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Have Dynamic Spillovers and the Connectedness of Trade Policy Uncertainty Changed During the COVID-19 Pandemic and Sino–US Trade Frictions?

Chien-Chiang LEE[*]

School of Economics and Management, Nanchang University, Nanchang, China
Research Center of Central China for Economic and Social Development, Nanchang University, Nanchang, China

Farzan YAHYA[*]

College of Finance and Economics, Nanchang Institute of Technology, Nanchang, China

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Abstract: *In this paper, we examine the spillover and connectedness between the trade policy uncertainty (TPU) of the United States (US), China, Japan, and the Republic of Korea (henceforth, Korea) under global geopolitical risk (GPR), infectious disease equity market volatility (EMVID), and GPR from North Korea (GPRNK) using a relatively novel time-varying parameter vector autoregression (TVP-VAR) approach. Additionally, method of moments quantile regression is utilised to estimate the asymmetric effect of GPR, GPRNK, and EMVID on TPU. Our findings suggest that there is a high total and directional spillover amongst underlying variables during Sino–US trade friction that further elevated during the coronavirus disease (COVID-19) pandemic period. The US is a net receiver of spillover from the TPU of all economies, while the Chinese TPU receives spillover from EMVID. The results further confirm that both the TPU of China (TPUCN) and the TPU of the US (TPUUS) are vulnerable to EMVID, but the effect is stronger for Chinese TPU in the higher quantiles. Although Japanese TPU is less vulnerable to GPR and EMVID, it is significantly exposed to GPRNK. Korean trade shows resiliency and immunity to pandemic-induced volatility and GPRNK.*

Keywords: Trade policy uncertainty, global geopolitical risk, Sino–US trade friction, COVID-19 pandemic

[*] Corresponding author. Email: cclee6101@gmail.com
ORCID: 0000-0003-0037-4347
[*] Corresponding author. Email: farzan.yahya@yahoo.com
ORCID: 0000-0001-5666-1279

1. Introduction

A high probability of a trade war generally restrains international sellers from developing long-term trade contracts with domestic buyers in other countries. Trade tensions between the United States (US) and China have greatly impacted their allies and neighbouring countries, leading to trade agreement uncertainty and a rise in trade policy uncertainty (TPU) (Kwan, 2020). The rise in TPU increases the costs of buying and pushes firms into piling up inventory (Handley and Limão, 2022). The escalated US–China tensions have significantly disrupted the global supply chain, leading to a lose–lose situation for the global economy (Ongan and Gocer, 2020). The US government's plan to reinvigorate its manufacturing sector by decreasing reliance on foreign resources has levied several tariffs on Chinese imports, intensifying the trade war (Boylan, McBeath, and Wang, 2021). The pandemic has exacerbated TPU by negatively affecting consumer spending and investor confidence, and increasing the rate of downsizing (Caldara et al., 2020). Thus, there is a need to thoroughly investigate how trade wars and pandemic-induced uncertainty are worsening the TPUs of key trading nations, an aspect that has not garnered sufficient attention (Narayan, 2021).

The Sino–US trade war reached a new level after US President Donald Trump imposed several trade barriers and tariffs on China in an effort to address the US–China trade deficit. To promote domestic manufacturing, the US took retaliatory actions to discourage Chinese exports to the US (Bown, 2021). Accordingly, the entry rate of new Chinese firms declined by 0.18% due to US import tariffs, resulting in a 6.13% reduction in new business establishments (Cui and Li, 2021), and China's overall exports to the US reduced by 52.3% (Li, Balistreri, and Zhang, 2020). This action has not only damaged the US and Chinese markets (Burggraf, Fendel, and Huynh, 2020) but also elevated the global geopolitical risk (GPR), which substantially increased the volatility of equity markets in the Republic of Korea (henceforth, Korea) and Japan (Choi, 2022). Although Japan is the closest US ally in the East Asian region and bilateral trade in goods is not sensitive to uncertainty (Ongan and Gocer, 2022), Japanese affiliates in China and their parent firms saw a significant drop in stock prices and a decline in sales from 2017 to 2020 (Zhang, 2021).

Owing to the high US import tariffs, China enhanced its penetration of Mexico, Canada, and the European Union (EU) to sustain its trade flows. Meanwhile, Korea displaced China's exports to the US, gaining a certain level of benefit from the trade war (Li, Balistreri, and Zhang, 2020). However, amid the US–Chinese trade conflicts, trade disputes between Korea and Japan arose and incurred large welfare losses for both countries (Shin and Balistreri, 2022). These trade conflicts significantly disrupted the supply chain and trade flow amongst the US, China, Korea, and Japan. From being major trade partners to trade rivals, the US–China trade tensions significantly changed the dynamics of their trade policies. Besides higher connectedness amongst these countries, we assume that the trade policy uncertainty of the US (TPUUS) received spillover from all its trading partners.

The current account imbalances and trade barriers were exacerbated by the coronavirus disease (COVID-19) pandemic. Despite the trade agreement,[1] China was unable to achieve purchase targets in the wake of COVID-19 (Boylan, McBeath, and Wang, 2021). The pandemic negatively influenced consumer spending, reduced investor confidence, and increased the rate of downsizing (Caldara et al., 2020), which exaggerated TPU. Nonetheless, despite pandemic-induced supply chain disruptions and efforts to de-globalise China, the country tightened its geographical, political, demographic, and economic ties with other countries (Hayakawa and Imai, 2022; Mukherji, 2021). For example, China accounts for almost 90% of North Korea's trade. However, the US considers North Korea a major threat to global peace and is striving to destabilise its nuclear weapons. Additionally, inter-Korean relations have been sour since 1950 when North Korea attacked the Republic of Korea with the help of China and the former Soviet Union. They still exchange warnings shots from time to time across the border (Choi and Shin, 2022).

Furthermore, Japan and North Korea have no diplomatic ties and their relations are deteriorating due to concerns over North Korea's abductions of Japanese citizens and Pyongyang's nuclear weapons programme (Easley, 2022). In April 2017, both the US and China agreed to deal with Kim's aggression at a meeting in Florida and to influence North Korea's diplomatic stance, potentially through diplomatic pressure or negotiation. However, the Trump administration escalated tensions with both China and North Korea. Consequently, the Chinese administration withdrew its willingness to contain Kim Jong-Un's nuclear ambitions (Larres, 2020). Due to the diverging role of North Korea, a higher probability of North Korean GPR is directly connected with the TPU of its neighbouring countries. Accordingly, we analyse the spillover effects and connectedness for the TPU of China, Japan, Korea, and the US under the influence of global GPR, geopolitical risk from North Korea (GPRNK), and infectious disease equity market volatility (EMVID). The second objective of the study is to estimate the non-linear relationship between EMVID, GPR, GPRNK, and TPU in the US, China, Korea, and Japan.

Especially under the post-COVID-19 era, trade policies have undergone several changes, elevating the trade uncertainties further due to the power plays and sanctions of some countries

[1] The US and China took steps to improve trade relations, culminating in a trade agreement reached in January 2020. As part of the deal, China committed to increasing its imports of US agricultural goods.

to promote domestic markets (Sun et al., 2022). Since China was hit hardest by COVID-19, along with US sanctions, the trade policies of China are more likely to be affected by COVID-19 compared with the US or its allies. Although international trade largely plunged in 2020, a recovery can be observed in 2021. Thus, the effect of COVID-19 is not homogenously distributed across TPU distribution. Additionally, GPRs add fuel to uncertainties and increase the probability of trade wars.

The primary contributions of the study are twofold. First, this paper seeks to incorporate EMVID and GPRNK into the TPU of the US, its allies (Korea and Japan), and China to examine the trade interdependency under GPRs and the pandemic period using a novel time-varying parameter vector autoregression (TVP-VAR). While the geopolitical and economic significance of Japan and Korea has been widely acknowledged, existing research has primarily concentrated on the interaction between the trade and economic policy uncertainties of China and the US. In contrast, the interconnectedness of the TPUs of Japan and Korea has received less attention. Furthermore, the potential impact of external risks such as EMVID and GPRNK on trade activities and global supply chains cannot be ignored. However, there is a notable gap in the literature as no prior research has attempted to investigate the relationship between these external risks and TPUs. Since the underlying variables change over time, TVP-VAR can capture changes in the relationship between the variables that are not captured by traditional VAR models, which assume that the parameters are constant over time.

Second, this study utilises a novel non-linear technique, i.e. method of moments quantile regression, to estimate the asymmetric effect of EMVID, GPRNK, and GPR on TPU. We propose that during times of high EMVID and GPRs, the uncertainty surrounding trade policy is more extreme, with both higher levels of uncertainty for pessimistic outcomes and lower levels of uncertainty for optimistic outcomes. This may lead to more cautious or reactive trade policy decisions, as policymakers may be more risk-averse in uncertain times. The existing literature does not provide a clear understanding of the relationship between TPU and the asymmetric impact of GPRs and pandemic-induced uncertainty.

The remaining parts of the paper are as follows. Section 2 presents the literature review and theoretical model. Section 3 introduces the methodology used herein. Section 4 discusses the empirical results. Section 5 presents the research conclusions and policy recommendations.

2. Literature Review

The current study is an investigation of the spatial network of TPU across the US, China, Korea, and Japan under GPR (global and North Korean) and pandemic-induced volatility. Based on the externality theory, previous studies have discussed the spatial dependence and spillover of policy uncertainty shocks between countries (Chiang, 2020; Gabauer and Gupta, 2018; Liow, Liao, and Huang, 2018). The international spillover of policy uncertainty mainly influences economies through three major channels, i.e. a firm's production planning[2] (Baker, Bloom, and Davis, 2016), the real exchange rate[3] (Wei, 2019; Khan et al., 2024), and financial markets[4] (Chiang, 2020; Li, Zhang, and Li, 2022). Previously, Huang et al. (2018) examined the interconnectedness of policy uncertainties between the US and China using the vector autoregression (VAR) framework and found that the direction of spillover ran from the US to China. We investigate the spatial spillover further by including Korea and Japan, which are major US trading partners. Additionally, it is not clear in the previous literature if the spillover effects amongst the US and East Asian countries are influenced by pandemic and global (regional) GPR.

A wide range of empirical studies has linked the detrimental effect of global trade wars and uncertainty with capital markets, employment opportunities, economic activities, investments, exports, tariffs, commodity prices, and firms' entry or expansion decisions (Baker et al., 2019; Huynh, Nasir, and Nguyen, 2023; Ren, Zhong, and Gozgor, 2022; Steinberg, 2019; Sui, Raza, and Zhang, 2022; Sun et al., 2021; Lee, Yan, and Wang, 2024). However, there are fewer studies related to the cause and effect of TPU. Existing studies on TPU can be mainly divided into two strands. The first strand of studies has empirically discussed the influence of TPU on macroeconomic indicators. The second strand of literature has examined the effect of TPU on asset returns.

Empirical evidence shows the destructive effect of high TPU on investment, output, and trade. For instance, Caldara et al. (2020) developed an aggregate measure of TPU based on tariff rates, a firm's earning calls, and newspaper coverage; and found its detrimental effect on business investment in the US. Using non-linear Granger causality estimations, Olasehinde-Williams (2021) posited that TPUUS is a significant predictor of global output volatility. Imbruno (2019)

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[2] Investment costs are substantially irreversible. Once production units are installed, the value of capital becomes minimal unless production is activated. Thus, firms become cautious of their production planning with changes in economic or trade policies.

[3] Policy uncertainty increases the volatility of exchange rates, causing trade imbalances. The price of goods and services increase with the increase in exchange rates. Accordingly, exports become expensive for other countries while imports become cheaper.

[4] Initially, the stock prices of domestic firms capture policy uncertainty, which spreads across international markets.

found that the decline in TPU promotes market-seeking foreign direct investment and high-quality foreign goods in China. Similarly, Zhou and Wen (2022) pointed out that high TPU reduces the intensive and extensive margins of Chinese firms' exports due to cost shock vulnerability. Crowley, Meng, and Song (2018) examined the time-variation of product-level TPU in Chinese firms and showed that firms are more likely to exit and less likely to enter a foreign market when TPU is high. Sun, Zhou, and Yu (2020) also showed that the decrease in regional TPU improves outward foreign direct investment in China. Furthermore, a reduction in TPU improves labour market stability (Li, Luo, and Zhong, 2022). A significant influence of TPU on agricultural trade and commodities is also observed in previous studies (Gopinath, 2021; Sun et al., 2021; Liu, Zheng, and Lee, 2024).

Concerning firm- and market-level evidence, Ren, Zhong, and Gozgor (2022) analysed the impact of TPU on a firm's stock price crash risk based on A-share Chinese listed tourism firms from 2002 to 2020. They revealed that TPU significantly affects the stock price crash risk by hoarding negative management and bad company formation news. Gozgor et al. (2019) reported a time-varying and negative correlation between TPU and bitcoin returns using the wavelet analysis technique. On the other hand, Kyriazis (2021) revealed a positive effect of TPU on bitcoin prices. Hau et al. (2022) analysed the causality and dependence between rare earth metal prices and TPU. They revealed a positive effect of TPU on rare earth prices in the US but a negative effect for China. Additionally, the effect varies across different market conditions. Li, Zhang, and Li (2022) also asserted a negative impact of TPUUS on equity returns through trade and investor sentiment channels. Similarly, based on generalised autoregressive conditional heteroskedasticity (GARCH) with generalised error distribution, Chiang (2020) provided evidence of TPUUS spillover to Japanese, Chinese, and European equity markets. Hoque et al. (2022) examined the spillover of US, Chinese, and Japanese TPU on the stock markets of fragile economies – Turkey, South Africa, Mexico, Indonesia, and Colombia. Using vector autoregressive dynamic conditional correlation generalised autoregressive conditional heteroskedasticity (VAR-DCC-GARCH), they reported that China and the US are net shock transmitters of TPU while Japan is a net receiver.

Although TPU as a predictor is analysed empirically, the potential determinants of TPU are underexplored, especially under the non-linear framework. Additionally, Korean and Japanese TPU is largely ignored in the literature despite their strong bilateral relationship with the US and strategic importance in the Eastern Asian region. At a broader level, economic policy uncertainty (EPU) has received more attention than its individual components. To date, only two studies have examined the determinants of cross-country EPU spillover (according to our best knowledge). The first study by Balli et al. (2017) found trade and common language as important factors explaining EPU spillovers. The second study by Jiang et al. (2019) found that investor sentiment, exchange rate, and bilateral trade can explain cross-country US–China EPU spillover. By exploring these determinants further, we argue that the transmission of COVID-19-induced shocks largely disrupted supply chain linkages, especially during the first wave of the pandemic (Kejžar, Velić, and Damijan, 2022; Zhang,Tian, and Lee, 2024), which exaggerates the TPU.

Another important factor that influences TPU is GPR. As an indication of high trade wars, Gupta et al. (2019) revealed that GPR negatively affects trade flow using a gravity model. Furthermore, GPR adversely affects the consumer confidence of import-oriented countries and the producer confidence of export-oriented countries (Pehlivanoğlu, Akdağ, and Alola, 2021; Lou et al., 2024). Since East Asian countries are employed in this study, the role of regional GPR (GPRNK) is also of crucial importance, besides global GPR. Nonetheless, there is little empirical evidence on how GPRNK influences policy uncertainty. GPRNK led to a reduction in stock market returns, especially for domestic and Asian markets (An and Roh, 2018; Jung, Lee, and Lee, 2021). Nevertheless, most of these studies are conducted under the linearity framework. However, recent evidence has revealed the asymmetric and non-linear effect of the COVID-19 pandemic and GPR. COVID-19 behaves differently in low and high volatility regimes or under different market conditions (Ahmed and Sarkodie, 2021; Qin et al., 2020). However, it is not clear from the previous literature if pandemic-induced volatility and GPRs follow heterogeneous patterns under low and high TPU. This study may help in monitoring and analysing the cross-county transmission of trade policy shocks for countries with deep-seated economic and financial integration as well as trade linkages.

3. Methodology

3.1. Data Description

Our data set contains monthly time series data for the TPU of the US (Caldara et al., 2020); China (Davis, Liu, and Sheng, 2019); Japan (Saxegaard et al., 2022); and Korea (Cho and Kim, 2023). The TPU indexes developed by the respective authors rely on news indices that can provide valuable information on companies' perceptions. These indices calculate the proportion of newspaper articles discussing trade policy that feature specific keywords associated with TPU. Common trade policy keywords encompass terms such as tariffs, quotas, trade policy, and anti-dumping. On the other hand, keywords related to uncertainty include risk, uncertain, unpredictable, and unstable, amongst others.

Additionally, we employed the global GPR index (Caldara and Iacoviello, 2022), which is also based on a newspaper search and organised into eight categories, e.g. war threats, peace threats, military build-ups, etc. For GPRNK, Jung, Lee, and Lee (2021) adopted the methodologies of Baker, Bloom, and Davis (2016) and Caldara and Iacoviello (2022) and employed published articles from 18 Korean newspapers. They analysed four major types of GPR: economic cooperation, talks and agreements, sanctions, and military tensions. Lastly, EMVID by Baker et al. (2020) is used, which was developed from almost 3,000 US newspapers. Examples of keywords include economic, stock market, volatility, epidemic, pandemic, coronavirus, etc. Based on the data available from Economic Policy Uncertainty (https://www.policyuncertainty.com/index.html), we cover the period from January 2000 to December 2021. Descriptive statistics of the variables are in Table 1.

Table 1: Summary Statistics

Variable	TPUUS	TPUCN	TPUJPN	TPUKOR	GPRNK	GPR	EMV_ID
Mean	121.843	149.286	138.735	91.117	109.222	102.528	2.539
Std. Dev.	214.803	213.201	119.174	69.543	52.102	51.525	8.023
Min	7.673	0.000	26.291	22.501	35.000	45.060	0.000
Max	1,946.683	1,425.200	622.518	498.791	329.000	512.530	65.210
Skewness	4.401	2.860	2.034	2.610	1.423	4.689	5.010
Kurtosis	28.538	12.794	6.799	12.845	5.126	33.223	30.893
JB test	7,935***	1,399***	336.9***	1350***	137.2***	11,000***	9,553***
SW test	0.487***	0.641***	0.731***	0.755***	0.882***	0.594***	0.382***
ADF	-3.269**	-2.812*	-2.819*	-4.562***	-3.691***	-5.219***	-3.68***
PP	-5.699***	-6.13***	-4.776***	-6.899***	-4.919***	-6.243***	-5.701***

ADF = Augmented Dickey-Fuller stationarity test, EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea, JB = Jarque-Bera test, PP = Phillips–Perron test of stationarity, SW = Shapiro-Wilk test, TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.

Notes: N = 264. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' calculations using data from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

The data show that the average TPU of China is the highest amongst the countries while the volatility or standard deviation of both China and the US is higher than Korean and Japanese TPU. Skewness and kurtosis values show that most of the variables are positively skewed and follow a leptokurtic distribution. The normality of the variables is also rejected by the Jarque-Bera and Shapiro-Wilk tests at the 1% confidence interval. Lastly, the Augmented Dickey-Fuller and Phillips–Perron stationarity tests show that all variables are stationary at level.

3.2. Estimation Methods

Following the studies of Jiang et al. (2019); Yang, Niu, and Gao (2022); and Gabauer and Gupta (2018), we utilise the TVP-VAR approach to estimate the spillover level between TPU, GPR, and EMVID. The methodology will help us understand how trade policy shocks propagate spatially with the spillover effect of country i to country j. Diebold and Yilmaz (2009) proposed a measure to estimate connectedness through variance decomposition of the forecast error variance from a covariance stationary VAR, which can be written as follows:

$$y_t = \sum_{i=1}^{p} \emptyset_i \, y_{t-i} + \epsilon_t \tag{1}$$

where $y_t = (TPUUS_t, TPUCN_t, TPUJPN_t, TPUKOR_t, GPR_t, GPRNK_t, EMVID_t), \epsilon_t$ is white noise, and $\emptyset_i$ stands for parameter matrices. Antonakakis and Gabauer (2017) extended the original model by allowing the variances to vary via a stochastic volatility Kalman Filter estimation with forgetting factors:

$$y_t = \beta_i z_{t-i} + \epsilon_t \; \epsilon_t | F_{t-1} \sim N(0, S_t) \tag{2}$$

$$vec(\beta_t) = vec(\beta_{t-1}) + v_t \; v_t | F_{t-1} \sim N(0, R_t) \tag{3}$$

where y_t and $z_{t-i} = (y_{t-1}, \dots, y_{t-p})'$ represents $N \times 1$ and $N\,p \times 1$ dimensional vectors, respectively. β_t is an $N \times N\,p$ dimensional time-varying coefficient matrix and ϵ_t is an $N \times 1$ dimensional error disturbance vector with an $N \times N$ time-varying variance-covariance matrix, $S_t . vec(\beta_t), vec(\beta_{t-1})$, and v_t are $N^2 p \times 1$ dimensional vectors and R_t is an $N^2 p \times N^2 p$ dimensional matrix. The VAR model is remodelled into a vector moving average (VMA), as suggested by Pesaran and Shin (1998):

$$y_t = \sum_{j=0}^{\infty} L' W_t^j L \varepsilon_{t-j} \tag{4}$$

$$y_t = \sum_{j=0}^{\infty} A_{it} \varepsilon_{t-j} \tag{5}$$

where $L = [M_N, \dots K_p]'$ is an $P \times N$ dimensional matrix, $W = [\alpha_t M_{P-1}, \dots K_{(P-1)\times N}]'$ is a $P \times P$ dimensional matrix. Following a shock in variable *i*, generalised impulse response functions (GIRFs) are responses of all variables. The calculation involves determining whether variable *i* is shocked or not in the H-step ahead forecast, and this difference can be expressed as:

$$GIRF_t = E(Z_{t+H} | \varepsilon_{j,t} = \delta_{j,t}, F_{t-1}) - E(Z_{t+H} | F_{t-1}) \tag{6}$$

$$\Psi_{j,t}^{g}(H) = \frac{A_H \sigma_t^2 \varepsilon_{j,t}}{\sqrt{\sigma_{jj,t}^2}} \frac{\delta_{j,t}}{\sqrt{\sigma_{jj,t}^2}}, \delta_{j,t} = \sqrt{\sigma_{jj,t}^2} \tag{7}$$

$$\Psi_{j,t}^{g}(H) = \sigma_{jj,t}^{-1} A_{H,t} \sigma_t^2 \varepsilon_{j,t} \tag{8}$$

where *H* stands for the forecast horizon and $\Psi_{j,t}^{g}(H)$ is the GIRFs of the *j* variable. The value of $\delta_{j,t}$ equals 1 on the H_{th} position and 0 otherwise. F_{t-1} is the information of period *t-1*. The variance share that variable i explains on variable j can be interpreted through the generalised forecast error variance decomposition (GFEVD).

$$\hat{\theta}_{ij,t}^{g}(H) = \frac{\sum_{t=1}^{H-1} \Psi_{ij,t}^{2,g}(H)}{\sum_{j=1}^{N} \sum_{t=1}^{H-1} \Psi_{ij,t}^{2,g}(H)} \tag{9}$$

where $\sum_{j=1}^{N} \hat{\theta}_{ij,t}^{g}(H) = 1, \sum_{i,j=1}^{N} \hat{\theta}_{ij,t}^{N}(H) = N$. There are two different types of spillovers in this technique, as suggested by Diebold and Yilmaz (2009): variable i shocks that affect the error variance of variable j at the H-step ahead forecast (with the contribution $\Psi_{j,t}^{2.g}(H)$) and variable j shocks that affect the error variance of variable i at the H-step ahead forecast $\Psi_{j,t}^{2.g}(H)$). The total connectedness index is formulated to estimate spillover transmission as follows:

$$\mathrm{C}_{t}^{g}(H) = \frac{\sum_{i,j=1,i\neq j}^{N} \hat{\theta}_{ij,t}^{g}(H)}{\sum_{i,j=1}^{N} \hat{\theta}_{ij,t}^{g}(H)} \times 100 = \frac{\sum_{i,j=1,i\neq j}^{N} \hat{\theta}_{ij,t}^{g}(H)}{N} \times 100 \tag{10}$$

The total directional connectedness to others (spillovers of i to j) can be formulated as:

$$\mathrm{C}_{i\rightarrow j,t}^{g}(H) = \frac{\sum_{i,j=1,i\neq j}^{N} \hat{\theta}_{ij,t}^{g}(H)}{\sum_{i,j=1}^{N} \hat{\theta}_{ij,t}^{g}(H)} \times 100 \tag{11}$$

On the other hand, the total directional connectedness from others (spillover from $_j$ to $_i$) can be estimated by:

$$\mathrm{C}_{i\leftarrow j,t}^{g}(H) = \frac{\sum_{i,j=1,i\neq j}^{N} \hat{\theta}_{ij,t}^{g}(H)}{\sum_{i,j=1}^{N} \hat{\theta}_{ij,t}^{g}(H)} \times 100 \tag{12}$$

Lastly, the net spillover effect is assessed through the following equation:

$$\mathrm{C}_{i,t}^{g}(H) = \mathrm{C}_{i\rightarrow j,t}^{g}(H) - \mathrm{C}_{i\leftarrow j,t}^{g}(H) \tag{13}$$

The value of $\mathrm{C}_{i,t}^{g}(H), \mathrm{C}_{i\rightarrow j,t}^{g}(H), \mathrm{C}_{i\leftarrow j,t}^{g}(H)$ indicates the total overall spillover effect. The values of $\mathrm{C}_{i,t}^{g}(H)$ show whether the variable i is shocked by j ($\mathrm{C}_{i,t}^{g}(H) < 0$) or influence j ($\mathrm{C}_{i,t}^{g}(H) > 0$. Additionally, the net pairwise directional connectedness can be developed using the following equation:

$$NPDC_{i,j}(H) = \frac{\hat{\theta}_{ji,t}^{g}(H) - \hat{\theta}_{ij,t}^{g}(H)}{N} \times 100 \tag{14}$$

The value of *NPDC* denotes the dominating economic variables.

Since the underlying variables follow non-normal distribution (proved by the Jarque-Bera and Shapiro-Wilk tests), we estimate the asymmetric effect of GPR, GPRNK, and EMVID on TPU using method of moments quantile regression. The basic quantile regression model is as follows:

$$Q_{yi}(\tau | x_i) = \alpha(\tau) + x_i^T \beta_\tau \tag{15}$$

$Q_{yi}(\tau|x_i)$ denotes the τ conditional quantile of y_i (TPU), x_i signifies the explanatory variables (*GPR, GPRNK, EMVID*) responsible for the changes in y_i, the unobserved effect of the quantile model is denoted by $\alpha(\tau)$, and τ is the quantile value between 0 and 1. β_τ is computed as follows:

$$\hat{\beta}(\tau) = argmin_{\beta \in R_p} \sum_{i=1}^{n} \rho_T \left(y_i - x_i'\beta(\tau) - \alpha(\tau)\right) \quad (16)$$

The check function for $\beta(\tau)$ is described as $\rho_\tau(\mu) = \mu(\tau - I(\mu < 0))$, and the indicator function I(.) is defined as $(\mu = y_i - x_i'\beta(\tau) - \alpha(\tau))$.

4. Empirical Results

Before estimating the TVP-VAR model, the optimal lag lengths are evaluated using the Hannan-Quinn information criterion, the Schwarz information criterion, the Akaike information criterion, Final Prediction Error, and Likelihood Ratio. The results in Appendix I show that the optimal lag length is 3 as per the minimum value principle of Final Prediction Error and Akaike information criterion. Table 2 shows the average dynamic connectedness amongst variables. The average forecast error variance coming from cross-variable spillovers is 19.25%. The results show that the spillover effect of TPUUS to other countries is greater than the spillover effect of TPU from other countries. More specifically, TPUUS has the highest spillover effect on Japanese TPU (22.51%). The dynamic total connectedness is demonstrated in Figure 1. The findings of time-varying spillovers show major jumps after 2017. In 2018, the trade conflicts and frictions initiated by President Donald Trump against China elevate TPU amongst countries. The evidence further suggests that the uncertainty spillover peaks during the COVID-19 pandemic.

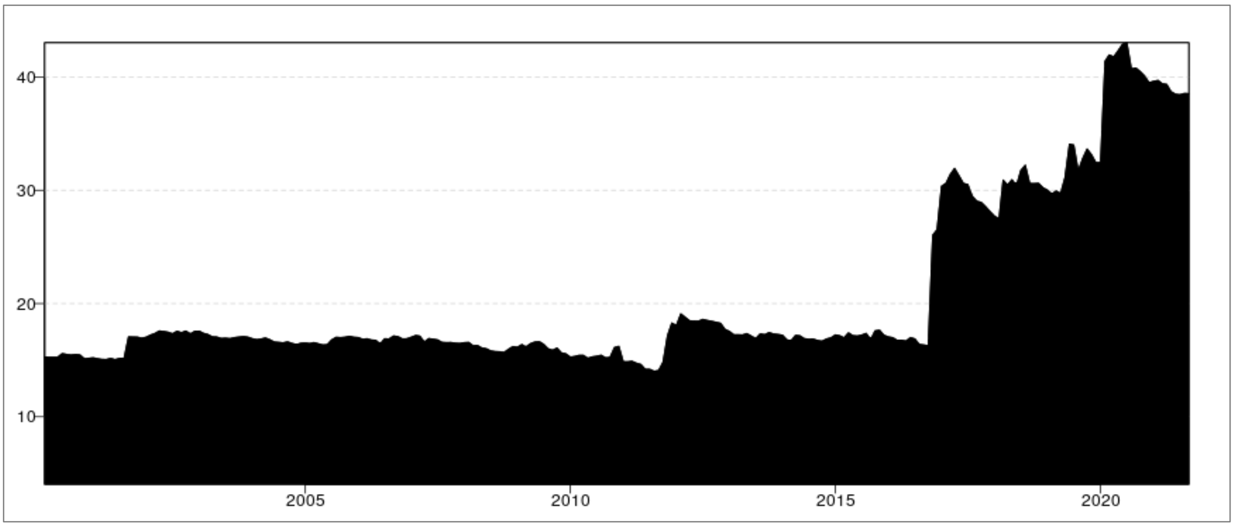
Table 2: Dynamic Connectedness

Item	TPUUS	TPUCN	TPUJPN	TPUKOR	EMV_ID	GPR	From
TPUUS	78.81	3.05	7.59	5.7	0.89	3.95	21.19
TPUCN	1.64	85.52	3.08	3.53	4.54	1.69	14.48
TPUJPN	6.51	3.7	79.11	7.01	2.72	0.96	20.89
TPUKOR	4.53	2.94	7.53	82.49	1.74	0.77	17.51
EMV_ID	1.16	1.9	2.4	0.59	92.69	1.25	7.31
GPR	5.11	2.96	1.9	1.85	3.03	85.15	14.85
To	18.96	14.55	22.51	18.69	12.92	8.62	96.24
Inc. Own	97.77	100.06	101.61	101.18	105.61	93.77	TCI
NET	-2.23	0.06	1.61	1.18	5.61	-6.23	19.25

EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: Authors' calculations using data from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

Figure 2 shows the spillover of TPUUS to the TPU of other countries, the pandemic, and GPR. The results demonstrate that TPUUS is substantially connected with the TPU of Japan, China, and Korea, especially during the US–China trade war and pandemic period. Additionally, TPUUS has a high dynamic connectedness with EMVID during the pandemic period. However, compared with other variables, there is a lower spillover to GPR and GPRNK. On the other hand, TPUUS is a net receiver of spillover from Korean and Japanese TPU, followed by the TPU of China (TPUCN) during Sino–US trade frictions, which further accelerated during the pandemic (Figure 3). Additionally, GPRNK affects TPUUS by potentially increasing it due to concerns over political instability, security threats, and potential disruptions in regional trade relationships, especially during trade conflicts and the pandemic period, leading to higher uncertainty and cautious trade policy decision-making by the US. Similar patterns can be observed for global GPR. Geopolitical tensions create unstable international relations and uncertainties about future trade agreements, market access, and potential disruptions in global trade flows, prompting the US to reassess its trade policies and strategies.

Figure 1: Dynamic Total Connectedness

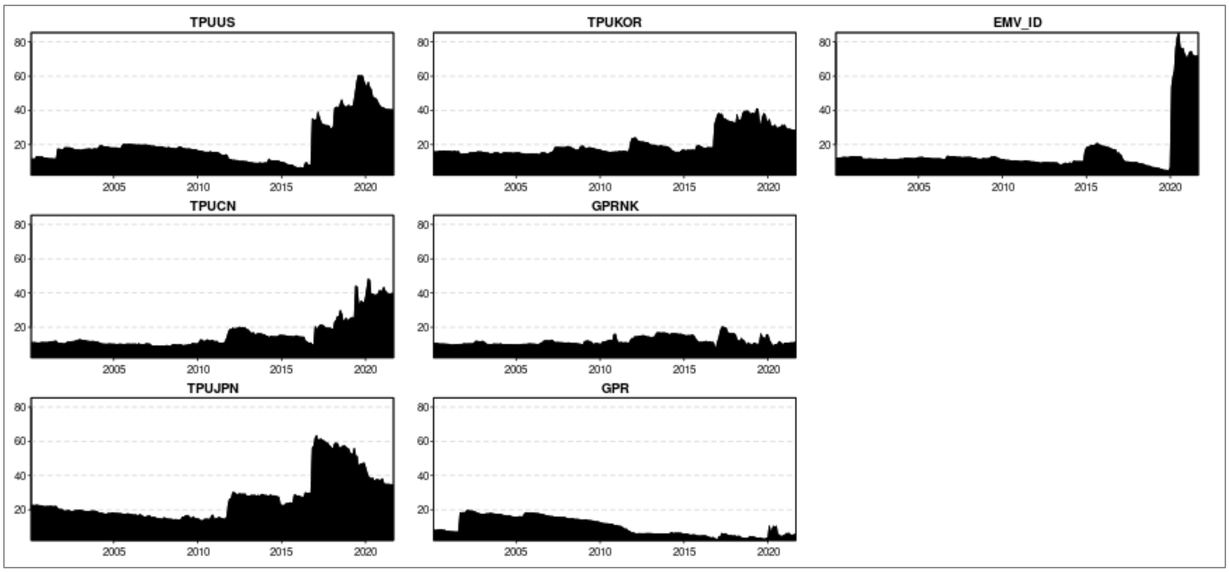


Note: The total connectedness index estimated with a time-varying parameter vector autoregression (TVP-VAR) with a 10-step ahead forecast horizon.
Source: The illustration is derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

In 2021, the US traded $280 billion with Japan, exporting $112 billion in goods and services and importing $168 billion, mostly goods such as motor vehicles and parts, so trade uncertainty in one country has a significant effect on the other country. Nonetheless, the US–China trade war forced Korea to play a complex role. On the one hand, Korea is a major trade partner of China, and any proactive alliance with the US could elevate North Korean security threats and distort asymmetric economic interdependence with China. On the other hand, Korea needs the US to expand its trade and resolve the North Korean nuclear threat issues (Sohn, 2019). Albeit with a smaller gain, Korea has benefitted from the US market following the levying of US tariffs on Chinese exports (Lovely, Xu, and Zhang, 2021). Thus, TPUUS was also substantially affected by the TPU of Korea (TPUKOR). Additionally, the Sino–US trade war, accompanied by COVID-19, enhanced the time-varying spillover of GPR and GPRNK on TPUUS.

Except for GRPNK and EMVID, all variables switch between the net receiver and net transmitter of spillover (Figure 4). The COVID-19 pandemic significantly changed the dynamics of international trade. In particular, uncertainty in the trade policy of US allies (Korea and Japan) escalated its TPU after the spread of the pandemic. TPUUS is also a net transmitter of spillover for EMVID during the pandemic period. Before 2010, TPUUS was a net transmitter of GPR as the 9/11 terrorist attack enforced a disruption of trade flows and higher frictional trading costs, and a large chunk of budget was allocated to the war on terrorism. While the US was engaged in military interventions in Iraq, Libya, and Afghanistan, China moved to strategic and economic expansion in Asia (Rozman, 2012). Meanwhile, the financial crisis of 2007/08 severely distorted US financial markets and trade, causing the US to receive spillover from the GPR it generated after 2010. Previously, Yang, Niu, and Gao (2022) found a time-varying and positive effect of TPU shocks on GPR.

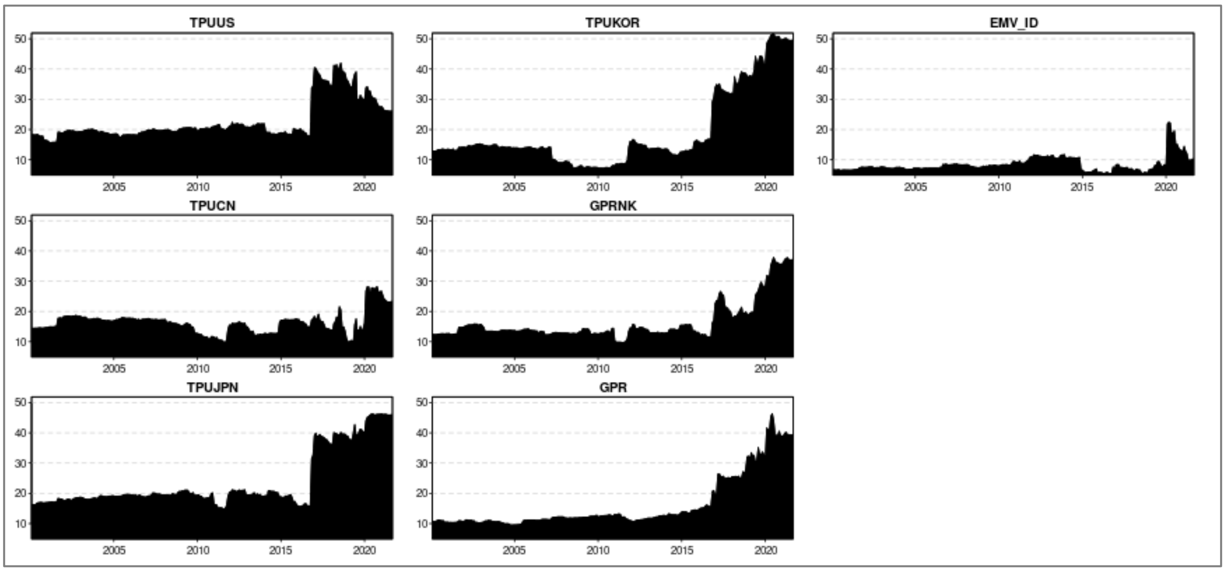
Figure 2: Total Directional Connectedness to Others



EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: The illustrations are derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

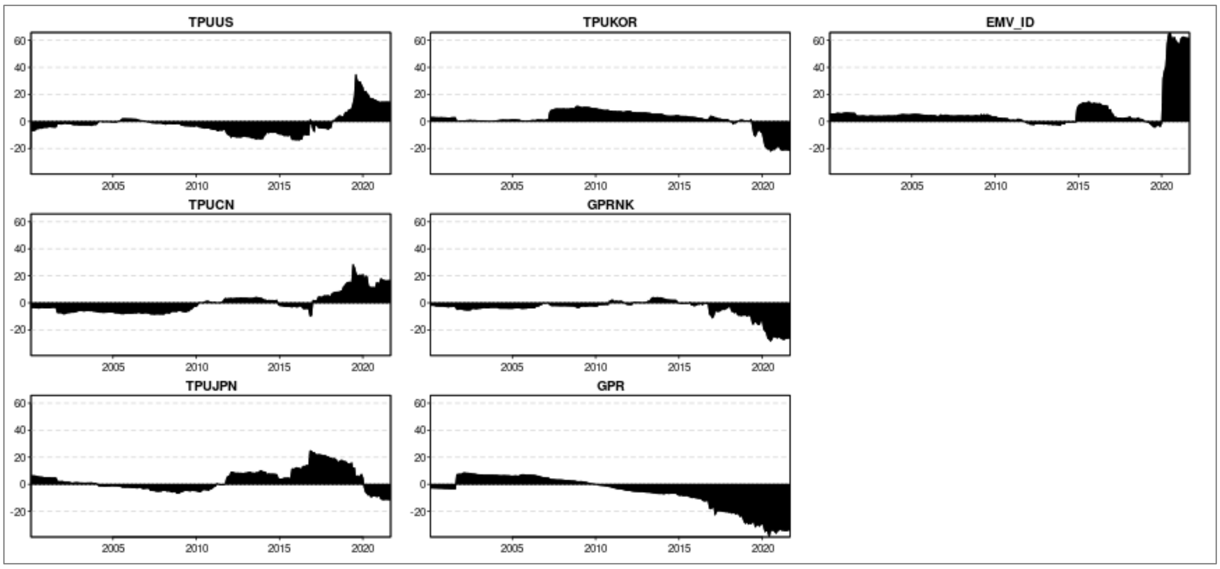
A more holistic view of the evidence can be extracted from the net pairwise directional connectedness network shown in Figure 5. The findings suggest that EMVID is the net transmitter of spillover to the TPU of China and the GPR of North Korea, followed by the TPU of Korea and GPR. Amongst the economies affected by the impact of COVID-19, Korea's trade experienced significant challenges, leading to a shift in its trade dynamics from a position of centrality to one of peripherality (Vidya and Prabheesh, 2020). Nonetheless, Korea gained control over the pandemic and opened its borders for trade earlier than China. While the pandemic was the primary factor affecting Chinese trade, TPUUS reflects uncertainties influenced by the trade policies of all three trading partners, indicating a more comprehensive set of influences on TPUUS. Previous studies have confirmed that losses for China are relatively small compared with those of the US during the trade war (Bouët and Laborde, 2018). These results are confirmed by the time-varying net pairwise directional connectedness and dynamic pairwise connectedness shown in Appendixes II and III.

Figure 3: Total Directional Connectedness from Others



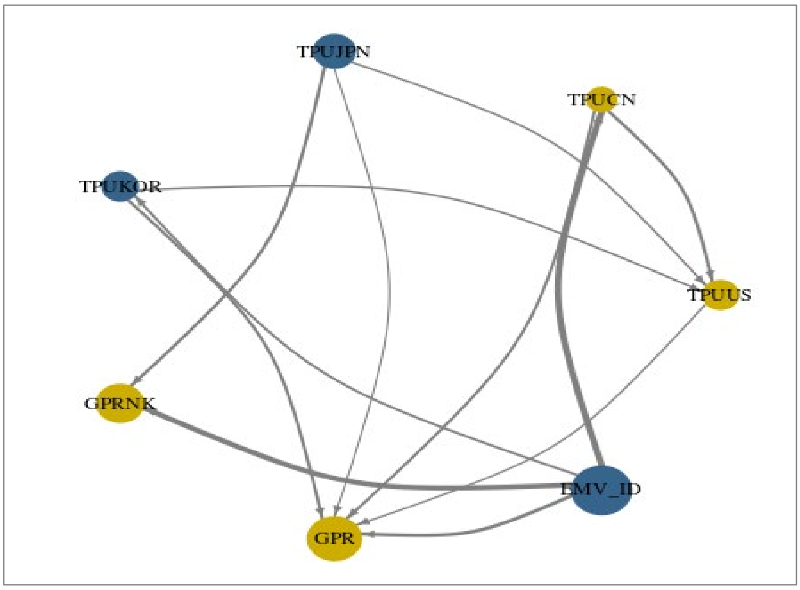
EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: The illustrations are derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

Figure 4: Net Total Directional Connectedness



EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: The illustrations are derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

Figure 5: Network Plot



EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: The illustrations are derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

The findings of quantile regression shown in Table 3 suggest that the effects of EMVID, GPRNK, and GPR are largely asymmetrical and heterogenous across TPU quantiles. For the US, EMVID significantly influences TPU in seven out of nine quantiles. Nonetheless, the effect of the pandemic is higher in the lower quantiles of TPU distribution. On the other hand, quantile regression estimates for TPUCN show a higher asymmetric effect of EMVID on TPU. Except for the 90th quantile, evidence shows a positive and increasing effect of the pandemic from low to high TPU. Trade remains most vulnerable to pandemic shocks in China compared with other countries in Eastern Asia.

Both Korea and Japan show resilience towards the pandemic, especially under high TPU. Compared with China and the US, the strong stimulus packages of Japan and Korea helped their economies reduce market crashes and uncertainties (Phan and Narayan, 2020). The GRPNK significantly explains the TPUUS at the lower quantiles (10th to 50th), the lower to middle quantile for TPUCN (10th to 70th), and the lower to higher quantiles for TPUKOR (10th to 80th). Formally, the relationship between Japan and North Korea was never established. Previous experience of armed conflicts between Japan and North Korea has shaken Japanese trade interests and dynamics. Concerns over nuclear weapons and the abduction of Japanese citizens are the main sources of GPR spillover to TPUJPN. Although Japanese TPU is vulnerable to GPRNK, it shows resilience to global GPR. However, the effect of GPR is significant at the lower quantiles of the TPUUS, TPUCN, and TPUKOR distributions.

4.1. Robustness Checks

We further assessed the effect of the COVID-19 pandemic on the TPU of the respective countries by employing an alternative measurement by Narayan, Iyke, and Sharma (2021) who disaggregated the COVID-19 index into a medical index, a vaccine index, a travel index, and an uncertainty index. Owing to the high correlation (multicollinearity) of the COVID-19 index and the aggregate COVID-19 index, we excluded them from the model. The results in Appendix IV show that the effects of the medical, vaccine, travel, and uncertainty indexes are heterogeneous and vary across the quantiles of TPU. Since COVID-19 recovery is good news for trade, it has a negative effect on the TPU of all countries, with a larger effect for China. On the other hand, travel bans and restrictions largely affect the trade and supply chain, which elevates TPU. Consequently, we find a positive effect of the travel index on the TPU of all countries, except China, which successfully contained the infectious disease through travel bans and lockdowns (Xue et al., 2021). This evidence is supported by the findings of Phan and Narayan (2020), indicating that the Chinese market exhibited a bullish trend following the announcement of a travel ban.

The impact of COVID-19-induced uncertainty is largely heterogeneous on TPU. The effect is negative and significant for the US (at upper quantiles) and Korea (lower quantiles), insignificant for Japanese TPU, and positive for China (in all quantiles). This evidence further confirmed that Chinese trade was markedly vulnerable to COVID-19 uncertainty compared with other countries. Lastly, our results show a negative and significant effect of the vaccine index on the TPU of all countries, except China, which is insignificant. The development of vaccination and related programmes helped markets to revert the effect of the pandemic and stabilise the trade flows (Rouatbi et al., 2021).

Table 3: Method of Moments Quantile Regression

Variables	Quantiles								
	10th	**20th**	**30th**	**40th**	**50th**	**60th**	**70th**	**80th**	**90th**
US									
EMV_ID	2.077***	2.051***	2.029***	2.001***	1.958***	1.919***	1.857**	1.771	1.177
	(0.482)	(0.381)	(0.319)	(0.293)	(0.385)	(0.547)	(0.845)	(1.294)	(4.458)
GPRNK	0.133*	0.131**	0.128**	0.126**	0.121*	0.118	0.112	0.103	0.045
	(0.081)	(0.064)	(0.053)	(0.049)	(0.064)	(0.092)	(0.141)	(0.216)	(0.745)
GPR	0.119**	0.108**	0.100**	0.089**	0.072	0.056	0.032	-0.002	-0.236
	(0.060)	(0.047)	(0.040)	(0.037)	(0.048)	(0.069)	(0.106)	(0.165)	(0.568)
cons	-9.943	-1.001	6.406	16.115**	30.795***	44.391***	65.572***	95.387**	299.620**
	(11.478)	(9.195)	(7.886)	(7.730)	(10.269)	(13.991)	(21.813)	(43.100)	(141.257)
China									
EMV_ID	4.011***	4.312***	4.648***	4.809***	5.094***	5.458***	6.325**	7.893*	11.525
	(1.145)	(0.976)	(0.961)	(1.025)	(1.229)	(1.586)	(2.615)	(4.634)	(9.577)
GPRNK	0.422***	0.412***	0.402***	0.397***	0.388***	0.377***	0.350*	0.302	0.190
	(0.082)	(0.070)	(0.069)	(0.073)	(0.087)	(0.112)	(0.184)	(0.327)	(0.667)
GPR	0.148***	0.108**	0.065	0.044	0.007	-0.041	-0.154	-0.358*	-0.831*
	(0.052)	(0.044)	(0.043)	(0.046)	(0.056)	(0.073)	(0.123)	(0.217)	(0.464)
cons	-44.850***	-26.738**	-6.603	3.112	20.230	42.067**	94.122***	188.321***	406.471***
	(13.344)	(11.058)	(10.735)	(11.393)	(14.441)	(19.352)	(33.710)	(59.463)	(135.939)
Japan									
EMV_ID	0.395*	0.244	0.061	-0.105	-0.289	-0.410	-0.619	-1.161	-4.042*
	(0.207)	(0.170)	(0.162)	(0.188)	(0.245)	(0.291)	(0.397)	(0.766)	(2.100)
GPRNK	0.526***	0.536***	0.549***	0.560***	0.573***	0.581***	0.596***	0.633***	
	(0.068)	(0.055)	(0.051)	(0.060)	(0.080)	(0.095)	(0.125)	(0.209)	0.832 (0.658)

Variables	Quantiles								
	10th	20th	30th	40th	50th	60th	70th	80th	90th
GPR	-0.053	-0.065*	-0.080**	-0.093**	-0.108**	-0.118*	-0.134	-0.178	-0.409
	(0.046)	(0.037)	(0.034)	(0.041)	(0.054)	(0.064)	(0.085)	(0.144)	(0.446)
cons	5.852	16.152**	28.686***	40.021***	52.540***	60.801***	75.077***	112.104***	308.758***
	(9.571)	(7.923)	(7.624)	(8.685)	(11.233)	(13.316)	(18.688)	(39.495)	(98.256)
Republic of Korea									
EMV_ID	-0.268	-0.349*	-0.432**	-0.486**	-0.587**	-0.729**	-0.907**	-1.168*	-1.542*
	(0.199)	(0.182)	(0.185)	(0.198)	(0.240)	(0.319)	(0.434)	(0.617)	(0.895)
GPRNK	0.006	0.002	-0.002	-0.005	-0.010	-0.017	-0.026	-0.039	-0.058
	(0.044)	(0.040)	(0.041)	(0.044)	(0.052)	(0.070)	(0.095)	(0.136)	(0.195)
GPR	0.091***	0.077***	0.062**	0.053*	0.035	0.010	-0.021	-0.067	-0.133
	(0.031)	(0.028)	(0.029)	(0.031)	(0.037)	(0.050)	(0.068)	(0.096)	(0.140)
cons	25.804***	36.393***	47.170***	54.217***	67.415***	85.905***	109.128***	143.282***	191.994***
	(6.629)	(6.108)	(6.439)	(7.008)	(9.028)	(11.755)	(15.793)	(21.945)	(34.359)

EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea, TPU = trade policy uncertainty, US = United States.

Note: The asymmetric effect of EMV_ID, GPRNK, and GPR on the TPUs of the respective countries are analysed. ***, **, and * denote significant at the 1%, 5%, and 10% levels of confidence, respectively.

Source: The calculations are derived from the author's analysis using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

5. Conclusion

The trade war between China and the US and its spillover on global economies is well documented. We extended the literature by including the TPU spillover of Korea and Japan during the pandemic and the GPR from North Korea using the TVP-VAR connectedness approach. Additionally, we examined the asymmetric effect of GPR, GPRNK, and EMVID on the TPU of the respective economies. Especially during the Sino–US trade war and the pandemic period, the directional and total connectedness across variables is higher, which indicates a close interrelationship between TPU, GPR, GPRNK, and EMVID. The TPUUS is a net receiver of spillover of TPU from Japan, Korea, and China. However, Chinese TPU is a net receiver of spillover from EMVID.

The quantile regression outcomes confirm that the TPU of the US is significantly influenced by EMVID at lower quantiles of TPU distribution, while EMVID elevates uncertainty at higher quantiles of TPUCN. Japanese TPU shows resilience to the pandemic and global GPR but is vulnerable to GPR from North Korea. Korean TPU proved to be the most resilient amongst the other economies, as it is only influenced by global GPR and only in lower quantiles.

Since TPU is a prominent barrier to trade and delays investment in new markets, the study helps identify the policy shock transmission process between China, the US, Korea, and Japan. Additionally, under the Chinese zero-COVID-19 policy and the Sino–US trade war scenario, the findings suggest that Chinese trade remains vulnerable to the former while US trade was substantially affected by the latter scenario. The Chinese and US governments should implement conflict resolution mechanisms to address trade frictions, alleviating the policy uncertainty experienced by their allies and global geopolitical relationships.

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Appendix I

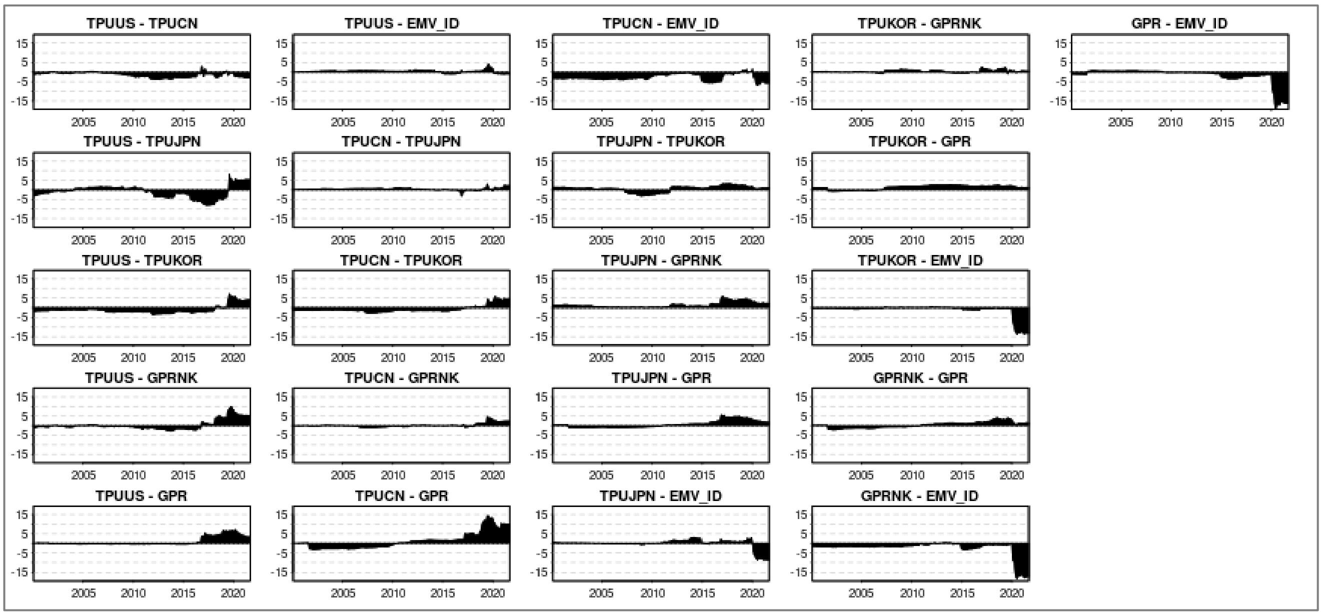
Table A.1: Optimal Lag Length

Lag	Log L	LR	FPE	AIC	HQIC	SBIC
0	-9,875.40	N/A	5.90E+24	76.91	76.94	77.00
1	-9,288.50	1173.80	9.00E+22	72.72	73.03	73.49***
2	-9,188.11	200.78	6.00E+22	72.32	72.90***	73.77
3	-9,125.66	124.91***	5.5e+22***	72.23***	73.07	74.34
4	-9,095.33	60.66	6.30E+22	72.36	73.49	75.16

Note: *** denotes significance at the 1% level of confidence.
Source: The calculations are derived from the author's analysis using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

Appendix II

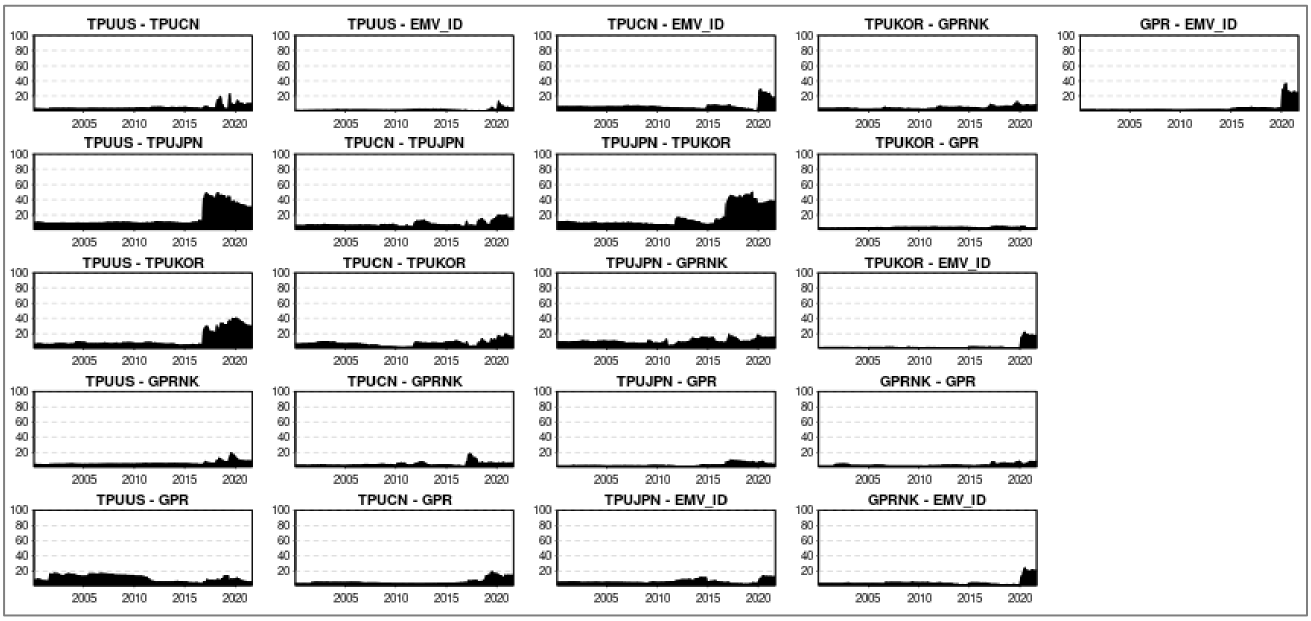
Table A.2: Net Pairwise Directional Connectedness



EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea, TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: The illustrations are derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

Appendix III

Table A.3: Dynamic Pairwise Connectedness



EMV_ID = infectious disease-related market uncertainty, GPR = global geopolitical risk, GPRNK = geopolitical risk from North Korea, TPU = trade policy uncertainty, TPUCN = trade policy uncertainty of China, TPUJPN = trade policy uncertainty of Japan, TPUKOR = trade policy uncertainty of the Republic of Korea, TPUUS = trade policy uncertainty of the United States.
Source: The illustrations are derived from the author's analyses using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

Appendix IV

Table A.4: COVID-19 and TPU

Variables	Quantiles								
	10th	**20th**	**30th**	**40th**	**50th**	**60th**	**70th**	**80th**	**90th**
US									
Medical	-3.987***	-3.810***	-3.684***	-3.546***	-3.170***	-2.830**	-2.408	-1.803	-1.187
Index	(0.836)	(0.828)	(0.841)	(0.874)	(1.029)	(1.234)	(1.528)	(1.995)	(2.498)
Travel	3.769***	3.871***	3.945***	4.025***	4.242***	4.439***	4.684***	5.034***	5.391***
Index	(0.526)	(0.521)	(0.530)	(0.551)	(0.648)	(0.777)	(0.962)	(1.256)	(1.572)
Uncertainty	-0.184	-0.644	-0.974	-1.333	-2.313**	-3.198**	-4.296***	-5.871***	-7.477***
Index	(0.871)	(0.861)	(0.879)	(0.934)	(1.106)	(1.344)	(1.646)	(2.120)	(2.624)
Vaccine	-0.733**	-0.969***	-1.138***	-1.322***	-1.825***	-2.278***	-2.842***	-3.649***	-4.472***
Index	(0.308)	(0.304)	(0.312)	(0.341)	(0.406)	(0.501)	(0.606)	(0.769)	(0.939)
cons	161.905***	196.200***	220.809***	247.616***	320.681***	386.659***	468.601***	586.052***	705.783***
	(30.139)	(29.619)	(30.598)	(34.565)	(41.658)	(52.490)	(62.343)	(77.394)	(92.974)
China									
Medical	-3.432**	-4.378***	-6.117***	-7.191***	-7.844***	-10.185***	-12.106***	-13.503***	-17.376***
Index	(1.703)	(1.556)	(1.552)	(1.712)	(1.893)	(2.669)	(3.388)	(3.969)	(5.958)
Travel	-3.124***	-3.737***	-4.864***	-5.560***	-5.983***	-7.500***	-8.745***	-9.650***	-12.159***
Index	(1.020)	(0.936)	(0.937)	(1.030)	(1.140)	(1.604)	(2.030)	(2.378)	(3.607)
Uncertainty	4.435**	5.091***	6.295***	7.038***	7.490***	9.112***	10.442***	11.409**	14.090**
Index	(1.970)	(1.779)	(1.758)	(1.956)	(2.152)	(3.057)	(3.916)	(4.588)	(6.663)
Vaccine	-0.741	-0.577	-0.274	-0.088	0.026	0.433	0.767	1.010	
Index	(0.683)	(0.615)	(0.606)	(0.675)	(0.742)	(1.056)	(1.357)	(1.590)	1.683 (2.288)
cons	160.181***	226.073***	347.130***	421.922***	467.358***	630.410***	764.145***	861.401***	1131.052***
	(53.742)	(51.187)	(52.930)	(56.605)	(63.703)	(87.745)	(106.989)	(125.170)	(213.716)

Variables	Quantiles								
	10th	20th	30th	40th	50th	60th	70th	80th	90th
Japan									
Medical	-2.263***	-2.232***	-2.202***	-2.175***	-2.141***	-2.096***	-2.042***	-1.974**	-1.831
Index	(0.295)	(0.265)	(0.273)	(0.309)	(0.382)	(0.501)	(0.662)	(0.875)	(1.339)
Travel	0.634**	0.814***	0.984***	1.142***	1.341***	1.602***	1.916***	2.309***	3.140***
Index	(0.257)	(0.227)	(0.234)	(0.265)	(0.327)	(0.424)	(0.564)	(0.752)	(1.144)
Uncertainty	0.226	0.031	-0.154	-0.326	-0.542	-0.825	-1.166	-1.593	-2.495
Index	(0.344)	(0.307)	(0.316)	(0.358)	(0.442)	(0.575)	(0.763)	(1.013)	(1.545)
Vaccine	-0.188	-0.260**	-0.329***	-0.394***	-0.475***	-0.580***	-0.708***	-0.868**	-1.205**
Index	(0.115)	(0.102)	(0.105)	(0.119)	(0.147)	(0.191)	(0.254)	(0.337)	(0.514)
cons	169.409***	181.809***	193.533***	204.464***	218.230***	236.195***	257.926***	285.082***	342.417***
	(13.419)	(11.755)	(12.088)	(13.724)	(16.964)	(21.912)	(29.186)	(38.998)	(59.181)
Rep. of Korea									
Medical	-1.017***	-1.100***	-1.161***	-1.242***	-1.370***	-1.523***	-1.676***	-1.932***	-2.477**
Index	(0.198)	(0.182)	(0.185)	(0.208)	(0.269)	(0.362)	(0.469)	(0.663)	(1.071)
Travel	0.377**	0.446***	0.496***	0.562***	0.667***	0.793***	0.918**	1.128**	1.574*
Index	(0.165)	(0.153)	(0.155)	(0.174)	(0.225)	(0.303)	(0.393)	(0.556)	(0.897)
Uncertainty	0.499**	0.476**	0.459**	0.436*	0.399	0.356	0.313	0.241	
Index	(0.237)	(0.218)	(0.221)	(0.245)	(0.318)	(0.432)	(0.559)	(0.783)	0.087 (1.275)
Vaccine	-0.100	-0.138*	-0.166**	-0.202**	-0.260**	-0.329**	-0.398**	-0.514*	-0.760*
Index	(0.080)	(0.074)	(0.076)	(0.085)	(0.110)	(0.148)	(0.191)	(0.271)	(0.437)
cons	41.990***	50.936***	57.433***	66.051***	79.815***	96.137***	112.533***	139.864***	198.100***
	(8.381)	(7.837)	(8.051)	(9.407)	(12.107)	(15.800)	(20.481)	(29.990)	(46.884)

COVID-19 = coronavirus disease, TPU = trade policy uncertainty, US = United States.

Notes: The asymmetric effect of the COVID-19 index by Narayan, Iyke, and Sharma (2021) on the TPUs of respective countries are analysed. ***, **, and * denote significance at the 1%, 5%, and 10% levels of confidence, respectively.

Source: The calculations are derived from the author's analysis using data obtained from Economic Policy Uncertainty (n.d.), Economic Policy Uncertainty Index. https://www.policyuncertainty.com/index.html (accessed 1 May 2022).

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