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Working Paper

Asymmetric spillovers in ASEAN bond markets

ADB Economics Working Paper Series, No. 697

Provided in Cooperation with:

Asian Development Bank (ADB), Manila

Suggested Citation: Yahya, Muhammad et al. (2023) : Asymmetric spillovers in ASEAN bond markets, ADB Economics Working Paper Series, No. 697, Asian Development Bank (ADB), Manila, <https://doi.org/10.22617/WPS230389-2>

This Version is available at:

<https://hdl.handle.net/10419/298143>

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ASYMMETRIC SPILLOVERS IN ASEAN BOND MARKETS

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Shu Tian, and Ranadeva Jayasekera*

NO. 697

October 2023

**ADB ECONOMICS
WORKING PAPER SERIES**

ADB Economics Working Paper Series

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No. 697 | October 2023

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ISSN 2313-6537 (print), 2313-6545 (electronic)
Publication Stock No. WPS230389-2
DOI: <http://dx.doi.org/10.22617/WPS230389-2>

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ABSTRACT

The financial markets of members of the Association of Southeast Asian Nations (ASEAN) have become increasingly integrated with regional and global markets. ASEAN economies also exhibit strong trade connectedness and interdependence with regional and global business cycles. Such connectedness can foster the spread of global shocks to ASEAN members and distress local financial markets. Global shocks, such as financial crises or commodity price changes, can have asymmetric and nonlinear effects on other financial and commodity markets around the world. This paper aims to estimate and evaluate the intensity and directionality of bond market connectedness between ASEAN and major regional and global markets. Furthermore, we aim to identify factors impacting the interconnectedness dynamics among these markets. This study derives an uncertainty connectedness measure grounded on the attributes of static and dynamic dependence frameworks and empirically evaluates its role in transmitting or receiving shocks based on various information spillover and contagion channels. The findings of this study have important implications for market participants, regulators, and policymakers.

Keywords: asymmetric spillover, uncertainty, connectedness, ASEAN

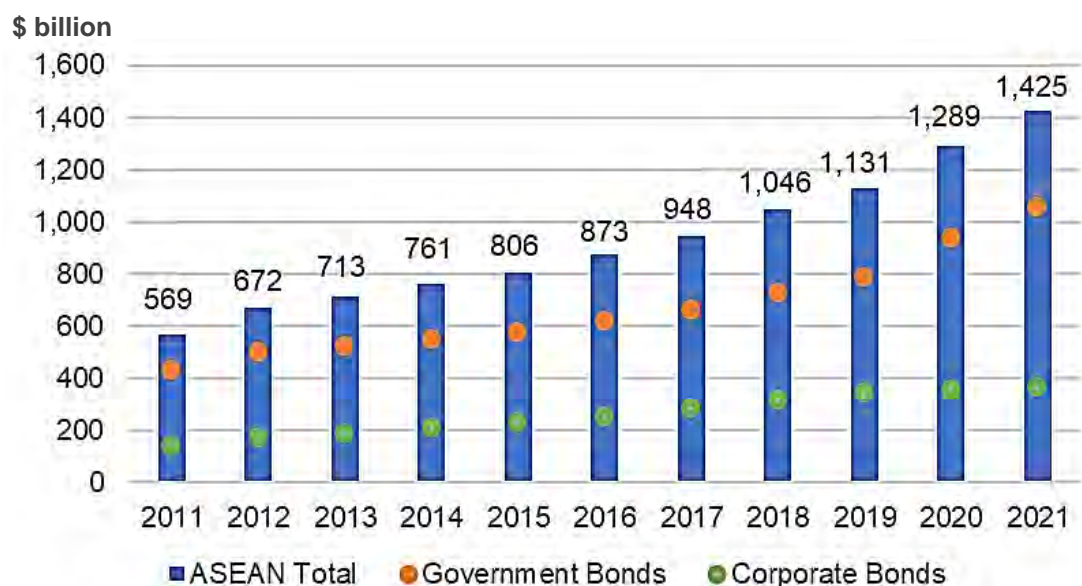
JEL codes: E52, E58, F42

1. INTRODUCTION

Since the debt crisis in the euro area, which began in 2009, sovereign bond yield spillovers have been a crucial topic for policymakers, risk regulators, and investors. The linkages between sovereign bonds are considered potential threats to financial stability. Given that the European debt crisis, which was centered on sovereign bonds, was exacerbated by the effects of the global financial crisis, similarly, today's market participants are worrying that there will be a new debt crisis in the post-pandemic era. Therefore, in this study, we utilize data from Association of Southeast Asian Nations (ASEAN) bond markets and major global financial markets to evaluate the asymmetric network connectedness among these markets. This is important given the increased divergence of investments from traditional bond and financial markets to emerging markets such as ASEAN.

To overcome the large economic fallout from the coronavirus disease (COVID-19) pandemic, ASEAN members have resorted to monetary policies focused on the issuance of government bonds. For example, the central banks of Indonesia and the Philippines have directly or indirectly contributed to the issuance of government bonds to finance the government budget and provide liquidity (Rhee and Svirydzhenka 2021). In **Figure 1**, we plot the amount of outstanding bonds from 2011 to 2021 in ASEAN-4 countries: Indonesia, Malaysia, the Philippines, and Thailand. ASEAN bond issuance experienced significant growth and achieved unprecedented levels in the last decade, which could potentially cause sovereign debt risks and crisis.

Figure 1. ASEAN-4 Local Currency Bonds Outstanding



ASEAN = Association of Southeast Asian Nations.

Notes: ASEAN-4 comprises Indonesia, Malaysia, the Philippines, and Thailand. Outstanding bonds were computed based on data through 31 December 2021.

Source: AsianBondsOnline. <https://asianbondsonline.adb.org>.

After decades of development, ASEAN financial markets have become increasingly integrated with global and regional markets for several reasons. First, ASEAN bonds sometimes provide a higher investment return because of Southeast Asia's relatively more rapid growth in output, investment, foreign direct investment, and trade liberalization (Zhu et al. 2016, Bogmans et al. 2020, Bacchetta et al. 2021). Market participants and financial institutions invest in ASEAN economies seeking higher returns, leading to significant foreign capital inflows from other regions. Second, ASEAN markets provide risk-hedging possibilities. With the substantial trade diversion effects caused by trade disputes between the People's Republic of China (PRC) and the United States (US), ASEAN economies have a higher level of trade openness (Cerutti et al. 2019), which reduces inequality in emerging and developing countries (Bacchetta et al. 2021) and creates an asymmetric response to global shocks in different markets. The nonsynchronous dynamics of bond yields could be used for portfolio diversification (Plummer and Click 2005, Teo 2009, Arellano and Ramanarayanan 2012, Devereux et al. 2020). Third, with the heightened uncertainty

of COVID-19 and geopolitical conflicts, investors tend to buy Treasury bonds from a diversified set of economies for risk-resistance and safe-haven aims (Bekaert et al. 2009; Costantini and Sousa 2022).

Nevertheless, the literature investigating ASEAN markets responding to global shocks is scarce (Plummer and Click 2005, Gimet 2011, Banerji et al. 2014). This may be attributed to the fact that the financial integration and internationalization of ASEAN bond markets remains in an early stage. Among the few studies, Plummer and Click (2005) summarize the opportunities and challenges associated with the formation of an ASEAN bond market. Teo (2009) analyzes the geographical factors involved in hedging funds in Asian markets, the US, and the United Kingdom (UK). Gimet (2011) studies the reaction of ASEAN stock indices to shocks in international financial exchanges such as the global financial crisis. Banerji et al. (2014) analyze the external and domestic factors on the spread of sovereign debt in emerging Asian markets. However, to the best of our knowledge, there are no studies examining the asymmetric risk spillover between ASEAN markets and international markets.

This paper examines the directional connectedness of government bond yields between ASEAN and international bond markets—in particular, Asia (the PRC, Japan, the Republic of Korea, and India) and the financial centers of the US, UK, and European markets—over the period 4 January 2012 to 31 January 2022. We make the plausible assumption that all Treasury bonds are linked by a topological network of spillover risk. We first depict the picture of a bond network in a static horizon and then investigate the dynamics of the connectedness. We answer the questions of whether ASEAN markets exhibit increasing connectedness with global markets over time and how the spillover relationship changes during shocks such as the PRC–US trade dispute and COVID-19.

In the methodology, we adopt the connectedness of Diebold and Yilmaz (2014) estimated by a vector autoregression and generalized variance decomposition. Specifically, we detect the connectedness in three panels—full return panel, positive return panel, and negative return panel—which are regarded as representing asymmetric connectedness by Mensi et al. (2021).

The full panel estimated connectedness includes the co-movement in same market expectation, as well as a competitiveness effect that capital flows between a pessimistic market and an optimistic market. The positive and negative panel focus on connectedness under the co-movement of market expectation. The positive panel shows the spillover risk with homogenous market expectation that the investment return will increase (i.e., optimistic expectation). Conversely, the negative panel measures the spillover risk in pessimistic expectation. The three-panel setting helps us to investigate the composition of the connectedness during a specific shock or period to identify whether it is the co-movement or competitiveness effect that contributes to the uncertainty spillover.

With an overview of the network of ASEAN and global bonds, we aim to elucidate the spillover uncertainty by examining the driving forces of the connectedness. Although there is more evidence on energy, stock, and cryptocurrency markets (e.g., Andrada-Félix et al. 2020, Saeed et al. 2021, Bouri et al. 2021, Akyildirim et al. 2022), the literature investigating the determinants of connectedness in the fixed-income network is still scarce. The Chicago Board Options Exchange (CBOE) Volatility Index (VIX), geopolitical risk, and COVID-19 are found effective in the explanation of connectedness in literature such as Andrada-Félix et al. (2020) and Akyildirim et al. (2022). In addition, the determinants of bond risk have been investigated in developed countries and were found highly related to inflation (Ulrich 2013, Duffee 2018, Breach et al. 2020), capital flows and trade (Forbes and Warnock 2012, Evans and Hnatkovska 2014), and government bond issuance (Beetsma et al. 2018). By examining several relevant variables, we can identify the driving forces that contribute to the dynamics of connectedness between ASEAN and global bond markets. With the three-panel setting, we can understand the drivers of connectedness under a co-movement of optimistic and pessimistic market expectation, or under a capital substitute transferring based on the competitiveness effect. This allows us to provide projections of the investment performance and helps regulators deal with potential financial risk under the heightened uncertainty of COVID-19 and geopolitical conflicts. This study will also be valuable to both international and domestic investors in the participation of sovereign bond

markets. Cross-country diversification with developed and emerging bond markets may serve as an avenue in risk hedging and safe-haven strategies.

Our main findings show that the domestic connectedness within each ASEAN country dominated the network when there was no significant uptrend (growth) or downtrend (recession). Specifically, our study shows that the spillover risk between bonds with small difference in maturities are stronger under a pessimistic market expectation. Moreover, we find that US bonds are the major risk net exporter in all three panels. In the dynamic results, we find equality of connectedness between ASEAN and non-ASEAN Asian markets in the positive panel before 2017. While the pessimistic expectation spillover from non-ASEAN Asian markets to ASEAN in 2015 and 2016 could be related to the PRC's stock market. There are two peaks of the connectedness from developed countries (US, UK, and EU) to ASEAN in the full panel—in 2014 and 2017—which could be related to global recovery from the financial crisis and US trade policy, respectively. We also report that the big shock of US trade policy weakened the national bond connectedness. After the outbreak of COVID-19, there was a significant increase in international connectedness. Besides, we find that the positive spillover from ASEAN markets to the three big developed markets showed negatively correlated jumps with a higher magnitude. This may indicate that when the global economy was confronted with turmoil, ASEAN bonds injected positive sentiment into the three big markets. For the drivers of connectedness, our findings indicate a significant positive coefficient of VIX, trade balance, government bond issuance, and a significant negative coefficient of geopolitical risk (GPR) and COVID-19. One interesting finding is that the positive coefficient of government bond issuance is not significant under optimistic expectation, which may be because the strong confidence in economic and asset return growth weakens the threaten of potential fiscal problems.

The remainder of this paper is structured as follows. Section 2 describes the methodology employed. Section 3 presents the data on bond markets and their drivers. Section 4 discusses the results, and Section 5 concludes with the main findings.

2. METHODOLOGY

We utilize the Diebold and Yilmaz (2014) spillover framework to capture the connectedness dynamics among ASEAN markets and the other underlying assets.¹ Following Mensi et al. (2021), we measure asymmetric spillover in different panels, including return panel, return positive panel, and return negative panel. The applicable measurement situation and implications are stated.

2.1 Asymmetric Panels

The Diebold and Yilmaz (2014) framework provides an important insight into the directional spillovers and topological network structure. However, we may benefit from the connectedness in different data panels. The Diebold and Yilmaz (2014) framework focuses on the volatility connectedness to investigate investor fear and crisis spillover effects. Mensi et al. (2021) examine the asymmetric spillover in terms of the positive and negative returns to evaluate the response of good and bad news on the connectedness dynamics. In this paper, we study connectedness in six panels: (i) return panel, (ii) return positive panel, (iii) return negative panel, (iv) volatility panel, (v) volatility positive panel, and (vi) volatility negative panel (**Table 1**). We capture the positive and negative returns as follows:

$$r(+) = \begin{cases} r_t, & \text{if } r_t > 0 \\ 0, & \text{if } r_t \leq 0 \end{cases}, \quad r(-) = \begin{cases} r_t, & \text{if } r_t < 0 \\ 0, & \text{if } r_t \geq 0 \end{cases} \quad (1)$$

where $r(+)$ and $r(-)$ corresponds to the positive and negative returns, respectively. Note that the yield of bonds represents the opportunity cost of not being able to invest elsewhere. For the Treasury bond market, which offers a risk-free interest rate and acts as a benchmark of investment, a positive change of bond yield means an increase in the expected investment return, which could reflect a boom market expectation in terms of economic growth and a high investment return for a portfolio and assets. Correspondingly, the return negative panel reflects the connectedness in a recession market expectation in economics and low return in the financial market.

¹ We refer interested researchers to Diebold and Yilmaz (2014) for a detailed overview of the employed framework.

The return positive and negative panels with filtering of equation (1) capture the homogeneity of the market with same (good or bad) expectation because the heterogeneity is forced into zero. However, the connectedness estimated in a return panel without filtering measures the spillover in a natural horizon in which regional changes with different situations are reflected. For example, when market A is experiencing an increase of expected investment return, and simultaneously market B is experiencing a decrease of expected investment return, the spillover will be measured in the return panel.

Table 1. Asymmetric Panels and Implications

Type of Connectedness	Applicable Measurement Situation	Implication of Increased Connectedness between Two Bonds	Implication of Decreased Connectedness between Two Bonds
Full panel	Spillover of market expectation of investment return, with heterogeneously of regional situation; the full panel estimated connectedness include the co-movement in same market expectation, as well as a competitiveness effect that the capital flows between a pessimistic market and an optimistic market.	The stronger impact from investment return of one bond on the return of another bond	The weaker impact from investment return of one bond on the return of another bond
Positive panel	Spillover of market expectation of investment return, with homogenous increased expectation of investment return (i.e., optimistic expectation)	The stronger effect that the increased yield of one bond brings to the increased yield of another bond	The weaker effect that the increased yield of one bond brings to the increased yield of another bond
Negative panel	Spillover of market expectation of investment return, with homogenous decreased expectation of investment return (i.e., pessimistic expectation)	The stronger effect that the decreased yield of one bond brings to the decreased yield of another bond	The weaker effect that the decreased yield of one bond brings to the decreased yield of another bond

Source: Authors.

2.2 Drivers of Asymmetric Connectedness

To examine the determinants of the spillovers between ASEAN and global bond markets, we utilize a fixed-effect panel regression of the following form:

$$\begin{aligned}
 C_{i,t} = & \alpha_i + \beta_1 C_{i,t-1} \\
 & + \beta_2 VIX_t + \beta_3 GPRD_t \\
 & + \beta_4 PPI_{i,t} + \beta_5 TB_{i,t} + \beta_6 GB_{i,t} \\
 & + \beta_7 covid_{i,t} + \beta_8 Trend_t + \varepsilon_t
 \end{aligned} \tag{2}$$

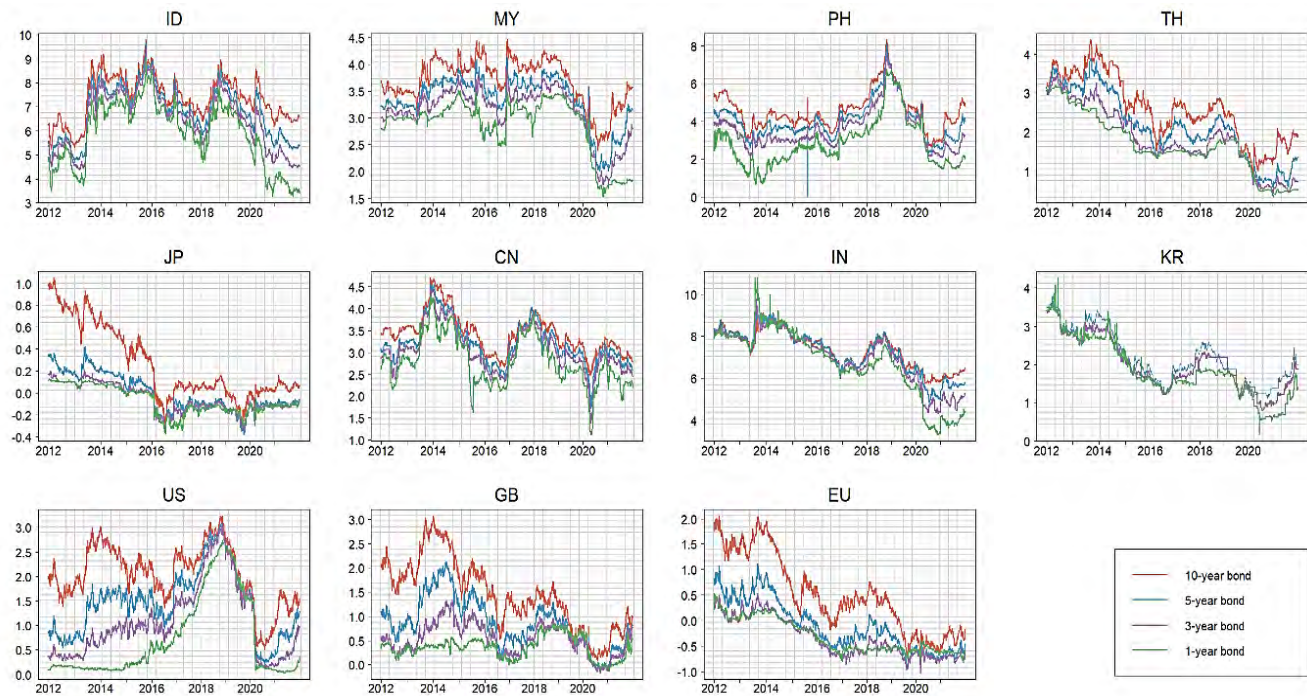
where $C_{i,t}$ represents the connectedness from ASEAN country i to others, or in the opposite direction. For the panel regression, we take the quarterly average value of the rolling window connectedness results as $C_{i,t}$. The $C_{i,t-1}$ is the connectedness with a 1-quarter lag. The VIX_t is the Chicago Board Options Exchange's VIX, which is a 30-day forward projection of market volatility derived from the S&P 500 Index options. The VIX is widely used as a proxy for the "fear" gauge of market participants (Whaley 2000, Białkowski et al. 2022). The GPR_t is the newspaper-based index of geopolitical risk at the global level. Constructed by Caldara and Matteo (2022), the GPR index is widely used in the literature (e.g., Baur and Smales 2020 and Al et al. 2020). It measures the geopolitical risk of the threat, realization, and escalation of adverse events associated with wars, terrorism, and any tensions among states and political actors that affect the peaceful course of international relations. The $PPI_{i,t}$ is the Producer Price Index (PPI) of ASEAN country i , which measures inflation in selling prices from domestic production. The PPI has always been used as a barometer for long-term purchasing agreements and welfare (Massell 1969). The $TB_{i,t}$ is the trade balance of ASEAN country i , which is the difference between the value of a country's exports and imports. The $GB_{i,t}$ is local-currency-denominated government bond Issuance of ASEAN country i , which is related to the creation of domestic credit and the risk of a fiscal imbalance (Christoffel et al. 2021). The $covid_{i,t}$ variable is the quarterly average daily number of incremental COVID-19 cases. The $Trend_t$ is the time trend variable to control for potentially omitted trending variables, following the method of Białkowski et al. (2022).

3. DATA AND SUMMARY STATISTICS

Our study covers the Treasury bond yields of four ASEAN markets (Indonesia, Malaysia, the Philippines, and Thailand), four non-ASEAN Asian markets (the PRC, Japan, the Republic of Korea and India), and three developed markets (US, UK, and EU). The sample period spans from 4 January 2012 to 31 January 2022, comprising a total of 2,491 daily observations. We use Treasury bond yields with different maturities of 1, 3, 5, and 10 years. Bond maturities data are collected from Bloomberg.

Figure 2 shows the dynamics of bond yields with different maturities and across different economies. The bond yields of Indonesia and the Philippines were higher than those of Malaysia and Thailand. The bond yields of the US, UK, EU, and Japan are lower than those of all ASEAN members. The long-term bonds have higher yields than short-term bonds over the sample period. Between January 2018 and December 2020, the ASEAN-4 countries witnessed a similar trend. Global bond yields increased in 2018, which could be related to the PRC–US trade dispute and ASEAN’s economy recovery, while advanced economy bond yields decreased from 2019 to 2020, which could be related to the weakened impact of the PRC–US trade dispute. There are similar short-term jumps in ASEAN countries in early 2020, which can be attributed to the onset of the COVID-19 pandemic in the PRC temporarily bringing a positive signal to ASEAN markets. Then, because of subsequent COVID-19 developments in ASEAN, the market expectation of economy and investment returns sharply crashed in the second quarter of 2020. Notably, Thai Treasury bond yields have stronger similarity with the trends of the PRC, US, UK, and EU than with the other three ASEAN-4 countries.

Figure 2. Bond Yields in ASEAN-4 Countries and Advanced Economies



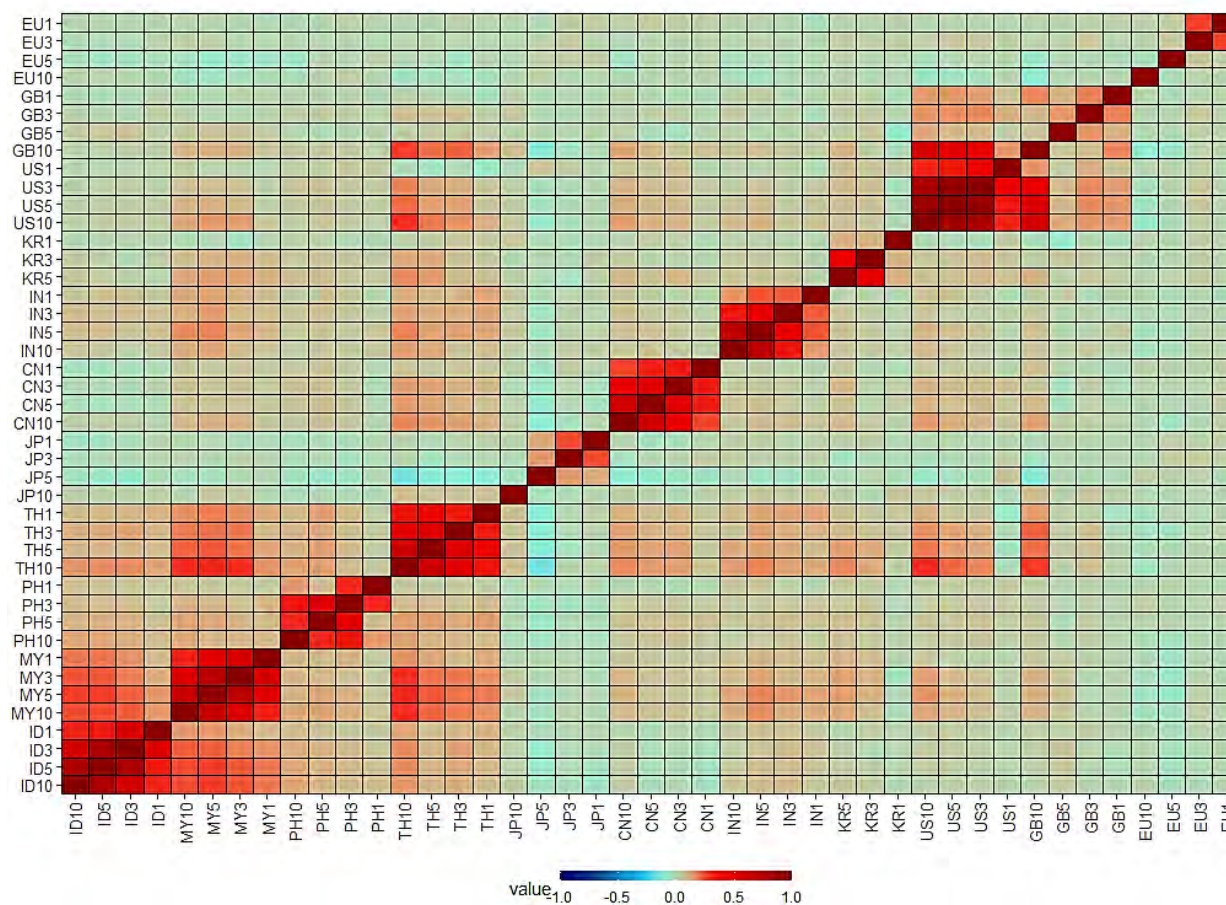
CN = People's Republic of China, EU = European Union, GB = United Kingdom, ID = Indonesia, IN = India, JP = Japan, KR = Republic of Korea, MY = Malaysia, PH = Philippines, TH = Thailand, US = United States.

Note: Bond yields are from 4 January 2012 to 31 January 2022, with a total of 2,491 daily observations for each bond. 1-, 3-, 5- and 10-year Treasury bond yields are indicated by red, blue, purple, and green, respectively.

Source: Bloomberg.

Our empirical analysis is based on the daily returns of each bond, which is calculated as 100 times the logarithmic difference of a bond's yield at time t and $t-1$. **Figure 3** shows the correlation of daily returns. We observe that the intra-economy correlation is stronger than the inter-economy correlation. Compared with other Asian and global bonds, ASEAN bonds have higher correlation with themselves. In the four ASEAN countries, Thai bonds have the highest correlation with the PRC, India, the Republic of Korea, and the US, while Malaysian bonds ranked second.

Figure 3. Correlation of Daily Returns



CN = People's Republic of China, EU = European Union, GB = United Kingdom, ID = Indonesia, IN = India, JP = Japan, KR = Republic of Korea, MY = Malaysia, PH = Philippines, TH = Thailand, US = United States.

Note. The figure depicts the correlation of daily returns for bonds across different economies and with different maturities. We utilize daily data for the sample period from 4 January 2012 to 31 January 2022, with a total of 2,491 daily observations. The x-axis and y-axis labels are named by the "economy-maturity" of each bond.

Source: Bloomberg.

For the driver variables, we collect daily CBOE VIX readings from 4 January 2012 to 31 December 2021 and average by quarter. The quarterly data for Producer Price Index, trade balance, and LCY-denominated government bond issuance of the four ASEAN countries were collected from Bloomberg for the first quarter of 2012 to the fourth quarter of 2021. The COVID-19 case is the quarterly averaged daily incremental number of COVID-19 cases. The GPR index

is that constructed by Caldara and Matteo (2022).² The correlation and dynamics of examined variables are reported in **Table 2** and **Figure 4**, respectively.

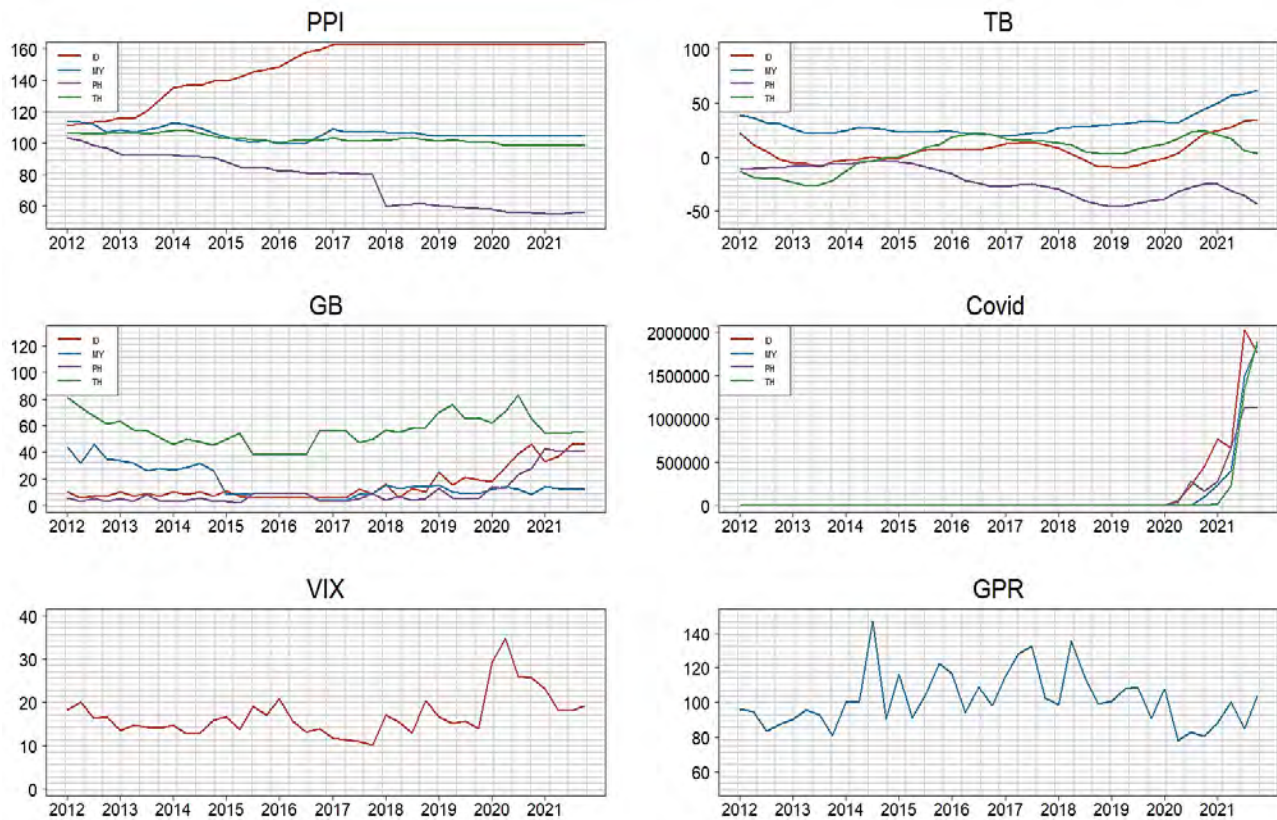
Table 2. Correlation Matrix for Examined Variables

	VIX	GPR	PPI	TB	GB	COVID-19
VIX	1					
GPR	-0.4145	1				
PPI	-0.0473	0.0485	1			
TB	0.0439	0.0029	0.4028	1		
GB	0.1469	-0.1471	-0.0343	0.1173	1	
COVID-19	0.134	-0.0963	0.0587	0.1515	0.1616	1

COVID-19 = coronavirus disease, GB = local-currency-denominated government bond issuance, GPR = geopolitical risk index, PPI = producer price index, TB = trade balance, VIX = volatility index.

Source: Authors' calculations.

Figure 4. Dynamics of Examined Variables



² For details, see <https://www.matteoiacoviello.com/gpr.htm>.

COVID-19 = coronavirus disease, GB = local-currency-denominated government bond issuance, GPR = geopolitical risk index, ID = Indonesia, MY = Malaysia, PH = Philippines, PPI = producer price index, TB = trade balance, TH = Thailand, VIX = volatility index.

Note: The drivers span from 2012 to 2021, with 40 quarterly observations.

Source: Authors' calculations.

4. RESULTS OF ASYMMETRIC CONNECTEDNESS

4.1 Static Results of Asymmetric Connectedness

We investigate asymmetric connectedness between ASEAN bonds and other bonds by the Diebold and Yilmaz (2014) framework, which is implemented in three panels: (i) full return panel, (ii) positive return panel, and (iii) negative panel. We start by giving an overview of the network relationship in the static horizon. **Table 3** shows the static results of asymmetric connectedness by country, estimated by generalized variance decomposition in equation (2–3) with $T = 2,491$ days, $P = 1$, and $H = 12$. US bonds are the major risk net exporter in all three panels. Malaysian bonds and Thai bonds are the risk exporter in the full panel, while receiving net spillovers when there is a homogenous optimistic expectation and uptrend co-movement in the global market. When global bond market participants have a negative expectation of bond yields, Indonesian bonds suffer the most from the spillover risk emanating from other ASEAN countries and the world. Philippine bonds also seriously suffer spillover risk from other ASEAN countries and the world in the optimistic expectation.

Figure 5 shows the topological visualization of the connectedness, with Figure 5(a) showing the results of the full return panel. The topological network of bonds are clustered mainly by sovereign issuer. Figure 5(a) shows many yellow and blue linkages, which are exported from Thailand and the US, respectively. Specifically, US bonds mainly influence the bond markets of Malaysia, Thailand, the UK, and other non-ASEAN Asian countries. While Thai bonds are the major exporter of connectedness to the other three ASEAN-4 countries. This may be attributed to the relatively more developed state of the Thai bond market and the increased integration of the Thai bond market with other ASEAN bond markets. Moreover, the connectedness is strong for

the links between two bonds with a smaller maturity difference. It can be attributed to the natural shape of a bond yield curve that plots yields with equal credit quality but differing maturity dates.

Figure 5(b) shows the results of net connectedness, which are obtained by taking the difference of the connectedness estimated by the positive return panel and full return panel. As mentioned below, the positive panel reflects the connectedness in a boom market expectation and a high investment return. The net connectedness in Figure 5(b) indicates the peculiarity of the bond network under an optimistic expectation globally. On the other hand, Figure 5(c) indicates the net connectedness under a pessimistic expectation. Figures 5(b) and (c) are dominated by blue linkages, illustrating that upward or downward movements of US bond yields can generate strong, consistent trends in global bond markets. Alternatively, the global homogenous trends in the world are always caused by US bonds. US bonds have higher centrality, which is not surprising given that US Treasuries' risk-free return and US monetary policy are highly impactful in both advanced and emerging economies (Albagli et al. 2019, Gilchrist et al. 2019). The higher value of US-to-ASEAN spillover in both the positive and negative panels than the return full panel reflects the lead-lag relationship between the US and ASEAN regarding growth and recession. In the full panel, the expectation of bond yields is unclassified and out of sync, depending on the economic and policy background of each country. It indicates that when there is no significant uptrend (growth) or downtrend (recession), the spillover from the US to ASEAN is weaker. Additionally, we find that the spillover from ASEAN to the US is negligible, while the spillover between two ASEAN countries is widely observed. Another interesting finding is that UK bonds have strong impacts in a positive market but not a negative market, indicating the asymmetric impact of the UK market on ASEAN bonds. This indicates that the optimism change in the UK could bring an uptrend of bond yields in ASEAN, while a recession or crisis in the UK will not cause a recession in ASEAN. Furthermore, it implies that investors could select ASEAN bonds for risk prevention during a crisis in the UK, while ASEAN bonds cannot be relied on as a hedging asset during a crisis in the US.

Finally, when there is a downward expectation, Thai bonds have a negative impact on many Asian markets, including the Philippines, the PRC, Japan, and the Republic of Korea. All observed maturities of Thai bonds have a strong impact on Japanese long-term yields, which may be attributed to the strong bilateral trade between the two countries (Pastpipatkul et al. 2020), driven by the Japan–Thailand Economic Partnership Agreement established in November 2007 and the ASEAN–Japan Comprehensive Economic Partnership signed in April 2008.

Table 3. Static Results of Connectedness

Panel A: Connectedness Estimated by Full Panel Return												
	ID	MY	PH	TH	JP	CN	IN	KR	US	GB	EU	FROM
ID	3.3835	0.3369	0.0448	0.1184	0.0179	0.0063	0.0376	0.0159	0.0212	0.013	0.0046	0.6165
MY	0.1643	3.1872	0.0347	0.2358	0.0121	0.0189	0.0655	0.0334	0.1711	0.0667	0.0102	0.8128
PH	0.065	0.0937	3.545	0.1133	0.0129	0.0318	0.0193	0.0206	0.0637	0.0267	0.008	0.455
TH	0.0691	0.1641	0.0429	3.0882	0.0236	0.0655	0.0754	0.0296	0.2729	0.1629	0.0058	0.9118
JP	0.0217	0.0138	0.0219	0.0549	3.7683	0.0232	0.0149	0.0089	0.0264	0.033	0.0129	0.2317
CN	0.0125	0.0229	0.0198	0.0817	0.0154	3.6901	0.0164	0.0113	0.09	0.035	0.0049	0.3099
IN	0.0297	0.089	0.0163	0.107	0.0123	0.0137	3.6301	0.0055	0.0698	0.0215	0.005	0.3699
KR	0.006	0.0506	0.0211	0.0542	0.0078	0.0146	0.0081	2.6425	0.1366	0.0548	0.0036	0.3575
US	0.0117	0.0551	0.0164	0.1259	0.0077	0.0434	0.0154	0.0305	3.3265	0.3602	0.0072	0.6735
GB	0.0177	0.0399	0.0092	0.1199	0.0151	0.0217	0.021	0.0248	0.5732	3.1488	0.0087	0.8512
EU	0.0068	0.0215	0.0152	0.015	0.0189	0.0113	0.0107	0.005	0.0151	0.0156	3.8648	0.1352
TO	0.4045	0.8875	0.2423	1.0261	0.1436	0.2506	0.2843	0.1855	1.44	0.7896	0.071	0.5205
NET	-0.212	0.0747	-0.2127	0.1143	-0.088	-0.0593	-0.0856	-0.1721	0.7665	-0.0617	-0.0642	

Panel B: Connectedness Estimated by Positive Panel Return												
	ID	MY	PH	TH	JP	CN	IN	KR	US	GB	EU	FROM
ID	2.5206	0.389	0.1874	0.2559	0.0404	0.0616	0.122	0.0527	0.2508	0.0733	0.0464	1.4794
MY	0.2046	2.3797	0.1317	0.3925	0.0417	0.0625	0.0777	0.068	0.46	0.1568	0.0248	1.6203
PH	0.259	0.2314	2.4674	0.1407	0.0528	0.1153	0.0959	0.0923	0.3553	0.1201	0.0697	1.5326
TH	0.2255	0.3573	0.1059	2.1529	0.0513	0.0846	0.116	0.023	0.5593	0.3055	0.0186	1.8471
JP	0.0723	0.0678	0.0835	0.0843	3.1173	0.07	0.045	0.0493	0.188	0.0976	0.1249	0.8827
CN	0.0656	0.0848	0.1121	0.0843	0.0478	2.9134	0.0955	0.0503	0.2636	0.2258	0.0568	1.0866
IN	0.1629	0.0942	0.1268	0.176	0.0418	0.0806	2.8732	0.0334	0.2555	0.1263	0.0294	1.1268
KR	0.0563	0.1314	0.0873	0.0504	0.0354	0.0458	0.0335	2.1428	0.2582	0.1157	0.0432	0.8572
US	0.1121	0.1255	0.1086	0.2438	0.0695	0.1089	0.0885	0.0426	2.608	0.43	0.0626	1.392
GB	0.0444	0.0693	0.0701	0.1855	0.0479	0.1219	0.0589	0.0442	0.6196	2.7043	0.0339	1.2957
EU	0.0852	0.0467	0.0903	0.0336	0.1197	0.0609	0.0297	0.0611	0.1488	0.0565	3.2675	0.7325
TO	1.288	1.5973	1.1036	1.6469	0.5484	0.8121	0.7628	0.517	3.359	1.7075	0.5103	1.2594
NET	-0.1915	-0.023	-0.429	-0.2002	-0.3343	-0.2745	-0.364	-0.3401	1.967	0.4119	-0.2222	

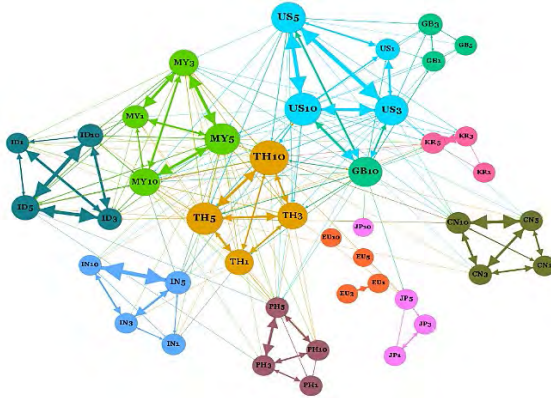
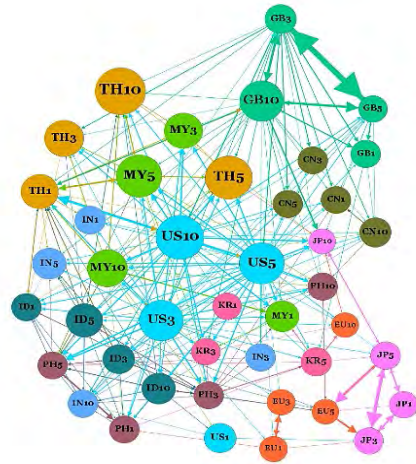
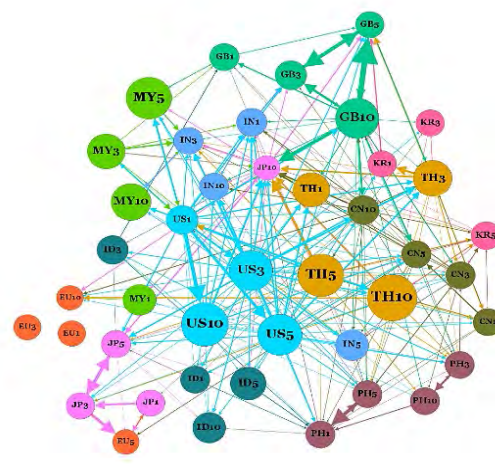
Panel C: Connectedness Estimated by Negative Panel Return

	ID	MY	PH	TH	JP	CN	IN	KR	US	GB	EU	FROM
ID	2.7335	0.2253	0.1258	0.1698	0.1094	0.1182	0.1233	0.0692	0.19	0.096	0.0394	1.2665
MY	0.1092	2.6945	0.0771	0.2151	0.082	0.1076	0.1786	0.0613	0.3061	0.1419	0.0266	1.3055
PH	0.1416	0.1178	2.7255	0.2275	0.0653	0.1677	0.1179	0.0698	0.2165	0.0972	0.053	1.2745
TH	0.0773	0.0934	0.1004	2.5171	0.0665	0.1759	0.1249	0.1127	0.465	0.2478	0.019	1.4829
JP	0.0891	0.1009	0.0764	0.1871	2.9307	0.1364	0.0694	0.0593	0.1953	0.0919	0.0634	1.0693
CN	0.0621	0.0793	0.1218	0.2203	0.0752	2.8478	0.0965	0.0736	0.2675	0.1202	0.0355	1.1522
IN	0.1169	0.2119	0.13	0.1966	0.0891	0.1501	2.6118	0.0651	0.2866	0.1091	0.0327	1.3882
KR	0.0358	0.0566	0.0663	0.1473	0.0471	0.0929	0.0542	2.1912	0.1945	0.0776	0.0366	0.8088
US	0.0797	0.1304	0.1068	0.1903	0.0697	0.1217	0.1054	0.0971	2.7445	0.3174	0.0369	1.2555
GB	0.0945	0.1018	0.0637	0.1652	0.0694	0.1291	0.1011	0.0797	0.5488	2.6223	0.0243	1.3777
EU	0.0517	0.0423	0.0769	0.0692	0.1064	0.0888	0.0405	0.0393	0.1104	0.0322	3.3422	0.6578
TO	0.8579	1.1599	0.9454	1.7885	0.7801	1.2883	1.0118	0.7272	2.7807	1.3313	0.3675	1.1853
NET	-0.4085	-0.1457	-0.3291	0.3056	-0.2892	0.1362	-0.3764	-0.0815	1.5252	-0.0463	-0.2903	

CN = People's Republic of China, EU = European Union, GB = United Kingdom, ID = Indonesia, IN = India, JP = Japan, KR = Republic of Korea, MY = Malaysia, PH = Philippines, TH = Thailand, US = United States.

Note: The results are estimated by generalized variance decomposition in equation (2-3) with T = 2,491 days, P = 1, H = 12.

Source: Authors' calculations.

Figure 5. Topological Network of Connectedness in Returns**(a) Full Panel, Connectedness****(b) Positive Panel, Net Connectedness****(c) Negative Panel, Net Connectedness**

GB = United Kingdom, ID = Indonesia, MY = Malaysia, PH = Philippines, TH = Thailand, JP = Japan, CN = People's Republic of China, IN = India, KR = Republic of Korea, US = United States, EU = European Union.

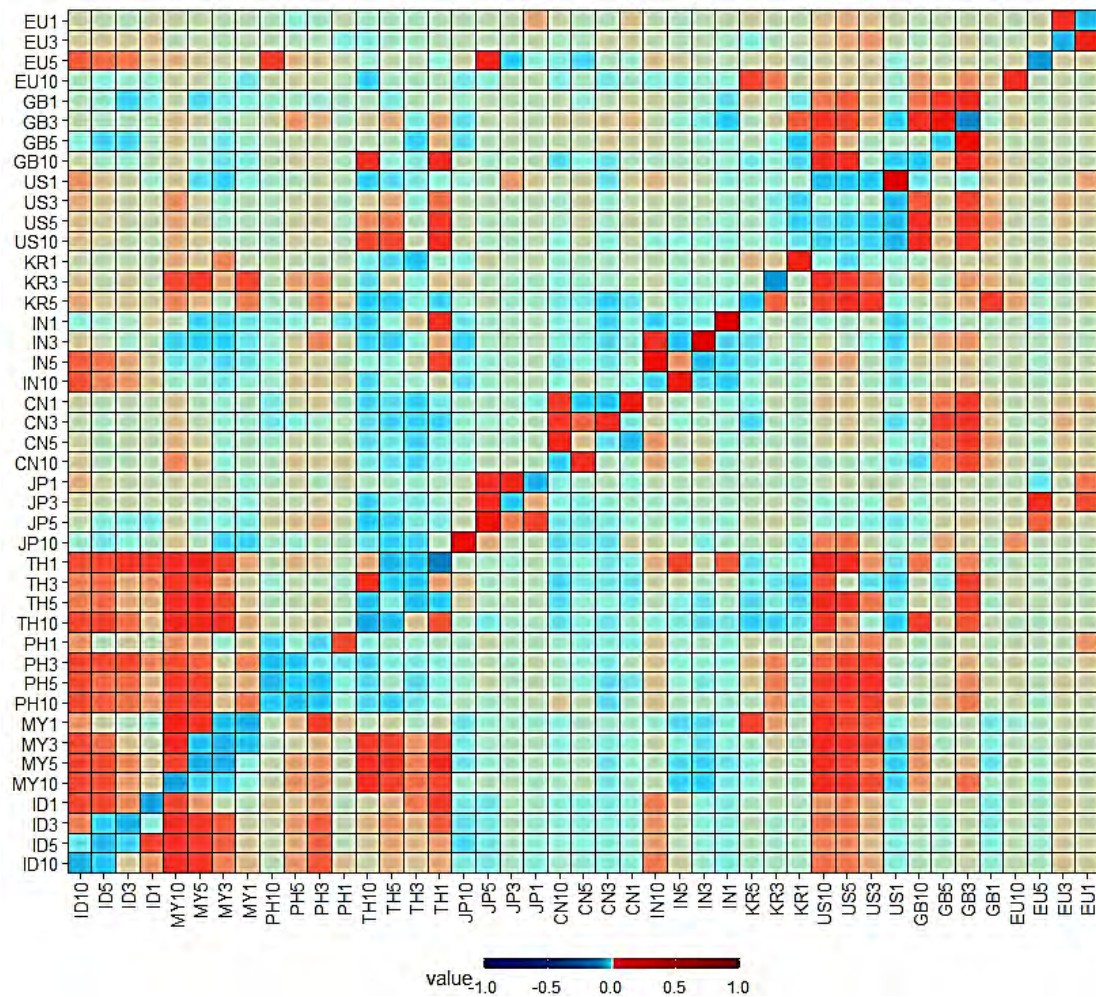
Notes: The color of the arrow denotes the source country of connectedness. The results are estimated by generalized variance decomposition in equation (2-3) with $T = 2,491$ days, $P = 1$, and $H = 12$. An arrow pointing from asset j to i reflects the increased variance value of target node i caused by a shock of output node j . To capture the essence of the networks, we filter the small connectedness, with only the top 300 links displayed. The thicker size and darker color of an arrow reflects the higher value of connectedness. A larger node reflects the higher value of degree. The nodes are named by the "country-maturity" of each bond.

Source: Authors' calculations.

In addition to examining the overall spillover, we also investigate the difference between spillover relationships in prosperous and turmoil markets by taking the difference of the connectedness estimated by positive and negative panels, as shown by the heatmap in **Figure 6**. Note that a positive value in this heatmap (colored by red) indicates that the spillover in a booming market is higher than that in a recession market, while a negative value in the heatmap (colored by blue) indicate that the spillover in a booming market is lower than that in a recession market.

Interestingly, we notice the blue entries near the diagonal line of the heatmap. This result indicates that the relationship between bonds with a small difference of maturities is stronger under a pessimistic market expectation. It tends to indicate that when the yield of a bond decreases, the adjustment of bond market will follow. The bond with a small difference of maturities is more likely to respond with a large decrease, indicating an asymmetric response to the negative shock compared with a positive response of equal magnitude. In addition, the decrease can be attributed to the adjustment of a bond maturity for safe-haven aims. The connectedness results between different ASEAN countries are mainly colored in red, and the connectedness from US bonds to ASEAN bonds are colored in red as well. This means that when the yield of a bond increases, the adjustment of the bond market will follow as well, albeit in an asymmetric fashion. The bond with a small difference of maturities is more likely to respond with a small increase, while bonds from different countries or those with a big gap in maturity are likely to respond with a big increase. Furthermore, when the world faces a homogenous positive prospect, the cross-country connectedness from the US to ASEAN is high. On the other hand, when the world is confronted with a negative shock, ASEAN bonds are less likely to be impacted by the US market. In addition, the impacts from Thailand to the Philippines and other non-ASEAN Asian countries are stronger under a pessimistic market expectation.

Figure 6. Connectedness Difference in Positive and Negative Panels



GB = United Kingdom, ID = Indonesia, MY = Malaysia, PH = Philippines, TH = Thailand, JP = Japan, CN = People's Republic of China, IN = India, KR = Republic of Korea, US = United States, EU = European Union.

Note: The results are obtained by taking the difference of the connectedness estimated by a positive return panel and a negative return panel, as shown by the heatmap. The x- and y-axis labels are named by the "country-maturity" of bond.

Source: Authors' calculations.

4.2 Dynamic Results of Asymmetric Connectedness

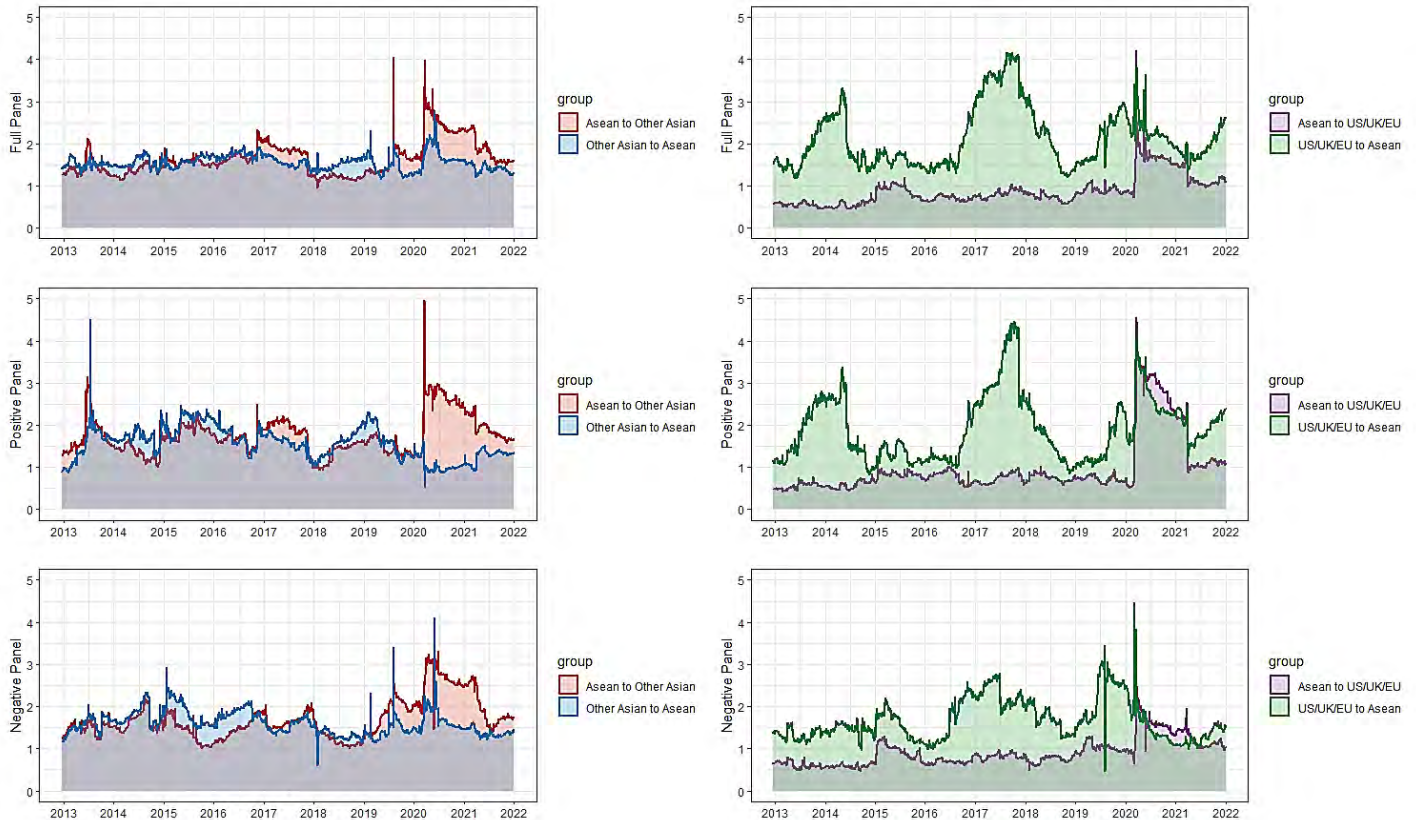
In the previous analysis, we considered the connectedness dynamics among the underlying assets in a static setting. However, it is well-documented in the literature that interconnectedness among the assets exhibit dynamic characteristics. Therefore, in this section, we turn to a more detailed analysis of spillovers between bond markets by utilizing a rolling window estimation.

Figure 7 plots the dynamic of intermarket connectedness estimated in the full panel, positive panel, and negative panel. The left three figures show the connectedness between ASEAN-4 and other underlying bond markets. From the graphs, we can make several key observations. First, before 2017, ASEAN and other non-ASEAN Asian markets exhibited bidirectional spillover, while the pessimistic expectation is the transmission from non-ASEAN Asian markets to ASEAN bond markets between 2015 and 2016, which could be associated with the contemporaneous crash of stock valuations in the PRC. In 2017, there was a higher value of connectedness spilling from ASEAN to other non-ASEAN Asian markets, rather than the opposite direction. From the asymmetric connectedness, we find that the optimistic investors' expectations transmitting between ASEAN and other non-ASEAN Asian markets significantly decreased, while the pessimistic spillover increased significantly. During 2018, the net connectedness indicated positive spillover from non-ASEAN Asian markets to ASEAN. In the beginning of 2020, corresponding with the outbreak of COVID-19, the optimistic expectation spillover increased from ASEAN to other non-ASEAN Asian markets, while the spillover decreased in the opposite direction. Meanwhile, negative connectedness increased in both directions, and ASEAN mainly acted as the exporter (instead of importer) of spillover. Since the outbreak of COVID-19 to 2022, ASEAN and other non-ASEAN Asian markets exhibit more asymmetric and nonlinear connectedness. ASEAN bonds are more pronounced in transmitting positive and negative spillover to other Asian markets, while they receive significantly less spillover from other underlying assets.

The three graphs on the right side of Figure 7 show the connectedness between ASEAN and three large developed markets—the US, the UK, and the EU. It is significant that ASEAN bonds are the receiver of spillover uncertainty, while the big markets always act as the transmitter of spillover. There are two peaks of the green line in the full panel, in 2014 and 2017. The strong spillover is mainly the result of the positive connectedness, which could be related to the recovery from the global financial crisis and the shift in US trade policy. After the outbreak of COVID-19, we report that the positive spillover from ASEAN to three developed markets increased

significantly and became higher than in the opposite direction. This implies that the turmoil in the global economy asymmetrically impacts the ASEAN bond market.

Figure 7. Global Connectedness



ASEAN = Association of Southeast Asian Nations, EU = European Union, UK = United Kingdom, US = United States.

Note: The results of connectedness are calculated by generalized variance decomposition in equation (2-3), estimated by a rolling sample panel of return, positive return, and negative return, with $T = 250$, $P = 1$, $H = 12$.

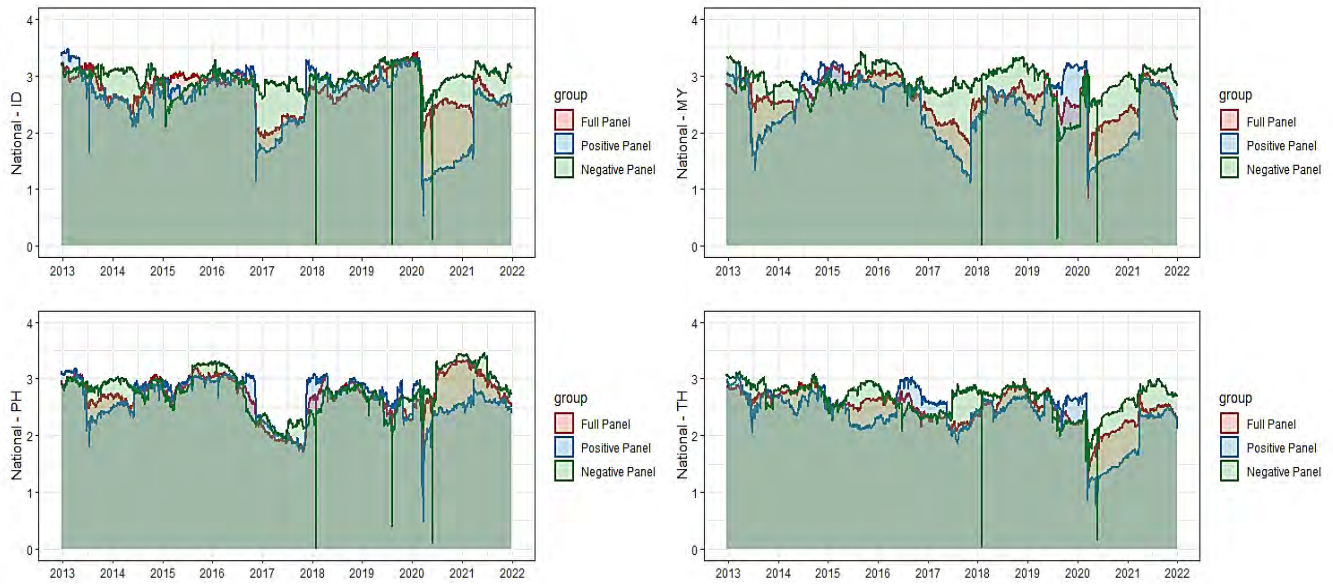
Source: Authors' calculations.

Figure 8 plots the dynamic of national connectedness in each ASEAN-4 country, estimated in the full panel, positive panel, and negative panel. In 2017, the national connectedness for the ASEAN countries declined. Considering the above evidence that the impacts from the three large developed markets to ASEAN increased, we find that the major shock of US trade policy weakened ASEAN markets' national bond connectedness. However, in Indonesia, Malaysia, and

Thailand, the impacts of US policy are not reflected by the negative panel: ASEAN bond yields increase because of US policy, while the lower bond yields are unrelated to US trade policy. Furthermore, in the year 2020, asymmetries in uncertainty spillover during the COVID-19 pandemic were grounded primarily to the market turmoil expectation of investment returns. This is indicative of the negative and asymmetric impact of the shocks on the risk transmission between ASEAN and other underlying bond markets.

Figure 9 shows the dynamics of connectedness between each ASEAN-4 country pairs, estimated in the full panel, positive panel, and negative panel. Note the connectedness shown in Figure 9 is the net value of connectedness, obtained by the difference of the two directions. It is clear that, in 2013, Indonesian bonds had positive impacts on the other three countries. After 2014, Malaysian bonds had overwhelming superiority regarding spillover to Indonesian bonds. In 2017, Indonesian bonds had a positive impact to Philippine bonds, while Philippine bonds had a lead-lag effect on the decline of yields for Indonesian bonds. During the COVID-19 pandemic, Thai bonds had positive impacts on the other three ASEAN-4 counties. The difference of these ASEAN countries shown in this pattern correlates well with their respective industrial revolution, digitalization speed, and trade relationships.

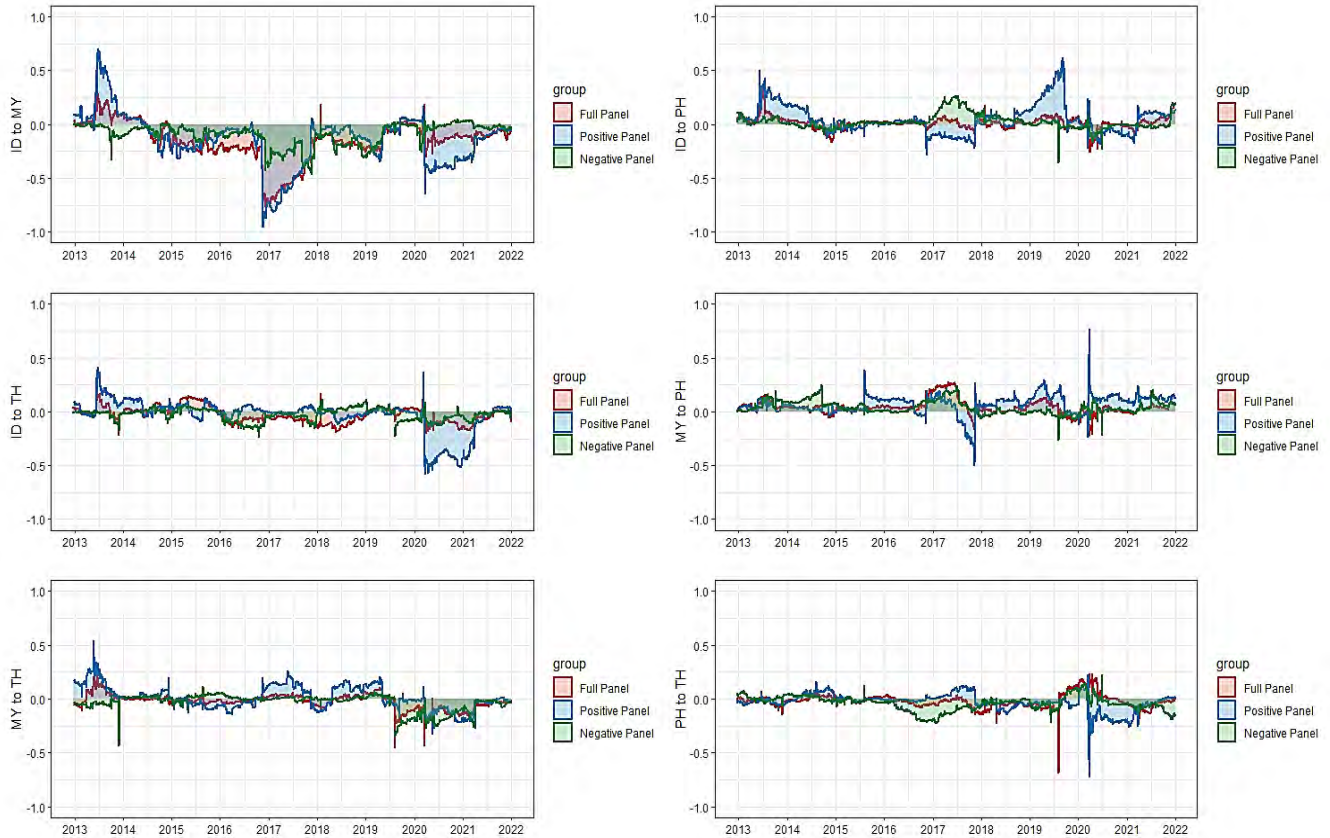
In addition, we find that ASEAN-4 connectedness is lower than 1.0, while national connectedness of each ASEAN-4 country is around 3.0. Global connectedness is more volatile than national and ASEAN connectedness, and sometimes the connectedness between the US, UK, and EU and ASEAN is higher than 4.0. In the national-level connectedness, we observe a domination influence of negative connectedness (i.e., the negative events play a more important role in determining the strength and direction of connectedness among the underlying markets).

Figure 8. National Connectedness

ID = Indonesia, MY = Malaysia, PH = Philippines, TH = Thailand.

Note: The results of connectedness are calculated by generalized variance decomposition in equation (2-3), estimated by rolling sample panel of return, positive return, and negative return, with $T = 250$, $P = 1$, $H = 12$.

Source: Authors' calculations.

Figure 9. ASEAN Connectedness

ASEAN = Association of Southeast Asian Nations, ID = Indonesia, MY = Malaysia, PH = Philippines, TH = Thailand.

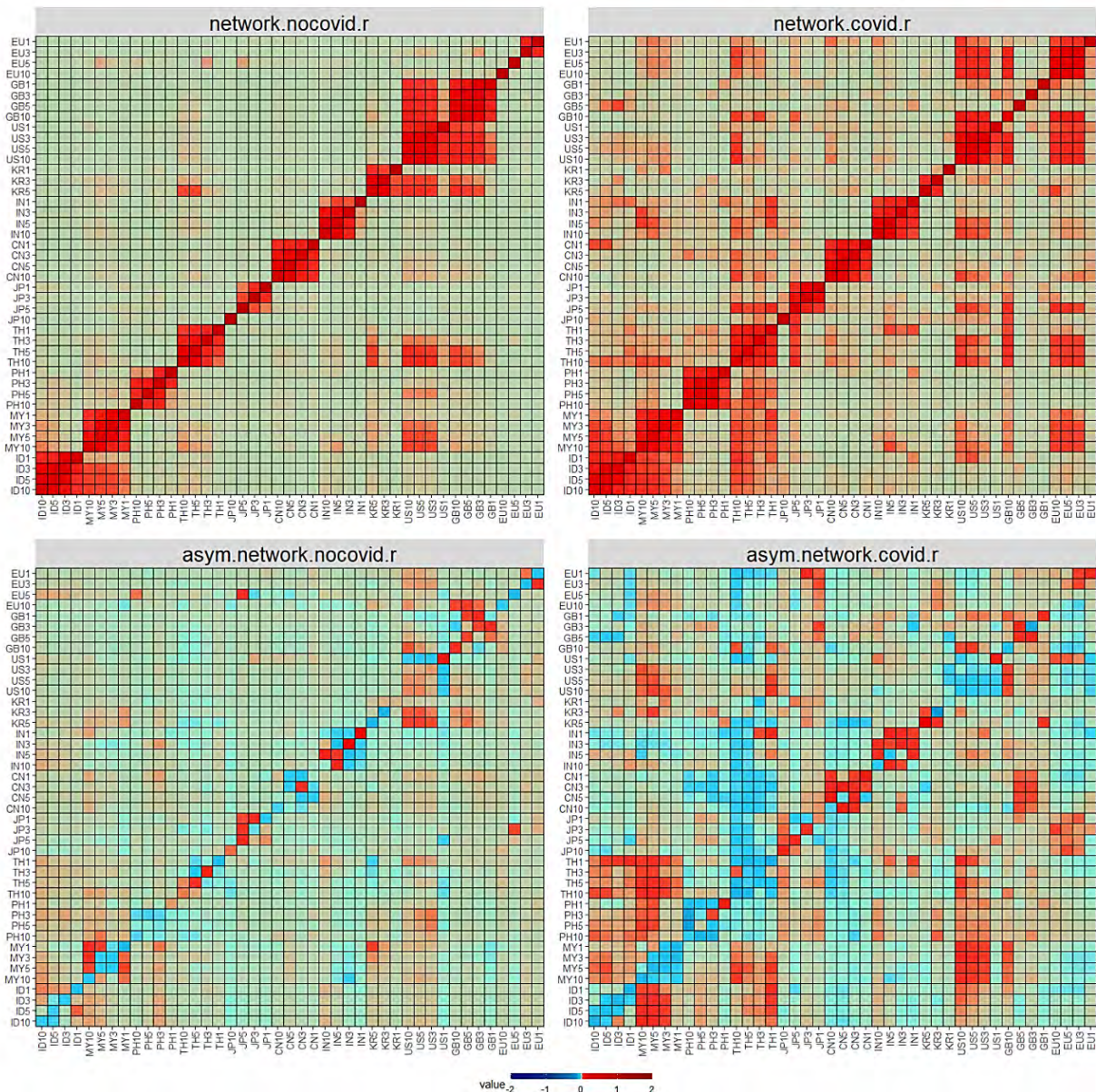
Note: The net value of connectedness between two countries is obtained by the difference of the two directional connectedness. The connectedness results are calculated by generalized variance decomposition in equation (2-3), estimated by rolling sample panel of return, positive return, and negative return, with $T = 250$, $P = 1$, $H = 12$.

Source: Authors' calculations.

Afterward, we compare the results of asymmetric connectedness before and after COVID-19. Before the pandemic, the connectedness matrix is dominated by domestic connectedness, while Thai, US, and EU bonds have more international and larger impacts on other underlying bond markets. After the outbreak of COVID-19, the spillover between bonds with different sovereignty and maturities is higher in the optimistic expectation, while Thai bonds and EU bonds exhibited more negative spillover to others after COVID-19. The reasoning behind the significant increase in international connectedness could be the homogenous trend of strained economic situation,

inflation, and reduced investment returns. The significant increase in the transmission of negative shocks for Thailand may be explained by the strong connectedness observed in the Thailand–US and Thailand–ASEAN pairs, as shown in both Figure 5 and **Figure 10**, thus indicating that Thailand plays a mediating role between ASEAN markets and developed markets.

Figure 10. Heatmaps of Connectedness Before and After COVID-19



ASEAN = Association of Southeast Asian Nations, CN = People's Republic of China, EU = European Union, GB = United Kingdom, ID = Indonesia, KR = Republic of Korea, MY = Malaysia, PH = Philippines, TH = Thailand, US = United States.

Note: We utilize daily data from 4 January 2012 to 2 December 2019 as the period before COVID-19 and utilize 2 December 2019 to 31 January 2022 as the period after COVID-19. The connectedness results (the upper two figures) are calculated by generalized variance decomposition in equation (2-3). The results of asymmetric connectedness (the lower two figures) are obtained by taking the difference of the connectedness of the positive and negative return panels. The x-axis and y-axis labels represent the “economy-maturity” of the bond.

Source: Authors’ calculations.

4.3 Drivers of Asymmetric Connectedness

In this section, we present the results of the analysis of factors impacting the relationship between ASEAN and other bond markets. For the panel regression, we take the quarterly average value of the rolling window connectedness results as the dependent variable. **Table 4** summarizes the panel regression results to show the primary driver influencing the connectedness between the US, UK, and EU and ASEAN-4 bond markets. Columns 1, 2, and 3, respectively, show the factors of connectedness between the US, UK, and EU and ASEAN in the full, positive, and negative panels; columns 4, 5, and 6, respectively, show the factors of connectedness from ASEAN to US, UK, and EU in the full, positive, and negative panels.

The coefficient of the CBOE VIX is positive and statistically significant, suggesting that volatility leads to the more active spillover of shocks across ASEAN and developed markets. By comparing columns 1-3 with 4-6, we find that the VIX has a significantly higher impact on the spillover from developed countries to ASEAN than in the opposite direction. This is in line with the results of Figure 7 that the “US, UK, and EU to ASEAN” connectedness has a higher value and change variance, indicating the risk-net-importer role of ASEAN bonds. Furthermore, we find significant effect of VIX in a prosperous market, while during market turmoil the “ASEAN to US, UK, and EU” connectedness is not significantly driven by the global fear sentiment. Alternatively, when the investors have a downward expectation of bond returns, an increase of global fear will not cause a significant change of spillover from ASEAN to developed markets.

Geopolitical risk reduces the connectedness from ASEAN to US, UK, and EU, and there is also a negative effect on the connectedness from the US, UK, and EU to ASEAN if there is

worldwide market turmoil expectation. The connectedness from the US, UK, and EU to ASEAN is not impacted by geopolitical risk in the full return panel, which can be attributed to geopolitical risk rarely occurring in ASEAN markets, while there is more political uncertainty and geopolitical shocks in US and European countries (Solarin et al. 2021, Caldara and Matteo 2022). When the US and European markets are shocked by geopolitical events, ASEAN receives smaller risk from the same event, causing the nonsynchronous dynamics of bond yields and lower connectedness. Białkowski et al. (2022) find that low-quality political signals, increased opinion divergence among investors, and exceptional equity market performance weaken the positive relationship between VIX and policy uncertainty. Our paper supplements these findings by providing detailed evidence regarding market-specific performance such as the downtrend of yield for all bonds and geopolitical risk counteracting the foster effect of VIX on connectedness.

In addition to these global drivers, we utilize macroeconomic fundamental variables to evaluate their impact on connectedness. If the PPI has a higher value, we expect that there will be inflation, economic growth, and prosperous investment returns in the market, while the connectedness with other countries may weaken because the strong internal drivers of the macroeconomy will soften the impact of international factors. The coefficient for the interaction is negative and highly significant in the full panel, while the insignificant coefficient for the “US, UK, and EU to ASEAN” connectedness in the negative panel indicates that the spillover from the US, UK, and EU to ASEAN will continue to be strong when there is market turmoil expectation with high inflation instead of an economic boom. Overall, these findings reflect the asymmetric behavior of the underlying drivers in capturing the dynamics of connectedness among the series.

In addition to these factors, we utilize data on the trade balance—the difference between the value of a country’s exports and imports—which exhibits significant and positive coefficients for all panels. It indicates that when ASEAN markets increase their trade surpluses, bond connectedness will increase at the same time. Trade is one of the most important risk contagion channels (Glick and Rose 1999, Forbes 2002, Abeyasinghe and Forbes 2005, Forbes and Warnock 2012). Direct trade between ASEAN and other countries is the basic mechanism for risk

spillover. For example, two companies linked by a supply chain could be highly connected in terms of political, operating, and default risk. The internationalization of ASEAN trade improves the degree of involvement in global trade networks. As an emerging region, ASEAN bonds have higher investment returns. A more international investment market attracts more foreign capital flows into ASEAN bond markets. During market turmoil, the effect of trade on connectedness is stronger. This result is in line with the findings of De et al. (2013) that being exposed to a country significantly increases the default risk connectedness, and this effect becomes stronger when the default risk of that country rises.

In the results of LCY-denominated government bond issuance, it is observed that a country with greater bond insurance has higher connectedness with global markets in the full panel and the negative panel. The underlying reason is that government bond issuance is related to the creation of domestic credit. A huge amount of new Treasury issuance could be related to the excess creation of domestic credit, typically prompted by a fiscal imbalance (Christoffel et al. 2021). The risk of fiscal imbalance leads to vulnerability in asset markets and the real economy. That also explains why the effect of government bond issuance is not significant in the positive panel: Market confidence based on expectation of economic and asset return growth weakens the threat of fiscal problems.

Finally, we examine the effect of the COVID-19 on connectedness. Surprisingly, in the full panel, a country with higher quarterly incremental COVID case has significantly lower connectedness with the US, UK, and EU. As shown in Figure 7 and Figure 10, the connectedness is higher during the COVID-19 period, which is in line with previous literature that COVID-19 intensified the spillover dynamics among countries. However, when the VIX and COVID-19 effects are examined simultaneously, the story becomes more complicated. As can be seen in Figure 10, after the outbreak of COVID-19, the global volatility expectation rapidly changed. Specifically, there was a jump in connectedness and almost simultaneously a jump in the VIX. Unlike the jump in VIX and connectedness, COVID-19 experienced several surges that were gradual. It indicates that the rapid increase of connectedness in the first quarter of 2020 was caused by the market

fear instead of the impact of COVID-19 on the real economy. More importantly, during the rapid investment adjustment, investors pulled their capital from countries with less ability for crisis management, a longer recovery duration, and less efficiency in COVID-19 control. In this way, a new COVID-19 surge further decreased the involvement of foreign capital.

Table 4. Connectedness Drivers between the US, UK, and EU, and ASEAN Bonds

	From US, UK, and EU to ASEAN			From ASEAN to US, UK, and EU		
	conn.r	conn.r.p	conn.r.n	conn.r	conn.r.p	conn.r.n
Conn_lag	0.1997*** (0.0302)	0.0431 (0.0468)	0.1755*** (0.0637)	0.1517*** (0.0313)	−0.0047 (0.0497)	0.1199* (0.0648)
VIX	0.0131*** (0.0016)	0.0254*** (0.0032)	0.0126*** (0.0031)	0.0076*** (0.0016)	0.0163*** (0.0035)	0.0033 (0.003)
GPR	0.0004 (0.0004)	0.0006 (0.0009)	−0.0014* (0.0008)	−0.0013*** (0.0005)	−0.002** (0.001)	−0.0024*** (0.0009)
PPI	−0.0012* (0.0006)	−0.0036*** (0.0013)	−0.0015 (0.0012)	−0.0015** (0.0007)	−0.0005 (0.0005)	−0.0026** (0.0012)
TB	0.0016*** (0.0006)	0.0039*** (0.0012)	0.0048*** (0.0011)	0.002*** (0.0006)	0.0016** (0.0007)	0.005*** (0.0012)
GB	0.0019*** (0.0007)	−0.0004 (0.0014)	0.0054*** (0.0013)	0.0018** (0.0007)	−0.0001 (0.0007)	0.0065*** (0.0014)
COVID-19	−0.0734*** (0.0274)	−0.1315** (0.0566)	−0.0821 (0.0525)	−0.0636** (0.0291)	−0.0784 (0.0576)	−0.0532 (0.0532)
Trend	0.008** (0.0033)	0.0096 (0.0065)	0.0106* (0.0059)	0.0119*** (0.0035)	0.0174** (0.0072)	0.0113* (0.0061)
Constant	−16.2603** (6.6169)	−19.0521 (13.0806)	−21.1989* (11.8977)	−23.7412*** (6.9494)	−34.8233** (14.413)	−22.2448* (12.3235)
Observations	144	144	144	144	144	144
R-squared	0.6177	0.3824	0.2998	0.564	0.3956	0.2608
Prob (F-statistic or chi2)	0.0471	0	0	0.0217	0	0
Fixed effects	Yes	Yes	Yes	Yes	No	Yes

ASEAN = Association of Southeast Asian Nations, GB = local-currency-denominated government bond issuance GPR = Geopolitical Risk Index, PPI = Producer Price Index, TB = trade balance, UK = United Kingdom, US = United States, VIXEEM = Volatility Index.

Note: The dependent variables conn.r, conn.r.p, conn.r.n are connectedness estimates in, respectively, full panel and positive panel with optimistic market expectation, and negative panel with pessimistic market expectation. COVID-19 refers to the quarterly average incremental number of COVID-19 cases in millions. ***= P-value < 1%, **= P-value < 5%, and *= P-value < 10%.

Source: Authors' calculations.

Table 5 shows the driver effects of the connectedness between other non-ASEAN Asian and ASEAN bonds. The fixed-effect panel regression shows significant positive coefficients of VIX, TB, and GB, and significant negative coefficients of GPR and COVID-19, which is consistent with the results between the US, UK, and EU, and ASEAN. The VIX has a higher effect on “the US, UK, and EU to ASEAN” connectedness than other non-ASEAN Asian and ASEAN connectedness. For the positive and negative panel of the connectedness from ASEAN to other non-ASEAN Asian markets, in columns 5 and 6, we can find that investor fear does not significantly intensify the connectedness when non-ASEAN Asian and ASEAN markets have the same expectation. As stated above, the full panel estimated connectedness includes the co-movement in same market expectation, as well as a competitiveness and substitute effect that capital flows between a pessimistic market and an optimistic market. The coefficients of VIX in columns 5 and 6 are not significant, indicating that more fear in the global market cannot intensify the co-movement between ASEAN and other non-ASEAN Asian markets, but it can result in a substitute strategy of capital. For GPR, which is only significant in columns 5 and 6, we infer that the co-movement between ASEAN and other non-ASEAN Asian bond markets is driven by the geopolitical risk sentiment and not stock market sentiment. The negative coefficient indicates that macroeconomic inflation and increased investment return will soften the impact of international factors. The negative effects of PPI on connectedness are stronger in the Asia panel than in the US, UK, and EU panel, which reflects that the connectedness between the US, UK, and EU and ASEAN is more stable and powerful, while Asian bonds are not impactful if ASEAN’s inflation and investment return is high. As can be seen in the TB coefficients, a higher trade surplus will significantly strengthen connectedness between ASEAN and other non-ASEAN Asian bond markets only when there is a co-movement in market expectation. Then, the impacts of GB on the other non-ASEAN Asian and ASEAN connectedness are stronger than in the US, UK, and EU panel, but only effective under pessimistic market expectation. Without the confidence of market participants, the risk of fiscal imbalance causes the vulnerability of ASEAN bond markets to respond to shocks from other Asian markets. Furthermore, we observe the negative significant

coefficient of COVID-19 in columns 3 and 6. The underlying reasoning could be related to the asynchronous surge of COVID-19 in non-ASEAN Asian and ASEAN markets. With the coexisting negative expectation in both non-ASEAN Asian and ASEAN markets, a new surge of the COVID-19 pandemic in an ASEAN country could disturb the synchronous change and co-movement, causing the decrease of connectedness.

Finally, we detect the autoregressive (1) effect of connectedness and R-square results in both Table 4 and Table 5. The regression in Table 5 has lower R-square results, indicating that the connectedness between non-ASEAN Asian and ASEAN markets cannot be explained very well by the global sentiments and ASEAN regional fundamentals. It could be attributed to the unsynchronous dynamics between Asian markets and large global markets. The higher coefficients in the autoregressive (1) effect in Table 5 indicate that the connectedness between non-ASEAN Asian and ASEAN markets are more stable, which is in line with the results in Figure 7. There are more risk-hedging opportunities between non-ASEAN Asian and ASEAN markets when the ASEAN markets have optimistic returns and high inflation. And when the global market is shocked by a major crisis, the investors who hedge ASEAN bonds with Asian bonds—instead of US, UK, and EU bonds—can avoid the sharp increase of spillover risk.

Table 5. Connectedness Driver—Between ASEAN and other non-ASEAN Asian Bonds

	From other non-ASEAN Asian to ASEAN			From ASEAN to other non-ASEAN Asian		
	conn.r	conn.r.p	conn.r.n	conn.r	conn.r.p	conn.r.n
Conn_lag	0.6294*** (0.1231)	0.2907*** (0.1022)	0.1024 (0.1196)	0.7003*** (0.1233)	0.2715** (0.1064)	0.0823 (0.1184)
VIX	0.0092*** (0.0026)	0.0099*** (0.0035)	0.0103** (0.0039)	0.0045* (0.0025)	0.0046 (0.0037)	0.0033 (0.004)
GPR	0.0004 (0.0007)	−0.0014 (0.001)	−0.0018 (0.0011)	−0.0011 (0.0007)	−0.0022** (0.0011)	−0.0027** (0.0012)
PPI	−0.0022** (0.001)	−0.0061*** (0.0014)	−0.0057*** (0.0016)	−0.0021** (0.001)	−0.0053*** (0.0015)	−0.0074*** (0.0017)
TB	−0.0001 (0.001)	0.0042*** (0.0014)	0.0067*** (0.0016)	0.0001 (0.001)	0.0034** (0.0014)	0.0067*** (0.0016)
GB	0.0016 (0.0011)	−0.0005 (0.0016)	0.0086*** (0.0018)	0.0014 (0.0011)	−0.0006 (0.0017)	0.0087*** (0.0018)

	From other non-ASEAN Asian to ASEAN			From ASEAN to other non-ASEAN Asian		
	conn.r	conn.r.p	conn.r.n	conn.r	conn.r.p	conn.r.n
COVID-19	−0.0274 (0.0452)	−0.0944 (0.0625)	−0.1899*** (0.0705)	−0.0443 (0.0455)	−0.0445 (0.0656)	−0.1574** (0.0722)
Trend	0.0087* (0.0052)	−0.0039 (0.0074)	0.0071 (0.0084)	0.0135** (0.0052)	−0.0022 (0.0077)	0.0085 (0.0085)
Constant	−17.4102* (10.4097)	8.9672 (14.9549)	−13.3519 (16.9972)	−26.8382** (10.4689)	5.5878 (15.4089)	−15.8118 (17.044)
Observations	144	144	144	144	144	144
R-squared	0.3522	0.1211	0.4417	0.3674	0.0871	0.4098
Prob (F-statistic)	0.0122	0	0.0006	0.0343	0.0145	0.0003
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

ASEAN = Association of Southeast Asian Nations, GB = local-currency-denominated government bond issuance, GPR = geopolitical risk index, PPI = producer price index, TB = trade balance, VIX = volatility index.

Note: The dependent variables conn.r, conn.r.p, conn.r.n are connectedness estimates in, respectively, full panel and positive panel with optimistic market expectation, and negative panel with pessimistic market expectation. Notes: COVID-19 refers to the quarterly average incremental number of COVID-19 cases in millions. ***= P-value < 1%, **= P-value < 5%, and *= P-value < 10%.

Source: Authors' calculations.

5. CONCLUSION

The surge in the interdependence between ASEAN and international markets has raised questions about the nature of bond spillover and what factors can explain such spillover risk. This study investigates the spillover risk network of bond markets in four ASEAN markets—Indonesia, Malaysia, the Philippines and Thailand; four non-ASEAN Asian markets—the PRC, Japan, the Republic of Korea, and India; and three developed markets—the US, UK, and EU. To construct the spillover network, we adopt the asymmetric connectedness measurement under substituted investment capital flows (or co-movement in and uptrend or downtrend).

We find evidence from the static horizon that domestic connectedness within each ASEAN country dominated the network when there is no significant uptrend (growth) or downtrend (recession). Specifically, our study shows the spillover risk between bonds with a small difference in maturities are stronger under a pessimistic market expectation. Moreover, we find that US

bonds are the major risk net exporter in all the three panels. In the dynamic results, we find an equality of connectedness between ASEAN and non-ASEAN Asian markets in a positive panel before 2017. There is pessimistic expectation transmission from non-ASEAN Asian markets to ASEAN markets in 2015 and 2016, which could be related to the crash in stock valuations in the PRC at this time. There are two peaks of the connectedness from developed countries (US, UK, and EU) to ASEAN in the full panel. We also find that the big shock of changes to US trade policy weakened national bond connectedness. After the breakout of COVID-19, there was a significant increase in international connectedness. Besides, we find that the positive spillover from ASEAN to the three developed large markets jumped to exceed spillover in the opposite direction. The implication is that when the global economy was confronted with serious threats, ASEAN bonds injected positive hedging into the three big markets. For the drivers of connectedness, results show significant positive coefficients of VIX, trade balance, and government bond issuance, and significant negative coefficients of geopolitical risk and COVID-19. One of the interesting findings is that the positive coefficient of government bond issuance is not significant under an optimistic expectation, which may be because the strong confidence in economic and asset return growth weakens the threat of potential fiscal problems.

This study will be valuable to both international and domestic investors participating in sovereign bond markets. A cross-country diversification with developed and emerging bond markets could be useful in risk-hedging and a safe-haven strategy. The results of driving forces on the spillover can also guide projections of investment performance and help risk regulators deal with potential financial risk under the heightened uncertainty caused by shocks such as COVID-19 and geopolitical conflicts.

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Asymmetric Spillovers in ASEAN Bond Markets

This study aims to estimate and evaluate the intensity and directionality of bond market connectedness between Association of Southeast Asian Nations (ASEAN) and major regional and global markets and to identify factors impacting the interconnectedness dynamics among these markets. It derives an uncertainty connectedness measure grounded on the attributes of static and dynamic dependence frameworks and empirically evaluates its role in transmitting or receiving shocks based on various information spillover and contagion channels. The findings of this study have important implications for market participants, regulators, and policymakers.

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