6.1	6.0	1.1	5.3	3.1	6.5	23.7	8.4	3.4	4.1	3.6	1.6	76.3
SG	4.4	1.2	1.6	0.3	0.6	1.6	2.3	1.9	7.1	6.7	6.3	6.3	1.2	1.7	3.4	6.0	7.9	22.6	5.0	5.0	5.1	1.8	77.4
MY	4.4	1.4	1.5	0.5	0.7	1.8	2.4	2.1	6.4	5.8	6.0	6.4	1.2	1.2	1.8	3.8	4.5	6.9	29.3	4.1	4.9	3.0	70.7
TH	3.5	1.5	1.3	0.3	0.7	1.9	1.7	1.3	5.6	5.5	5.8	6.0	1.5	1.2	2.1	3.8	5.7	7.2	4.1	32.5	4.7	2.1	67.5
ID	3.5	1.1	1.4	0.6	0.5	2.4	1.6	1.4	5.4	4.6	5.0	6.7	1.6	1.0	1.7	3.9	4.8	7.5	4.9	4.8	32.2	3.3	67.8
PH	5.0	1.2	1.6	0.4	0.6	1.9	2.4	2.2	7.8	6.2	6.1	7.3	1.0	0.6	1.6	3.2	3.3	4.6	3.9	3.2	4.5	31.7	68.4
Contribution to others	96.0	46.4	62.1	21.8	26.9	72.6	72.3	63.6	144.8	130.6	153.4	138.5	19.3	19.9	32.8	55.0	72.9	76.3	40.1	49.4	43.1	19.9	66.3
Contribution including own	126.3	91.6	99.2	86.0	86.0	105.0	97.7	92.6	168.5	152.1	172.6	161.0	74.1	73.4	59.2	81.1	96.6	98.8	69.4	81.9	75.3	51.6	2200.0

Figure 12. Selected ASEAN+3: Top Spillovers to Global Factors
(percent)
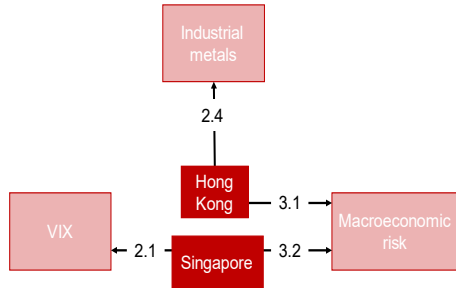
Source: AMRO staff calculations.
Note: The numbers displayed in the directional arrows represent the percentage of the movement in the global factor that is explained by a shock from an ASEAN+3 equity return, as calculated using the approach of Diebold and Yilmaz (2012, 2014). VIX = CBOE Volatility Index.

Figure 13. Selected ASEAN+3: Top Spillovers to Non-ASEAN+3 Economies
(percent)
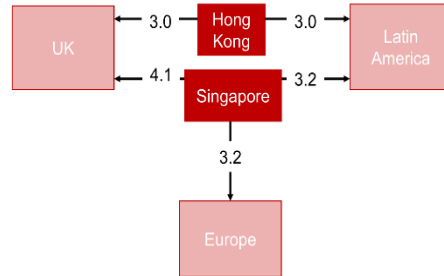
Source: AMRO staff calculations.
Note: The numbers displayed in the directional arrows represent the percentage of the movement in the equity returns of the non-ASEAN+3 region that is explained by a shock from an ASEAN+3 equity return, as calculated using the approach of Diebold and Yilmaz (2012, 2014). U.K. = United Kingdom.

Figure 14. Rolling Total Spillovers
(percent)

Source: AMRO staff calculations.
Note: The numbers represent the rolling total spillovers, as calculated using the approach of Diebold and Yilmaz (2012, 2014).

Figure 15. Rolling Net Spillovers
(percent)
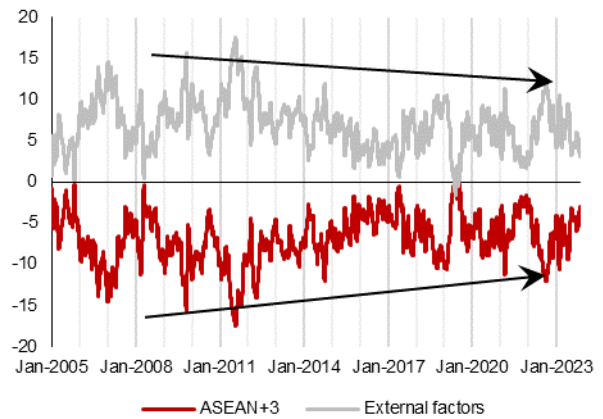
Source: AMRO staff calculations.
Note: The numbers represent the rolling net spillovers, as calculated using the approach of Diebold and Yilmaz (2012, 2014).

Cross-border Sectoral Spillovers

This subsection analyzes cross-border connectivity in the ASEAN+3 banking, insurance, real estate, and sovereign sectors. For each sector, a VAR of sector-specific equity returns for each economy was performed, and connectivity was calculated using the Diebold-Yilmaz (2014) methodology. For example, to measure banking sector connectivity, a VAR of banking stock equity returns from North America, the U.K., Europe, and various ASEAN+3 economies was conducted. Connectivity between these economies' banking systems was calculated by summing the total spillovers shared between these sectors. The intensity of the total spillovers between two economies is ranked from highest to lowest, with the top third indicating high connectivity, the middle third moderate connectivity, and the bottom third low connectivity. The results are now summarized.

The banking systems of advanced economies continue to have strong impacts on ASEAN+3 banks. All ASEAN+3 banking systems, except China's and Vietnam's, are either highly or moderately connected to banks in North America, the U.K., or Europe.

- Japanese and Korean banks, and the regional financial center (Hong Kong and Singapore) banks are particularly highly connected to banks in North America, the U.K., and Europe.

- Malaysian, Thai and Indonesian banks also have strong connections with European banks.

- Hong Kong banks are well connected with Singaporean and Thai banks and moderately connected with Malaysian and Indonesian banks. Singaporean banks, meanwhile, are also highly connected with Indonesian, Malaysian, and Thai banks and moderately connected to Philippine banks. Notably, Malaysian banks are highly connected to banks in Indonesia, and Thailand, and moderately connected to banks in the Philippines, making them important for ASEAN banking spillovers.

- Chinese banks have moderate connectivity with banks in Hong Kong and Singapore, and low connectivity with the rest, while Vietnamese banks have low connectivity with banks in other economies (Figure 16).

Figure 16. Selected ASEAN+3 and Regions: Bank-to-bank Connectivity
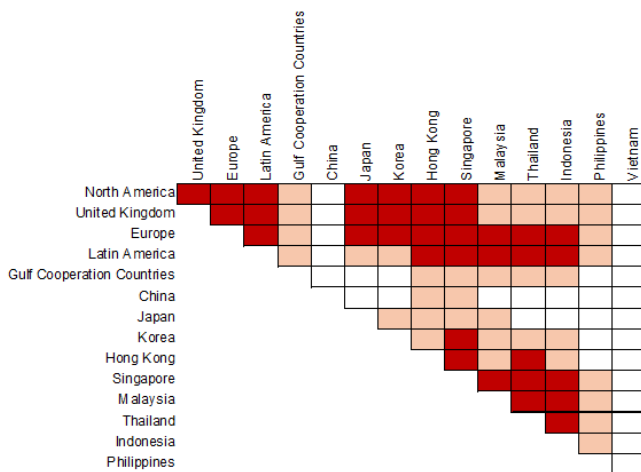
Source: AMRO staff calculations.
Note: The chart depicts the intensity of total (both to and from) implicit financial linkages among the banking sectors of various economies. The colors represent the strength of the linkages, measured in quantiles: white indicates the bottom third of all linkages, pink signifies the middle third, and red denotes the top third.

Figure 17. Selected ASEAN+3 and Regions: Insurer-to-insurer Connectivity
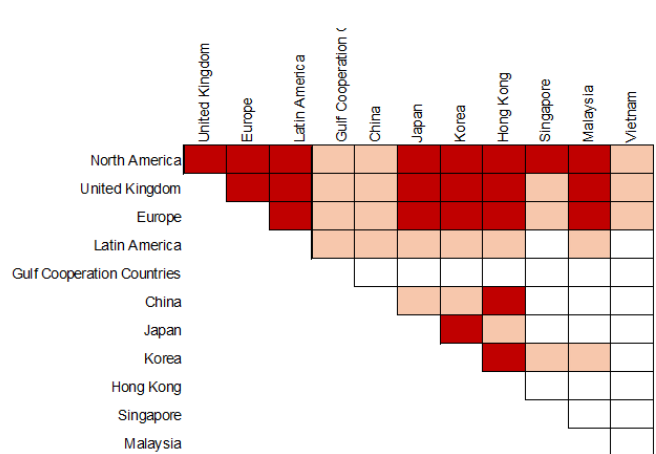
Source: AMRO staff calculations.
Note: The chart depicts the intensity of total (both to and from) implicit financial linkages among the insurance sectors of various economies. The colors represent the strength of the linkages, measured in quantiles: white indicates the bottom third of all linkages, pink signifies the middle third, and red denotes the top third.

Figure 18. Selected ASEAN+3 and Regions: Real-estate-to-real-estate Connectivity
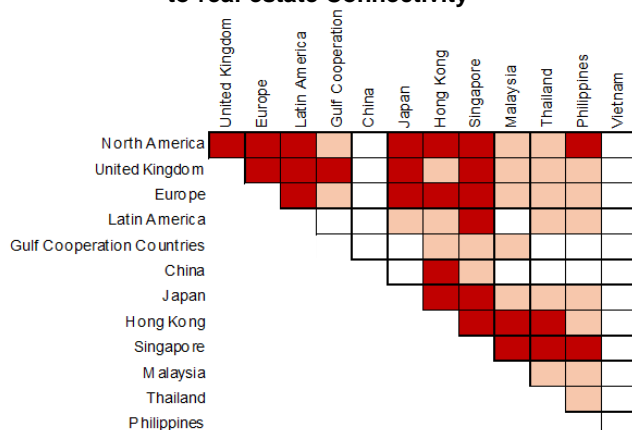
Source: AMRO staff calculations.
Note: The chart depicts the intensity of total (both to and from) implicit financial linkages among the real estate sectors of various economies. The colors represent the strength of the linkages, measured in quantiles: white indicates the bottom third of all linkages, pink signifies the middle third, and red denotes the top third.

Figure 19. Selected ASEAN+3 and Regions: Sovereign-to-sovereign Connectivity
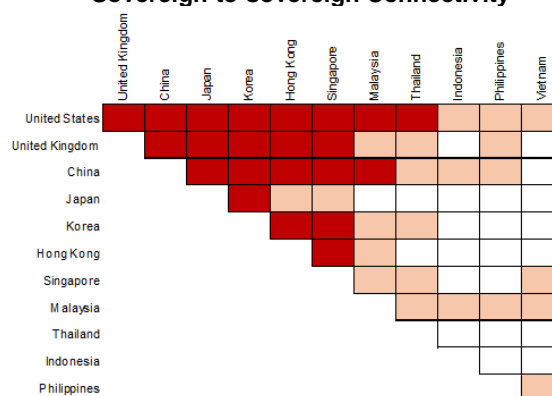
Source: AMRO staff calculations.
Note: The chart depicts the intensity of total (both to and from) implicit financial linkages among government bond indices of various economies. The colors represent the strength of the linkages, measured in quantiles: white indicates the bottom third of all linkages, pink signifies the middle third, and red denotes the top third.

ASEAN+3 insurers are highly or moderately connected to insurers in North America, the U.K., and Europe. The connections between insurers in China and Hong Kong, as well as those between Korea and Japan, and Hong Kong and Korea, are also robust (Figure 17).

Similarly, interconnections between the real estate sectors of advanced economies (North America, the U.K., and Europe) and those of ASEAN+3 economies are significant, except for China and Vietnam. Interconnections between advanced economies and ASEAN+3 are particularly high for Japan and Singapore. China and Vietnam's real estate sectors generally have low connectivity with others, except that China has strong interconnections with Hong Kong and moderate interconnections with Singapore (Figure 18).

Finally, strong and moderate connections between advanced economies and ASEAN+3 are also present for sovereign bonds. These connections are especially strong for Japan, Korea, and the two regional financial centers, and more moderate for other ASEAN countries. Hong Kong is also highly connected with Singapore and Korea. Additionally, Singapore has substantial connections with Korea and China (Figure 19).

VII.   Risk Scenarios Impact Analysis

This section examines how various risk scenarios can potentially affect ASEAN+3 financial systems. Using impulse response functions, [7] it simulates the impact on ASEAN+3 of: (a) shocks to the banking sector in North America, Singapore, and elsewhere; (b) U.S. dollar FX rate appreciation; (c) shocks to industrial metal commodities; and (d) the influence of China's real estate sector on other sectors of its domestic economy and on the real estate sectors of other ASEAN+3 economies. Key findings are:

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[7] The details of the methodology are explained in Section V. This includes the different VAR specifications for the various risk scenarios described below, with corresponding impulse responses summarized in the text.

- Banking sector shocks: Shocks to the banking sector in North America, U.K., and developed Europe remain significant contagion risks for ASEAN+3 regional banks. Although banking systems in the regional financial centers have also become systemically important within the region, North American banks are particularly important for banks in Hong Kong, Japan, and Korea (Figure 20). To ensure robustness, Appendix 4 examines the impact of the 2023 U.S. banking turmoil on the financial services industries of ASEAN+3 economies using an input-output approach. Meanwhile, Singaporean banks have the greatest impact on banks in Hong Kong, Indonesia, Korea, and Thailand (Figure 21).

Figure 20. Selected ASEAN+3: Impact of Shock to North American Banks
(percent)
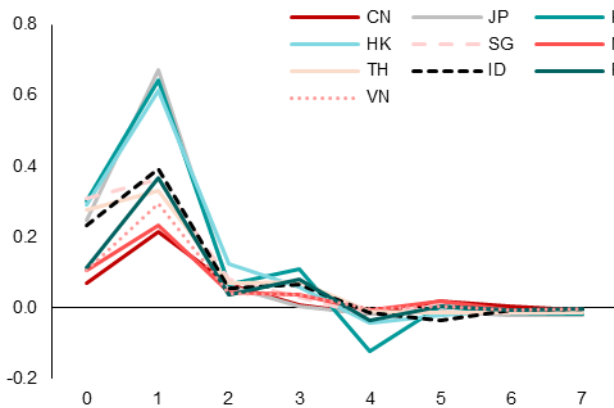
Source: AMRO staff calculations.
Note: The figure depicts generalized impulse responses of ASEAN+3 banking systems to a 1 standard deviation shock to North American banks, using daily data. CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN= Vietnam.

Figure 21. Selected ASEAN+3: Impact of Shock to Singaporean Banks
(percent)
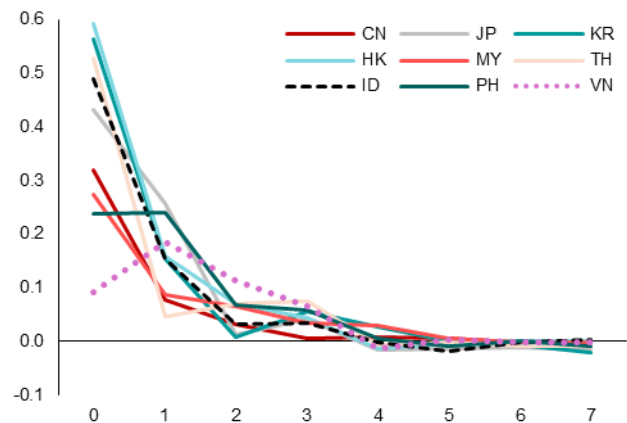
Source: AMRO staff calculations.
Note: The figure depicts generalized impulse responses of ASEAN+3 banking systems to a 1 standard deviation shock to SG banks, using daily data. CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; TH = Thailand; VN= Vietnam.

- U.S. dollar shock: ASEAN+3 financial systems are highly susceptible to U.S. dollar movements. Hong Kong is most affected by U.S. dollar foreign exchange fluctuations due to the Hong Kong dollar's official peg to the U.S. dollar. This link makes Hong Kong's open financial system vulnerable to capital outflows when the U.S. dollar appreciates (Figure 22). U.S. dollar appreciation also negatively affects other ASEAN+3 stock markets. On a positive note, stock markets in Hong Kong and other ASEAN+3 economies are expected to benefit from anticipated U.S. rate cuts in the coming quarters.

- Commodity shocks: Among ASEAN+3 stock markets, China, Hong Kong, and Korea are most impacted by developments in industrial metals. Metals are vital to the global economy as they are essential intermediate inputs for industrial production and construction. Metal production and consumption are concentrated in a few countries, with China being a major hub for both. Consequently, China and Hong Kong are the ASEAN+3 financial systems significantly influenced by metal prices (Figure 23), making metal price changes a particularly important global spillover to these economies. Major producers in Latin America and consumers of industrial metals in North America, U.K. and Europe are also significantly affected by metal prices. Looking ahead, developments in rare earth metals are worth monitoring, as they

could become crucial for supply chains in the U.S., China, and other economies aiming to lead in high-technology sectors.

Figure 22. Selected ASEAN+3: Impact of U.S. Foreign Exchange Depreciation
(percent)
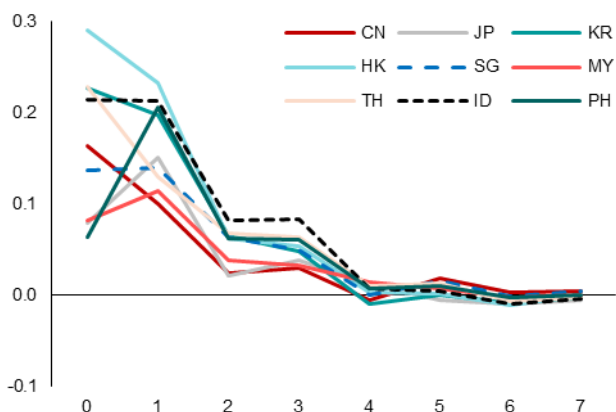
Source: AMRO staff calculations.
Note: The figure depicts generalized impulse responses to a 1 standard deviation U.S. nominal effective exchange rate (NEER) depreciation, using daily data. CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN= Vietnam.

Figure 23. Selected ASEAN+3 and Regions: Impact of Industrial Metals
(percent)
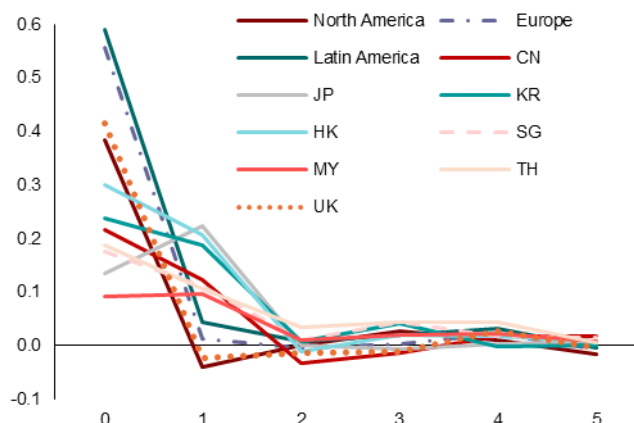
Source: AMRO staff calculations.
Note: The figure depicts generalized impulse responses to a 1 standard deviation shock to industrial metals, using daily data. CN = China; HK = Hong Kong; JP = Japan; KR = Korea; MY = Malaysia; SG = Singapore; TH = Thailand; VN= Vietnam.

Figure 24. China: Domestic Sectoral Impact of China Real Estate
(percent)
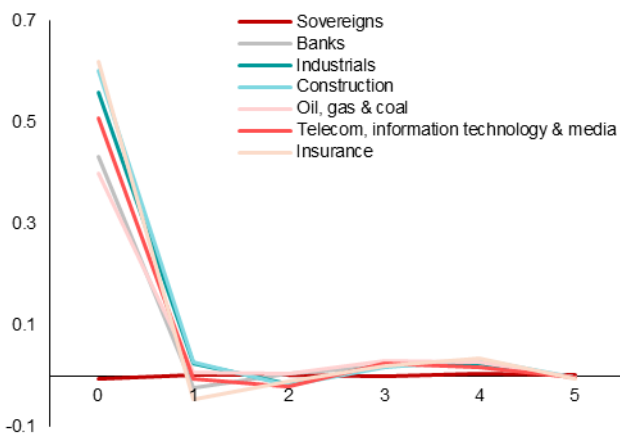
Source: AMRO staff calculations.
Note: The figure depicts generalized impulse responses to a 1 percent shock to CN real estate stock return, using daily data.

Figure 25. Selected ASEAN+3: Impact of China Real Estate
(percent)
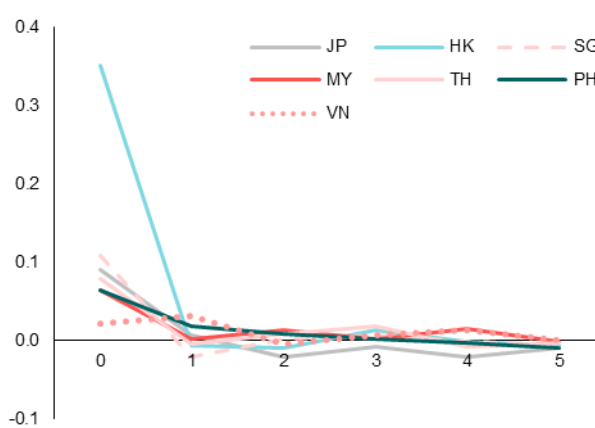
Source: AMRO staff calculations.
Note: The figure depicts generalized impulse responses to a 1 percent shock to CN real estate stock return, using daily data. HK = Hong Kong; JP = Japan; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

- China real estate shocks: Shocks to China's real estate sector have a significant impact on other sectors within China but the impact is short-lived. The shocks do not greatly affect other ASEAN+3 real estate sectors, except for Hong Kong. A 1 percent decrease in China's real estate stock returns would reduce stock returns in the construction, insurance, and industrial sectors by 0.6 percent; the

telecommunications, information technology, and media sectors by 0.5 percent; and the banking, oil, gas, and coal sectors by 0.4 percent (Figure 24). Additionally, it would decrease Hong Kong's real estate sector stock returns by 0.3 percent, but have a minimal effect on the real estate sectors of other ASEAN+3 economies (Figure 25).

VIII. Findings and Policy Implications

ASEAN+3 financial systems remain vulnerable to shocks from global factors and external economies. Despite growing interdependence among ASEAN+3 economies and the roles played by Singapore and Hong Kong as key financial hubs, macro-financial shocks from major advanced economies and global factors continue to be significant sources of inward spillover risks. The region is susceptible to global shocks—such as the VIX, energy prices, metal prices, the U.S. dollar exchange rate, and macroeconomic risks—as well as systemic financial events from the U.S., U.K., and Europe.

Singapore's and Hong Kong's extensive external connections and cross-border spillovers expose their financial systems to significant risks and make them potential sources of contagion for the region. The two financial hubs are particularly susceptible to global and regional macro-financial shocks. Given the size and connectivity of their financial networks, especially with other ASEAN+3 financial sectors, the impact of such shocks would be transmitted not only to Singapore and Hong Kong but also to financial systems across the region.

ASEAN+3 financial systems have become increasingly interconnected, making robust ASEAN+3-centric surveillance and cooperation essential. By taking a holistic macroeconomic and financial view of the region, authorities can better protect their economies from systemic risks and enhance overall financial resilience. Specifically, ASEAN+3 economies should strengthen:

- Cross-border surveillance and data sharing: Enables authorities to detect emerging risks that may originate in one economy but spread across the region. Sharing information and best practices helps identify vulnerabilities early and facilitate coordinated responses.

- Regional stress testing: Provides insight into how financial shocks in one part of the region might impact other areas. This helps prepare for potential crises by understanding transmission channels and the resilience of financial institutions.

- Home-host supervision: Cooperation between home and host jurisdictions is vital to supervise internationally active banks. Harmonized regulatory frameworks can reduce regulatory arbitrage and enhance financial stability.[8]

- Liquidity support: The interconnected nature of ASEAN+3 financial systems means that a crisis in one ASEAN+3 economy can spread quickly to others. In times of

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[8] While the existing frameworks under the BIS and the International Organization of Securities Commissions (IOSCO) provide a robust foundation for home-host supervision and cooperation, continuous improvement and adaptation are essential to meet the evolving challenges of global finance. Enhancing regulatory cooperation beyond current standards is crucial to prevent regulatory arbitrage, ensure consistent enforcement, address new challenges from fintech and digital currencies, and effectively manage systemic risks.

financial distress, access to liquidity can be crucial, and regional financing arrangements for liquidity support help stabilize financial markets.[9]

Contagion and spillovers can intensify in times of financial instability or tight financial conditions. For instance, the total spillover index surged during the Fed's tightening during Q2 and Q3 of 2006, and again during the GFC, the European debt crisis, and COVID-19. Additionally, net spillovers from ASEAN+3 economies have increased relative to external factors, particularly after the GFC and the European debt crisis.

In conclusion, monitoring the sources and transmission channels of risks from international spillovers is essential. Spillovers from advanced economies—such as the U.S., U.K., and Europe—as well as from financial institutions in these jurisdictions, pose ongoing risks to financial systems in the ASEAN+3 region. Monitoring global financial market volatility and strengthening the supervision of globally systemically important financial institutions are critical. At the same time, ASEAN+3 policymakers must take a holistic macroeconomic and financial view of the region to better protect their economies from systemic risks and enhance financial resilience. This dual approach will help mitigate the adverse effects of external shocks and strengthen financial stability across the ASEAN+3 region.

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[9] In this context, the Chiang Mai Initiative Multilateralisation (CMIM) regional financial arrangement, together with the network of bilateral swap agreements and the IMF's international financing framework, forms a robust architecture of defense against potential financial contagion and spillovers. The regional surveillance arm, AMRO, along with flagship reports like the AFSR, plays a crucial role in cross-border monitoring. Ongoing efforts to refine CMIM facilities, in collaboration with financial architecture partners, will further strengthen the defenses against spillover risks.

Appendix 1. Spillovers: To Others
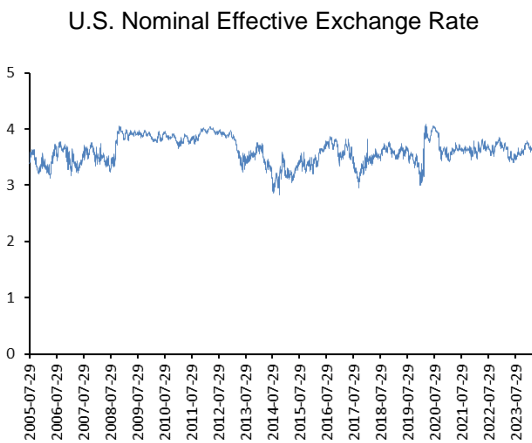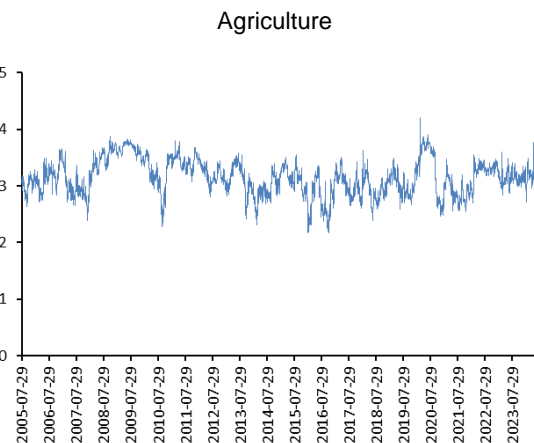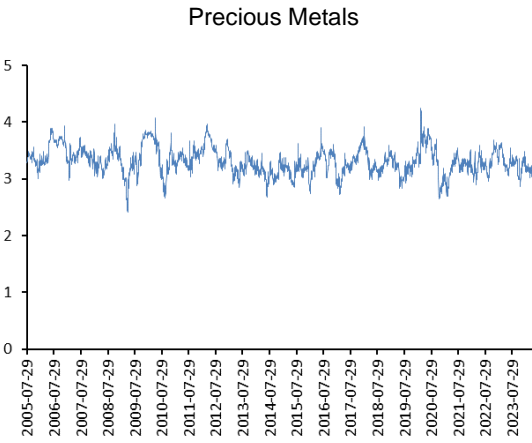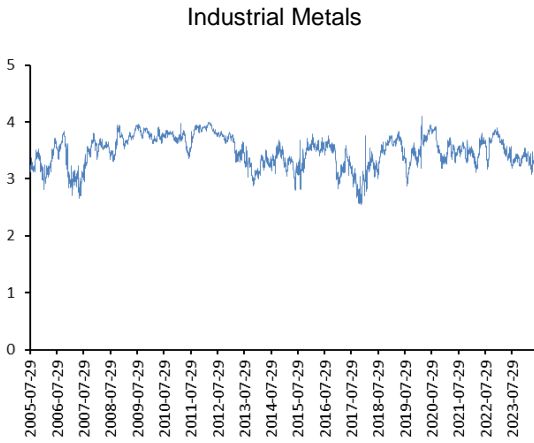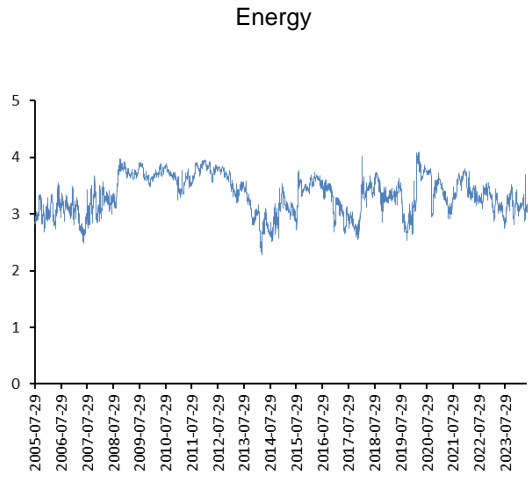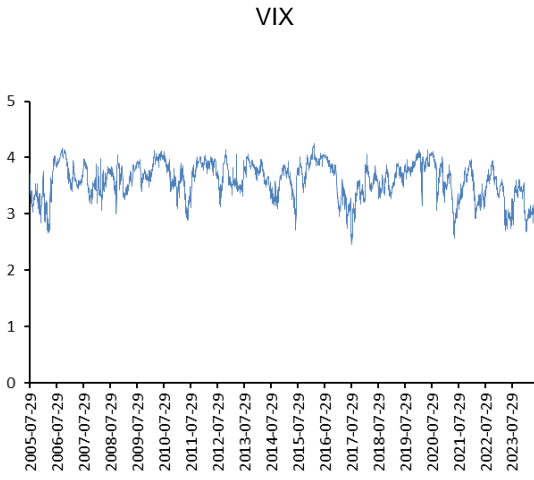
VIX

Energy

Industrial Metals

Precious Metals

Agriculture

U.S. Nominal Effective Exchange Rate
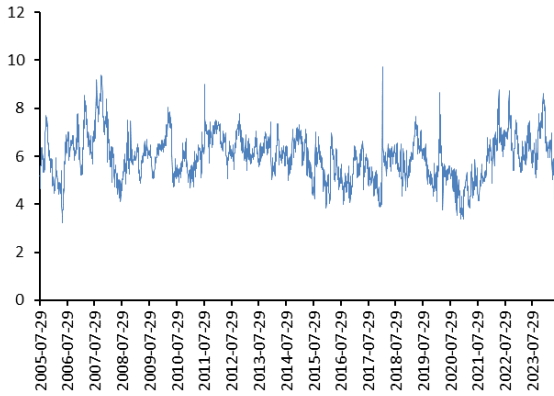
Appendix 1. Spillovers: To Others (continued)

Short-term Macroeconomic Risk
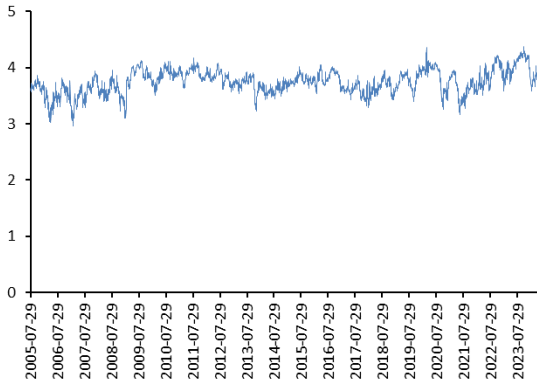
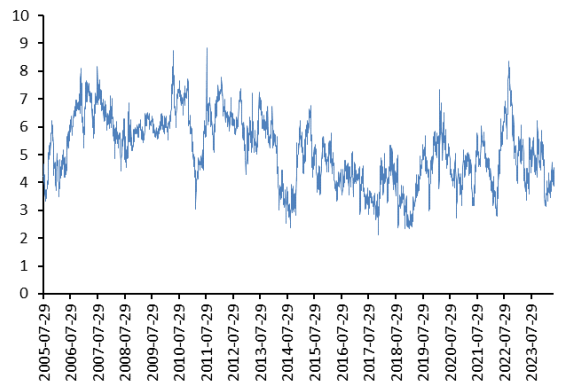## Long-term Macroeconomic Risk
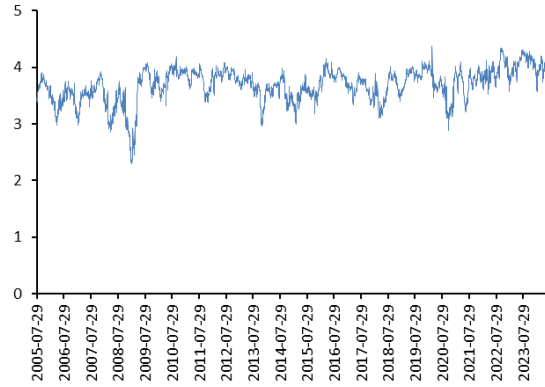
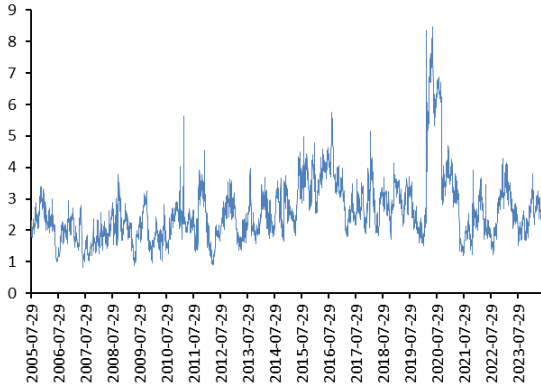

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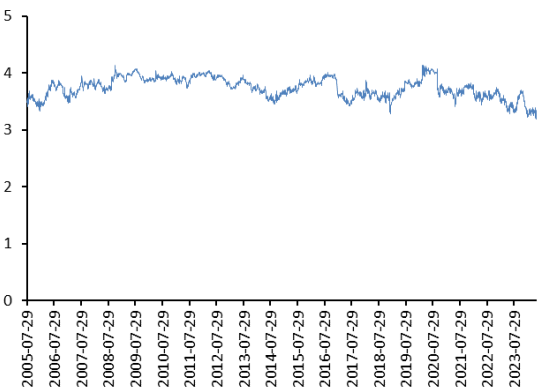
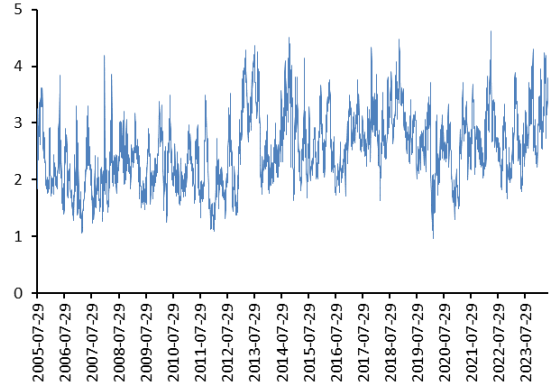## United Kingdom
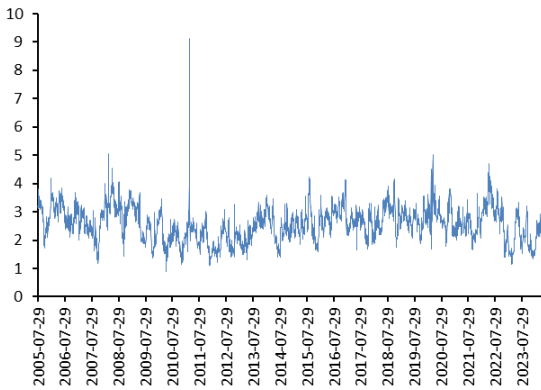

Europe
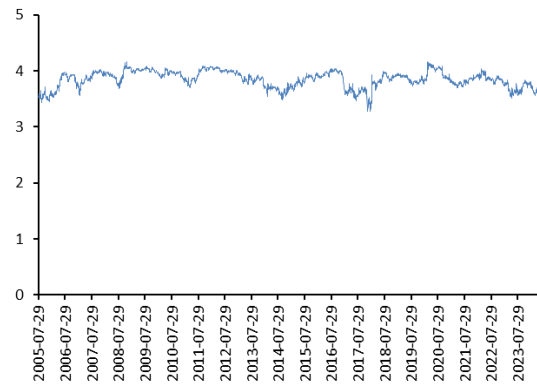
Latin America
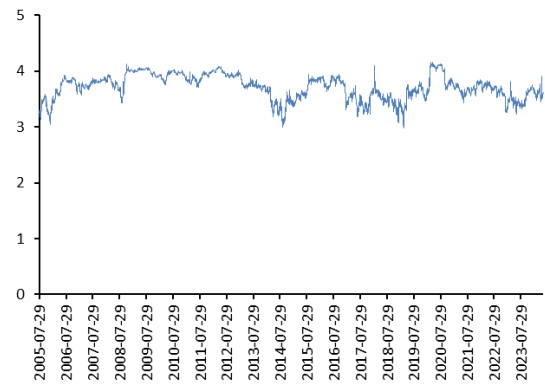
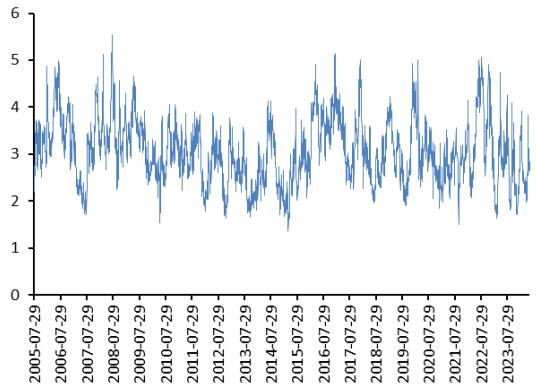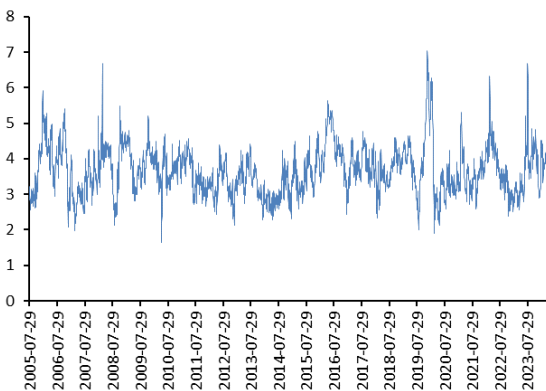## Appendix 1. Spillovers: To Others (continued)
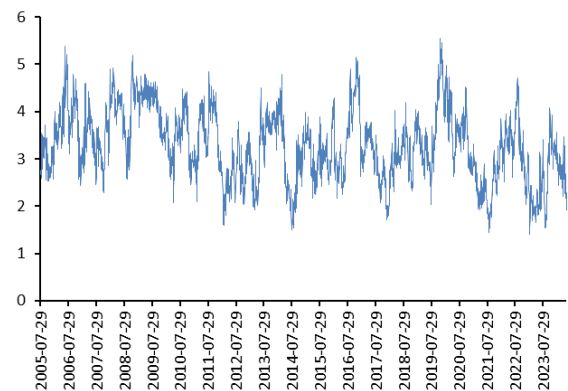
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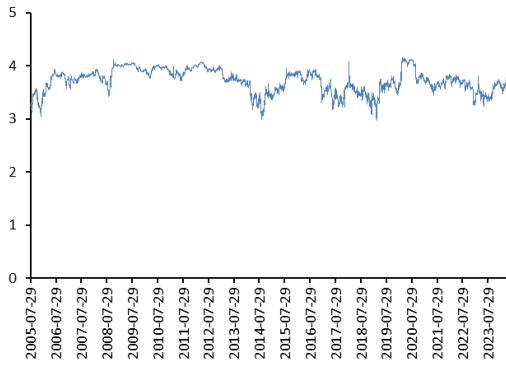
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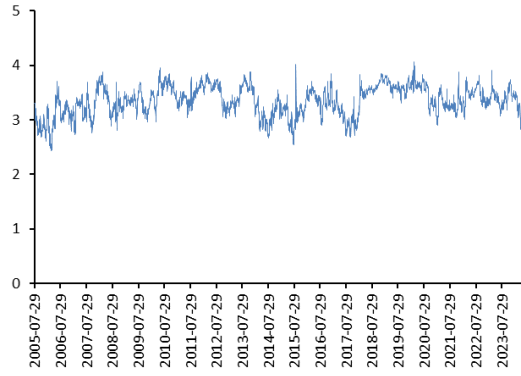
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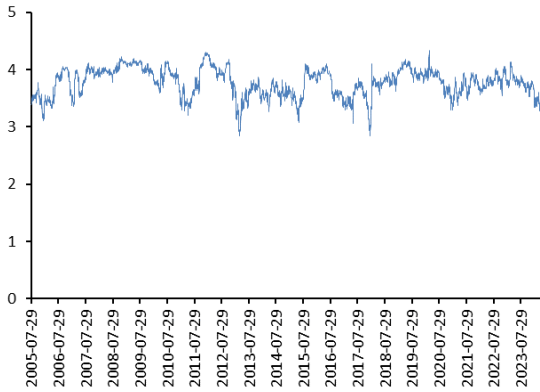
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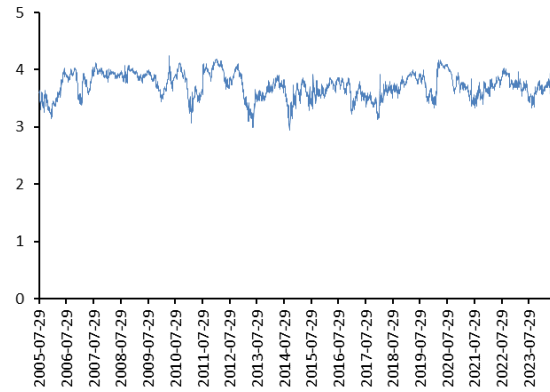
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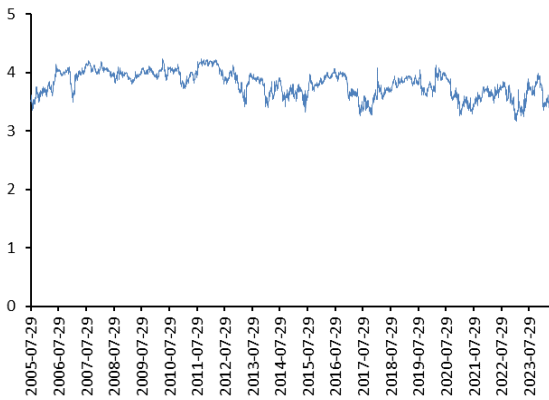
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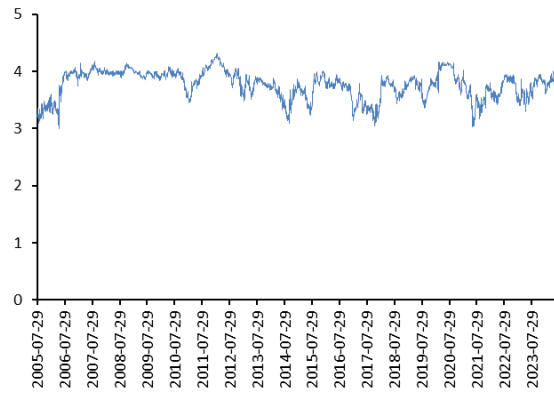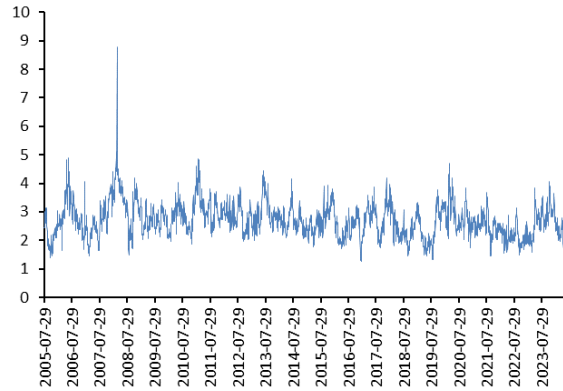
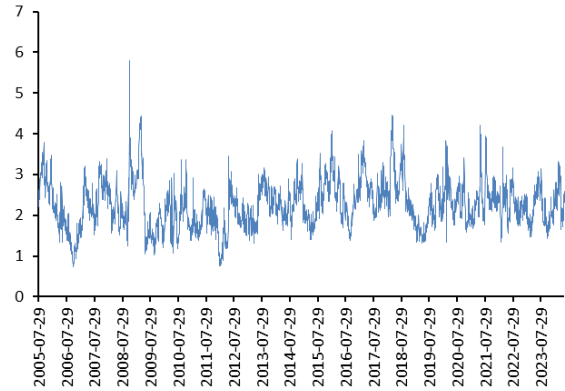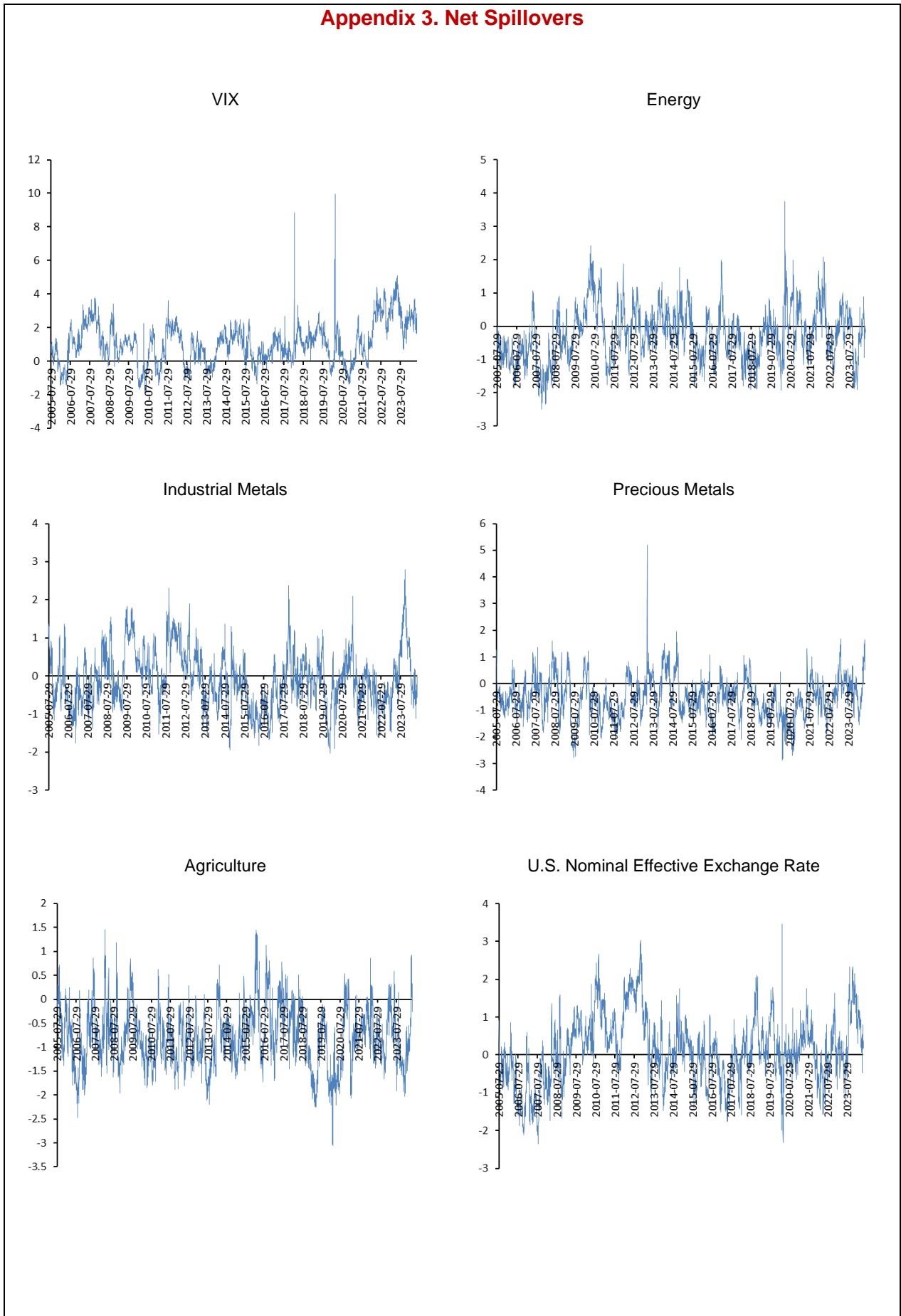**Appendix 1. Spillovers: To Others (continued)**
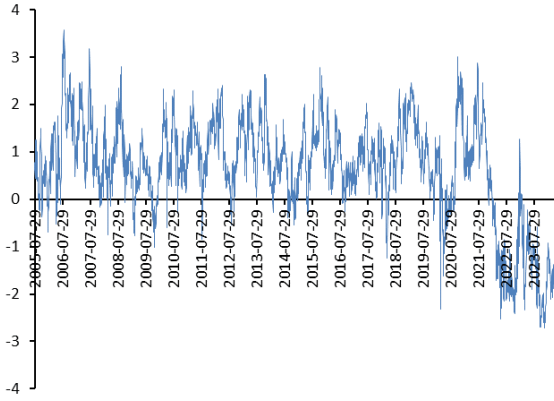
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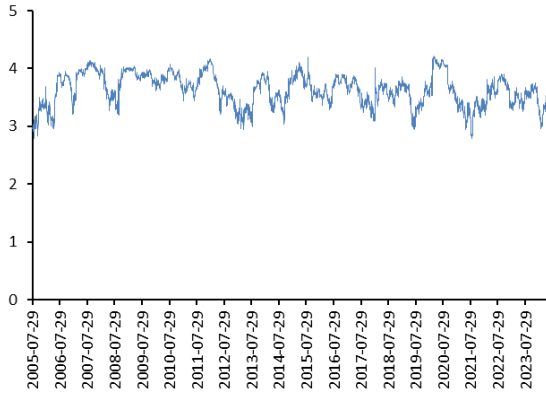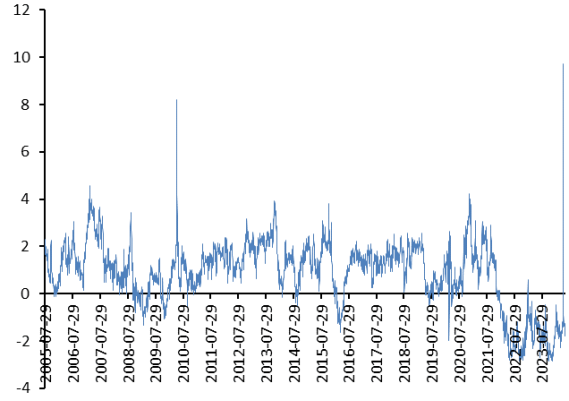
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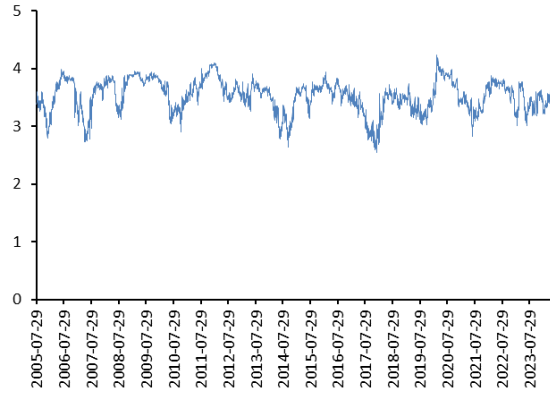
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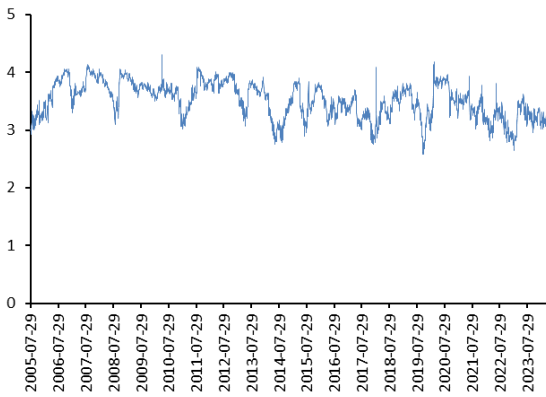
Philippines

Appendix 2. Spillovers: From Others
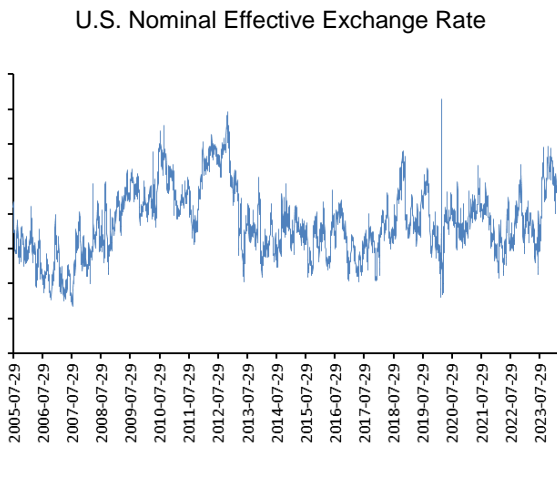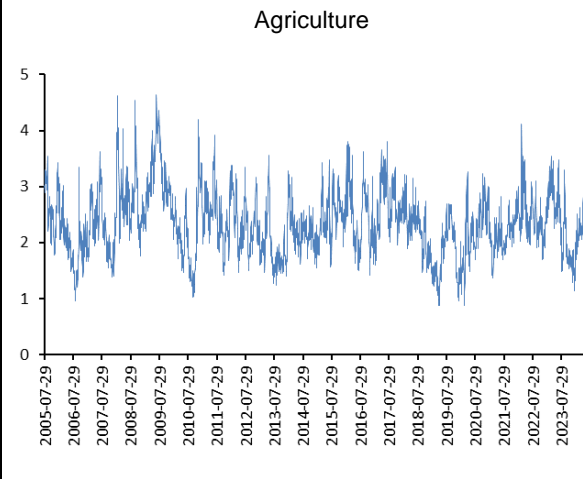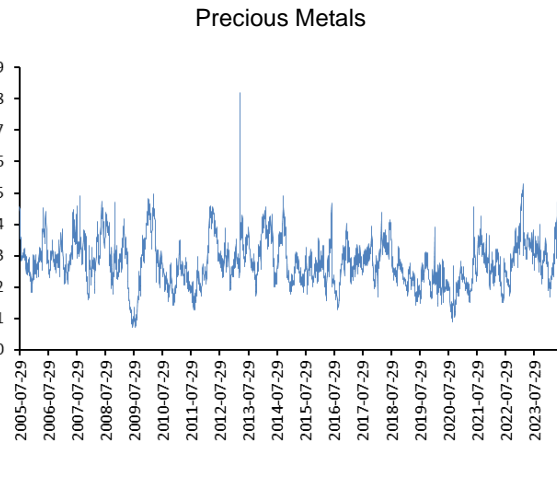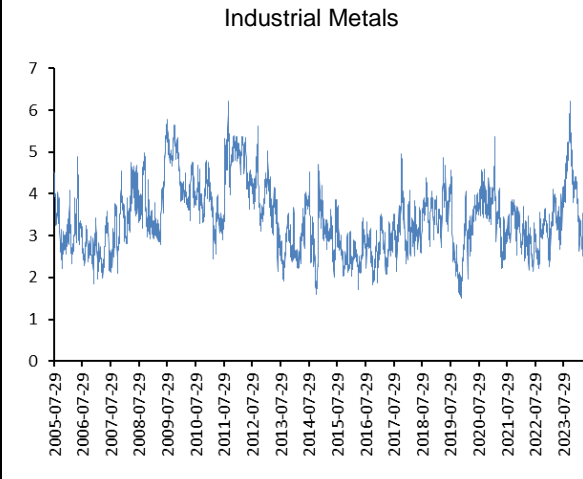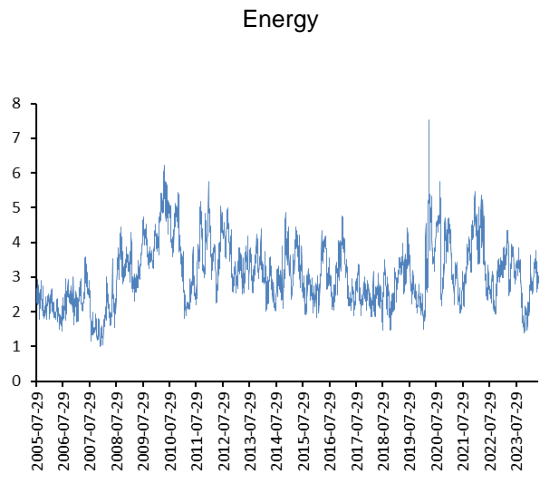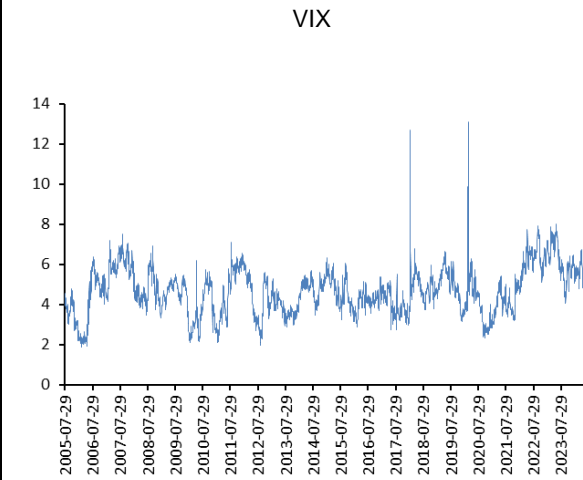
VIX

Energy

Industrial Metals

Precious Metals

Agriculture

U.S. Nominal Effective Exchange Rate

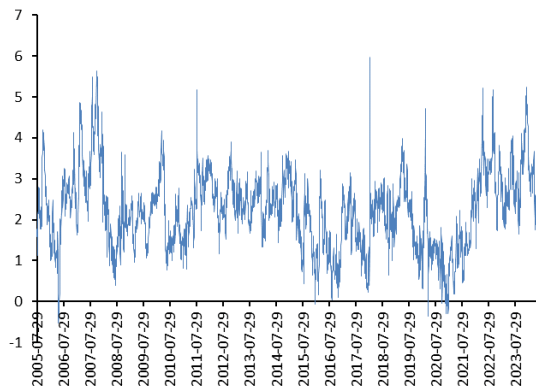# Appendix 2. Spillovers: From Others (continued)

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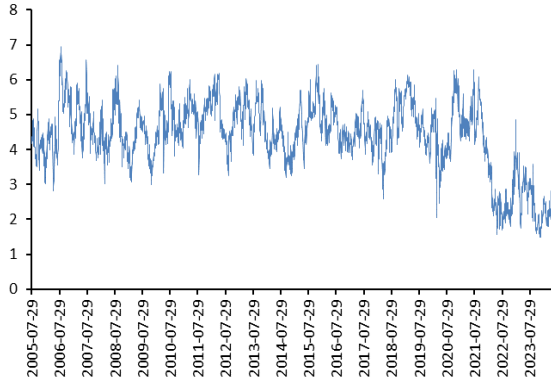
Long-term Macroeconomic Risk
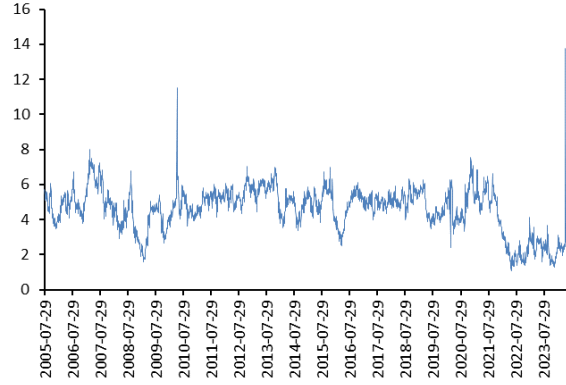
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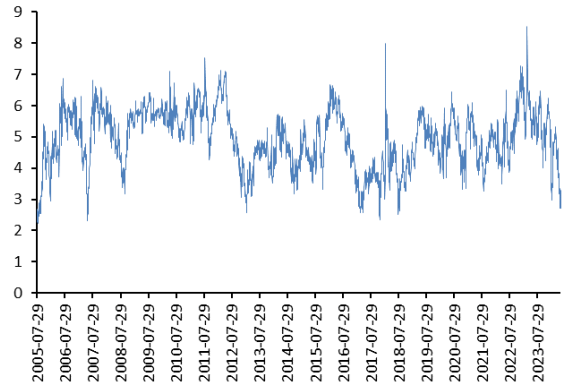
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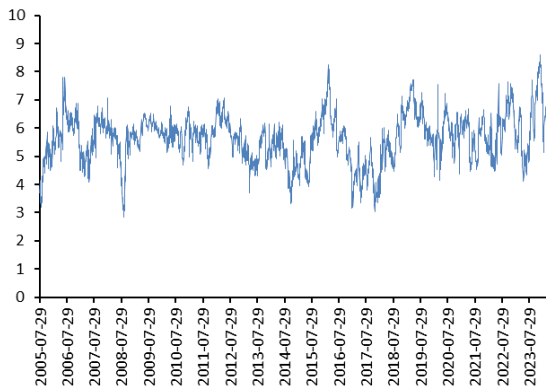
Latin America

Appendix 2. Spillovers: From Others (continued)

Gulf Cooperation Council

China

Japan

Korea

Hong Kong

Singapore

Appendix 2. Spillovers: From Others (continued)

Malaysia
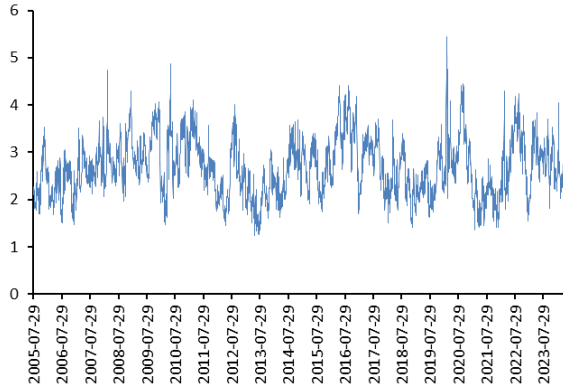
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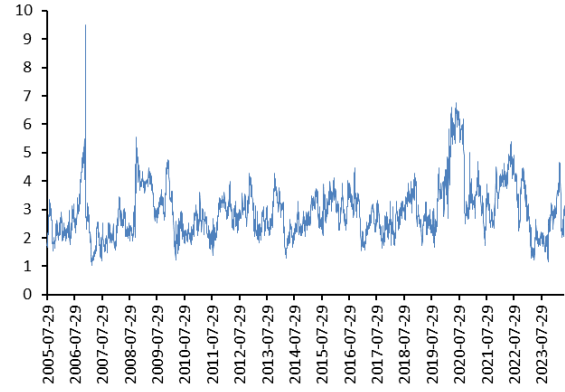
Indonesia

Philippines

Appendix 3. Net Spillovers

VIX

Energy

Industrial Metals

Precious Metals

Agriculture

U.S. Nominal Effective Exchange Rate

Appendix 3. Net Spillovers (continued)

Short-term Macroeconomic Risk

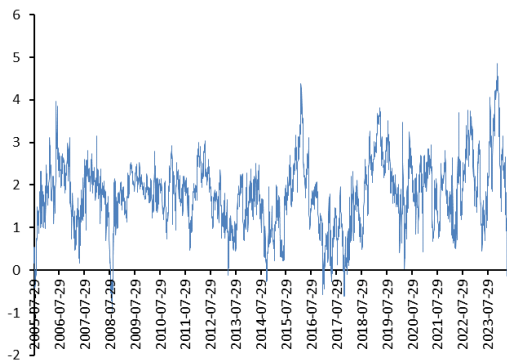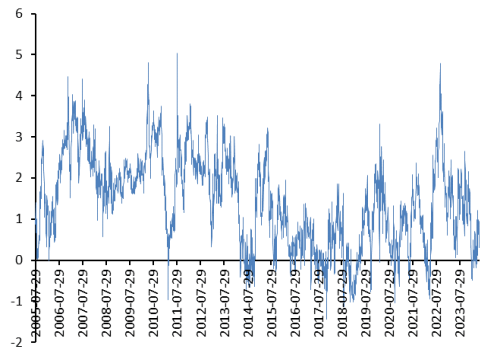### Long-term Macroeconomic Risk

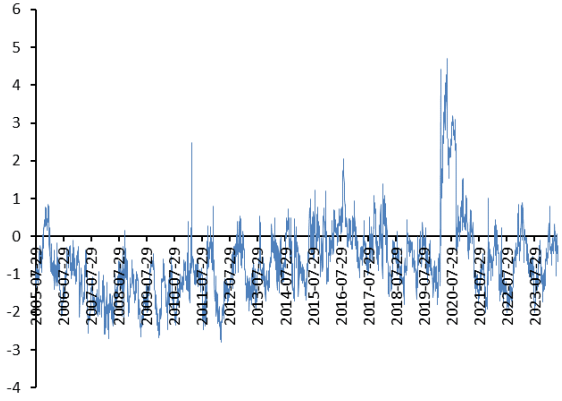### North America

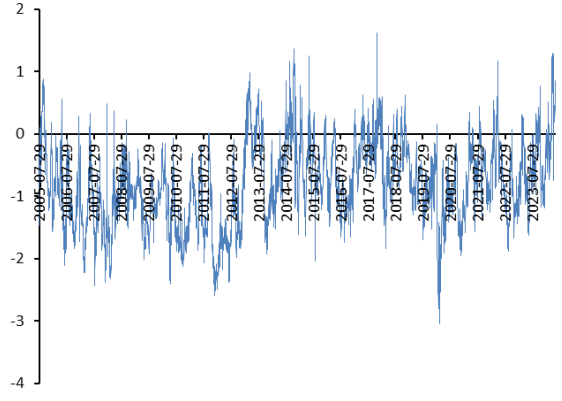### United Kingdom
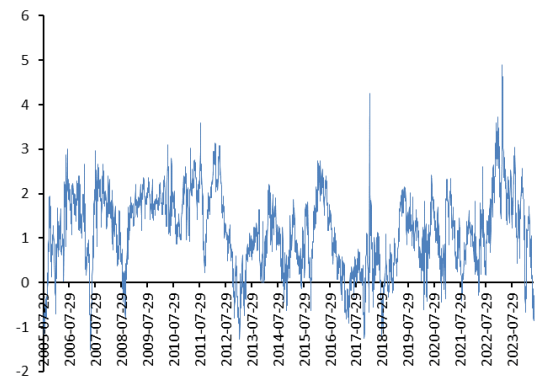
Europe
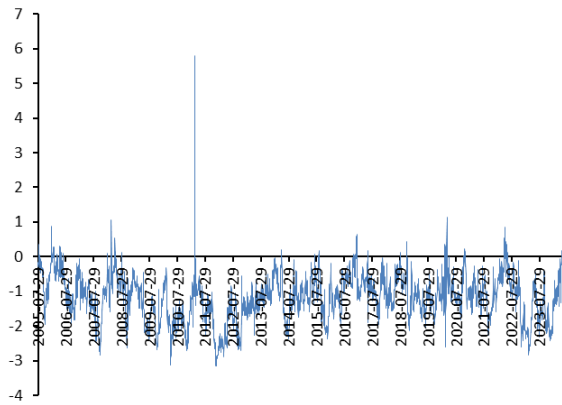

Latin America

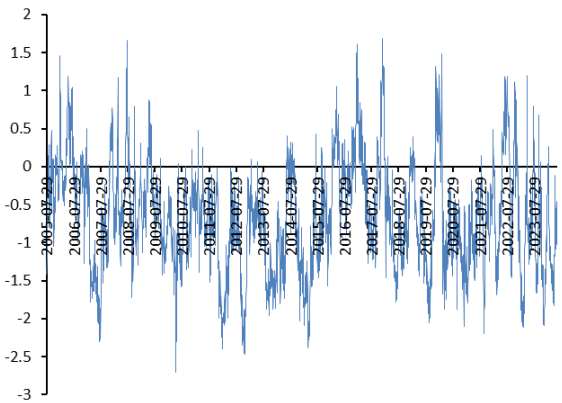# Appendix 3. Net Spillovers (continued)
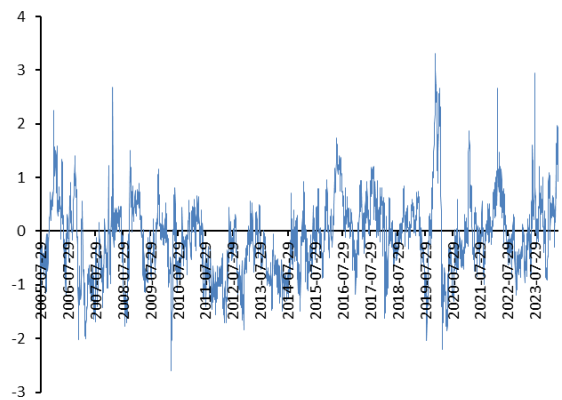
Gulf Cooperation Council
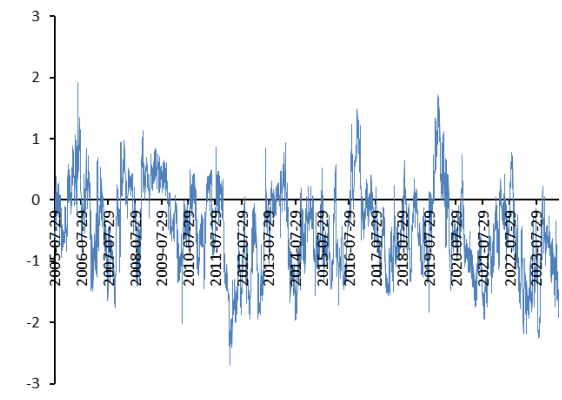

China

Japan

Korea
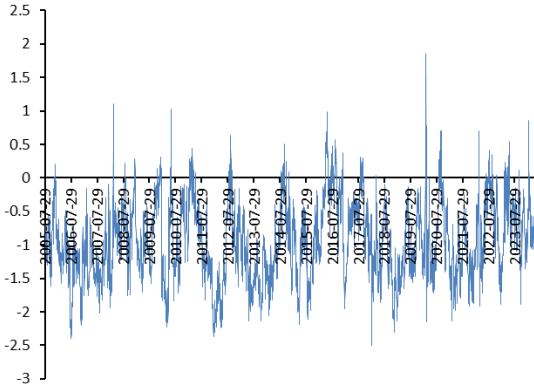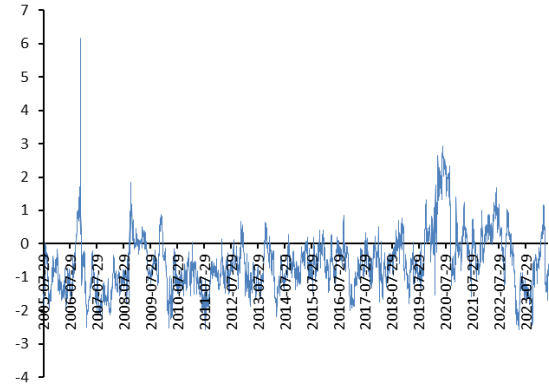

Hong Kong

Singapore
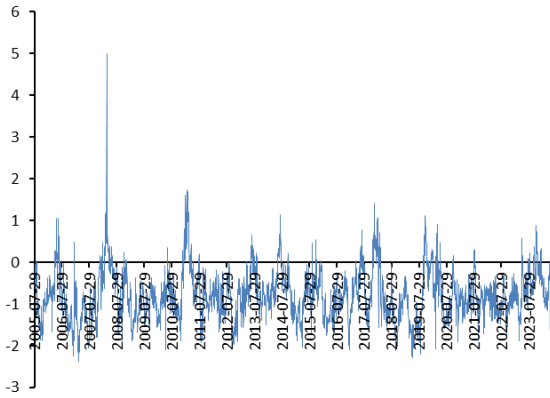
Appendix 3. Net Spillovers (continued)
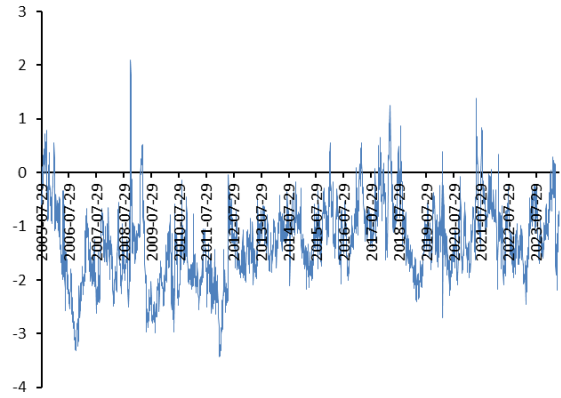
Malaysia

Thailand

Indonesia

Philippines

Appendix 4. Robustness Check: Analyzing the Spillover of the 2023 U.S. Banking Turmoil on the ASEAN+3 Financial Services Industry[10]

The U.S. financial system plays a pivotal role in global markets, and shocks originating from it can quickly spread across borders through various channels (Tran and Vo 2023). Analyzing these spillover dynamics helps authorities and market institutions understand potential vulnerabilities and develop appropriate policy responses (Fukuda and Tanaka 2020; ASEAN Main Portal 2023).

The literature suggests that a significant decline in the output of the U.S. financial services industry can have far-reaching effects on other countries' financial services industries. These spillovers are transmitted through both direct financial-industry-to-financial-industry channels and indirect channels that first impact nonfinancial industries and then feed back into the financial industry. Transmission occurs through both supply and demand. For example, most past U.S. financial crises affected different parts of the world through trade, financial, and other channels, highlighting the need to consider all economic and financial cross-market influences. A contraction in the U.S. financial services industry can reduce access to capital for financial institutions in other countries, hindering their ability to finance operations, expand services, and support economic activities. Additionally, nonfinancial industries, which rely on financial services for working capital, investment financing, and risk management, can be affected too. This ripple effect can spread to financial institutions in other countries that provide services to these nonfinancial firms, leading to a disruption of their business activities. Nonfinancial industries, particularly those that export to the U.S. or are a part of global supply chains, may experience a drop in the demand for their products and services, resulting in lower revenues and reduced financial services needs, thereby impacting financial institutions in other countries (Tomczak 2023; Sun and others 2020; Jovanovikj and Georgievska 2015; Mefford 2009).

This Appendix uses the international input-output table to capture all of these effects. This cross-economy and cross-industry micro-simulation method systematically incorporates various transmissions. It relies on two key formulae: (a) one reflecting production relationships from the supply side; and (b) one representing the distribution of output for various purposes from the demand side. These formulae link industries across different economies in the OECD Inter-Country Input-Output (ICIO) tables into an integrated global economic and financial system, enabling the analysis of spillover effects from any specific industry in one economy to any industry in other economies:

(a) Output value of industry j in economy i
$$= \sum_{\text{Economy } k1} \sum_{\text{Industry } l1} \text{Value of intermediate inputs from industry } l1 \text{ in economy } k1$$
$+ \text{Value of other production inputs including capital and labor for industry } j \text{ in economy } i$

(b) Output value of industry j in economy i
$$= \sum_{\text{Economy } k2} \sum_{\text{Industry } l2} \text{Value of output distributed as intermediate inputs for industry } l2 \text{ in economy } k2$$
$$+ \sum_{\text{Economy } k3} (\text{Value of output distributed as final products for private consumption in economy } k3$$
$+ \text{Value of output distributed as final products for public consumption in economy } k3$
$+ \text{Value of output distributed as final products for private and public investment in economy } k3)$

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[10] The author of this Appendix is Liyang (Alex) Tang.

The dataset includes the latest OECD ICIO table (updated to 2020) and the daily closing indices for the financial services or banking industry from S&P, Dow Jones, and Nasdaq. The ICIO table sets all parameters in the micro-simulation model across all economies and industries, following methodologies by Aroche Reyes and Marquez Mendoza (2021), Pichler and others (2021), Pichler and Farmer (2022), and Marquez Mendoza (2023). The financial indices determine the range of the maximum percentage decline in the output value of the U.S. financial services industry in 2023, based on lower and upper bound scenarios of the U.S. banking turmoil that began in early 2023.

Figure A4.1. Selected ASEAN+3: Spillover Effects from the U.S. Financial Services Industry on the Output Value of Domestic Financial Services Industries
(percent)
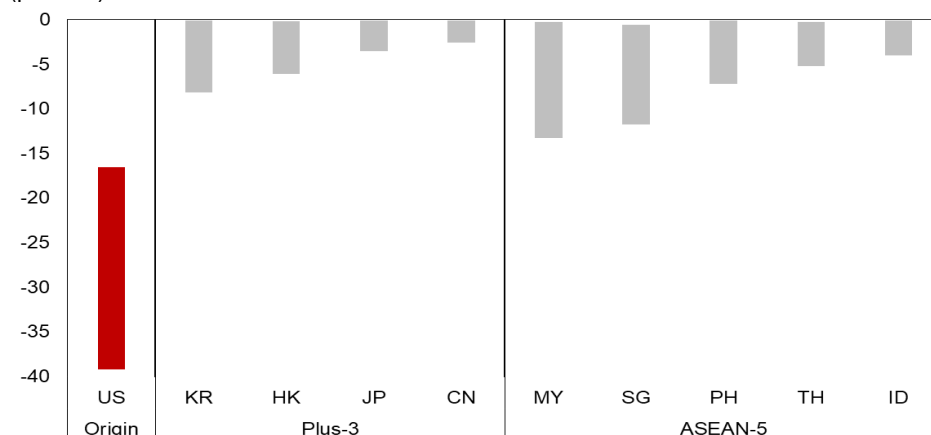
Source: AMRO staff estimates.
Note: The analysis can be divided into the following three steps. First, establish the upper and lower bound scenarios of the severe downturn in the U.S. financial services industry's output value since early 2023, based on industry indices such as S&P, Dow Jones, and Nasdaq. Second, refer to relevant literature to employ a cross-economy and cross-industry micro-simulation model. Third, apply the micro-simulation model to the scenarios from the first step to obtain the upper and lower bound estimates of the spillover effects of the U.S. financial services industry on the same industries in ASEAN+3 economies, further considering the uncertainties in the speed of transmission and the persistence and accumulation of spillover effects.
CN = China, HK = Hong Kong, ID = Indonesia, JP = Japan, KR = Korea, MY = Malaysia, PH = Philippines, SG = Singapore, TH = Thailand, US = United States.

The results presented in Figure A4.1 reveal important insights:

- Among the Plus-3 economies, Korea and Hong Kong's financial services industries are expected to experience significant upper bound spillover effects of -8.2 percent and -6.1 percent in output value respectively. China faces more moderate potential spillover effects of -2.6 percent, indicating it is less impacted than Korea and Hong Kong. Among the ASEAN economies, Malaysia and Singapore are more vulnerable, with upper bound spillover effects of -19.5 percent and -11.8 percent in output value respectively.

- Lower bound estimates for spillover effects from a significant downturn of the U.S. financial services industry provide a more optimistic outlook. For example, Korea and Hong Kong might experience lower bound spillover effects that are as small as -0.1 percent and -0.2 percent in output value, compared to upper bound estimates of -8.2 percent and -6.1 percent. The substantial divergence between lower and upper bound estimates arises from different assumptions about the speed of cross-economy and cross-industry transmission and the persistence of spillover effects. This underscores the importance of policies to reduce transmission speed and the persistence of spillover effects.

References

Acharya, V. V., and A. V. Thakor. 2016. "The Dark Side of Liquidity Creation: Leverage and Systemic Risk." *Journal of Financial Intermediation* 28 (C): 4-21.

Acharya, V. V., R. Engle, and M. Richardson. 2012. "Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks." *American Economic Review* 102 (3): 59-64.

Adrian, T., and M. Brunnermeier. 2016. "CoVaR." *American Economic Review* 106 (7): 1705-1741.

Aghion, P., P. Bolton, and M. Dewatripont. 2000. "Contagious Bank Failures in a Free Banking System." *European Economic Review* 44 (4-6): 713-718.

Allen, F., and A. Babus. 2009. "Networks in Finance." Wharton Financial Institutions Center Working Paper 08-07, 1-20, University of Pennsylvania, Philadelphia.

Antonakakis, Nikolaos, Ioannis Chatziantoniou, and David Gabauer. 2020. "Refined Measures of Dynamic Connectedness Based on Time-Varying Parameter Vector Autoregressions." *Journal of Risk and Financial Management* 13(4): 84.

Aroche Reyes, Fidel, and Marco Antonio Marquez Mendoza. 2021. "Demand-Driven and Supply-Sided Input–Output Models." Journal of Quantitative Economics 19(2): 251–67.

ASEAN Main Portal. 2023. "Joint Statement of the 26th ASEAN+3 Finance Ministers' and Central Bank Governors' Meeting." Incheon, 2 May. https://asean.org/joint-statement-of-the-26th-asean3-finance-ministers-and-central-bank-governors-meeting/

Baba, Yoshihisa, Robert F. Engle, Dennis Kraft, and Kenneth F. Kroner. 1990. "Multivariate Simultaneous Generalized ARCH." Department of Economics Working Paper, UCSD.

Bernanke, Ben S., Jean Boivin, and Piotr Eliasz. 2005. "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach." *Quarterly Journal of Economics* 120(1): 387–422.

Billio, M., M. Getmansky, A.W. Lo, and L. Pelizzon. 2012. Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors. *Journal of Financial Economics* 104:535–559.

Briccio, Jana and Teng Teng Xu. 2019. "Interconnectedness and Contagion Analysis: A Practical Framework." IMF Working Paper 2019/10/11, International Monetary Fund, Washington, DC. https://www.imf.org/en/Publications/WP/Issues/2019/10/11/Interconnectedness-and-Contagion-Analysis-A-Practical-Framework-48717

Cifuentes, R., and H. S. Shin, and G. Ferrucci. 2005. "Liquidity Risk and Contagion." *Journal of the European Economic Association* 3 (2-3): 556-566.

Cont, R., and E. Schaanning. 2019. "Monitoring Indirect Contagion." *Journal of Banking & Finance* 104 (July): 85-102.

Cont, R., and E. Schaanning. 2017. "Fire Sales, Indirect Contagion and Systemic Stress Testing." Norges Bank Working Paper Series 2/2017, Oslo.

Diebold, Francis and Kamil Yilmaz. 2014. "On the Network Topology of Variance Decompositions: Measuring the Connectedness of Financial Firms." *Journal of Econometrics* 182: 119-134.

Diebold, Francis and Kamil Yilmaz. 2012. "Better to Give Than To Receive: Predictive Directional Measurement of Volatility Spillovers." *International Journal of Forecasting* 28(1): 57-66.

Dogah, Kingsley and Gamini Premaratne. 2020. "Dynamic Interconnectedness and Risk Contagion Among Asian Financial Markets." *Singapore Economic Review.*

Engle, Robert F. 2002. "Dynamic Conditional Correlation: A Simple Class of Multivariate GARCH Models." *Journal of Business and Economic Statistics* 20(3): 339–350.

Engle, R. F. and B. T. Kelly. 2012. Dynamic Equicorrelation. *Journal of Business and Economic Statistics* 30:212–228.

Freixas, X., B. M. Parigi, and J. Rochet. 2000. "Systemic Risk, Interbank Relations, and Liquidity Provision by the Central Bank." *Journal of Money, Credit and Banking* 32 (3): 611-38.

Fukuda, Shin-Ichi, and Mariko Tanaka. 2020. "Financial Spillovers in Asian Emerging Economies." Asian Development Review 37(1): 93–118.

Gabauer, David, Ioannis Chatziantoniou, and Alexis Stenfors. 2023. "Model-Free Connectedness Measures." *Finance Research Letters* 54: 103804.

Guimaraes-Filho, Roberto, and Gee Hee Hong. 2016. "Dynamic Connectedness of Asian Financial Markets." *IMF Working Paper* WP/16/59. International Monetary Fund, Washington, D.C.

International Monetary Fund (IMF). 2021a. "People's Republic of China – Hong Kong Special Administrative Region: Financial System Stability Assessment". https://www.fstb.gov.hk/fsb/en/legco/docs/International%20Monetary%20Fund%20%E2%80%93%202021%20Financial%20Sector%20Assessment%20Program.pdf

International Monetary Fund (IMF). 2021b. "Philippines: Financial Sector Assessment". http://documents1.worldbank.org/curated/en/723591629840270335/pdf/Philippines-Financial-Sector-Assessment.pdf

International Monetary Fund (IMF). 2019. "Singapore: Financial System Stability Assessment". https://www.imf.org/en/Publications/CR/Issues/2019/07/15/Singapore-Financial-System-Stability-Assessment-47108

International Monetary Fund (IMF). 2017. Finland: Financial Sector Assessment Program: Technical Note-Stress Testing the Banking System and Interconnectedness Analysis, https://www.imf.org/en/Publications/CR/Issues/2017/01/11/Finland-Financial-Sector-Assessment-Program-Technical-Note-Stress-Testing-the-Banking-System-44516

International Monetary Fund (IMF). 2015. Norway: Financial Sector Assessment Program-Technical Note-Linkages and Interconnectedness in the Norwegian Financial System, https://www.elibrary.imf.org/view/journals/002/2015/256/article-A001-en.xml

Jovanovikj, Biljana, and Ljupka Georgievska. 2015. "Transmission Channels of the Global Economic Crisis: Micro Evidence for Macedonia." Journal of Contemporary Economic and Business 2(1): 5–20.

Marquez Mendoza, Marco Antonio. 2023. "An Analysis of Economic Growth Using Input–Output Tables." Journal of Economic Structures 12(1): 21.

Mefford, Robert N. 2009. "The Financial Crisis and Global Supply Chains." AIB Insights 9(3): 8–11.

Mensah, Jones Odei, and Gamini Premaratne. 2017. "Systemic Interconnectedness Among Asian Banks." Japan and the World Economy 41: 17-33.

Monetary Authority of Singapore (MAS). 2023. *Financial Stability Review: Statistical Appendix.* https://www.mas.gov.sg/publications/financial-stability-review/2023/financial-stability-review-2023

Pesaran, M. H and Y Shin. 1998. "Generalized Impulse Response Analysis in Linear Multivariate Models." Economics Letters 58: 17-29.

Pichler, Anton, and J. Doyne Farmer. 2022. "Simultaneous Supply and Demand Constraints in Input–Output Networks: The Case of COVID-19 in Germany, Italy, and Spain." Economic Systems Research 34(3): 273–93.

Pichler, Anton, Marco Pangallo, R. Maria del Rio-Chanona, François Lafond, and J. Doyne Farmer. 2021. "In and Out of Lockdown: Propagation of Supply and Demand Shocks in a Dynamic Input–Output Model." arXiv Preprint 2102.09608, 18 February. https://arxiv.org/abs/2102.09608

Remolona, Eli and Ilhyock Shim. 2015. "The Rise of Regional Banking in Asia and the Pacific." *BIS Quarterly Review*, Bank for International Settlements, Basel, September. https://www.bis.org/publ/qtrpdf/r_qt1509j.pdf.

Rosenkranz, Peter and Monica Melchor. 2022. "Asia's Financial Interconnectedness: Evolution, Implications, and Insights from Past Crises". *Economic Analysis and Policy* 76(2).

Shleifer, A., and R. W. Vishny. 1992. "Liquidation Values and Debt Capacity: A Market Equilibrium Approach." *Journal of Finance* 47 (4): 1343-1366.

Sun, Guofeng, Wenzhe Li, Qiong Liu, Chunyi Zhang, and Jingxuan Song. 2020. "International Financial Crisis: Expectation Transmission and Policy Synchronisation." Monetary Policy Committee Discussion Papers, the People's Bank of China, Beijing, 2 April. http://dx.doi.org/10.2139/ssrn.3567527

Tomczak, Kamila. 2023. "Transmission of the 2007–2008 Financial Crisis in Advanced Countries of the European Union." Bulletin of Economic Research 75(1): 40–64.

Tran, Minh Phuoc-Bao, and Duc Hong Vo. 2023. "Market Return Spillover from the US to the Asia-Pacific Countries: The Role of Geopolitical Risk and the Information & Communication Technologies." PLOS ONE 18(12): e0290680.

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