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China's Economic Policy Uncertainty Shocks and South Korea's Exports: A TVP-VAR Approach with an SMSS Structure*

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Abstract

Purpose – Since China has been South Korea's biggest export destination, uncertainty shocks originating from it would influence South Korea's exports. This paper evaluates the effects of China's economic policy uncertainty on Korea's exports to explore the transmission channels.

Design/methodology – Incorporating endogeneities and nonlinearities, this study employs a quarterly time-varying parameters vector autoregressive model to investigate the relationships between China's economic policy uncertainty and Korea's exports, where the overparameterization due to time-varying specifications is overcome by a novel stochastic model specification search framework. According to previous theoretical studies, this paper assesses two channels, demand shock channel and exchange rate channel, through which foreign uncertainty affects Korea's exports. This paper identifies the primary drivers of Korea's aggregate exports and analyzes the rationales for the time-variant impacts of China's economic policy uncertainty on Korea's exports to China.

Findings – Our empirical results reveal that Korea's aggregate exports are less responsive to China's economic policy uncertainty shocks and significantly move together with global demand. In contrast, its bilateral exports to China are highly responsive in a negative and time-variant way. Moreover, Chinese investment is an important channel through which China's economic policy uncertainty affects Korea's exports to China after 2010. Further, the time-variant effects of China's economic policy uncertainty on Korea's exports to China are related to changes in China's foreign trade policies, global economic conditions, and China's degree of economic freedom.

Originality/value – Few previous studies touch the effects of external uncertainty shocks on South Korea's exports. This paper attempts to fill this gap and explicitly investigate the impacts of China's economic policy uncertainty on Korea's exports from a time-varying perspective. As Korea is an export-oriented economy, this study provides insights for the Korean government to understand the transmissions of external uncertainty better.

Keywords: China's EPU, Exports, South Korea, Spillovers
JEL Classifications: C3, D80, F43

1. Introduction

The seminal study by Bloom (2009) has invigorated academic interest in the macroeconomic effects of economic uncertainty. Most of the literature, however, centers on the

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local or domestic influences of economic uncertainty, see Bloom (2014), Cerda, Silva and Valente (2018), Popp and Zhang (2016), and among others. As globalization has now linked the world tightly in both economy and finance, recent studies have focused on the cross-border spillovers of economic uncertainty shocks, see Berger, Grabert and Kempa (2017), Kido (2018), Klößner and Sekkel (2014), Trung (2019), and therein. Theoretically, economic uncertainty would be expected to dampen investment and consumption and, thus, play the role of aggregate demand shocks (Leduc and Liu, 2016), which might affect the demand for imports (i.e., the trade partner's exports). Furthermore, economic uncertainty could change the direction of capital flows by altering international investors' willingness of risk-taking and risk aversion, and the value-at-risk of home-country's assets (Gauvin, Cameron and Reinhardt, 2014; Schmidt and Zwick, 2015). Subsequently, for an economy adopting a flexible exchange rate regime, changes in capital flows lead to fluctuations in the exchange rate and, then, the exports.

South Korea (hereafter Korea)[1] is a small open economy and its exports play a vital role in its domestic economy. However, few studies explicitly assess the spillover effects of foreign economic uncertainty shocks on Korea's macroeconomy except Cheng (2017). However, he does not concentrate on the impact on exports. Korea and China are both export-oriented economies, where China still acts as a regional trade hub for processing commodities imported from Asian neighbors, such as Korea (Jin Fu-Rong and Jung Ji-Hyun, 2018). Since China has always been the biggest Korean export destination, shocks originating from its economic uncertainty would influence Korean exports. It is necessary for Korea to understand the spillover effects of China's uncertainty shocks on its exports to stabilize its foreign trade and domestic economy.

Linear vector autoregressive (VAR) frameworks are the standard tools in studying the impact of economic uncertainty (Bhattarai, Chatterjee and Park Woong-Yong, 2019; Colombo, 2013). However, the sample periods of the related empirical literature on identifying economic uncertainty shocks span the last three or four decades and, thus, cover periods of changing dynamics, policy regimes, and economic shocks (Mumtaz and Theodoridis, 2018). Meanwhile, Granger (2008) and Mishkin (2011) explicitly suggest that sometimes there are nonlinearities in macroeconomic variables because of financial crises and institutional changes. Moreover, both Caggiano, Castelnuovo and Figueres (2017) and Caggiano, Castelnuovo and Groshenny (2014) verify the existence of a nonlinear relationship among foreign uncertainty shocks and domestic economic activities through a smooth transition VAR model. Wen, Xiao and Wu (2019) find an asymmetric impact of foreign economic policy uncertainty on China's macroeconomy using a nonlinear cointegrating autoregressive distributed lag model. So, it is reasonable to take nonlinearities into account when investigating the impacts of economic uncertainty.

To incorporate nonlinearities, a time-varying parameters (TVP) model is more suitable. Granger (2008) proves that any nonlinear model can be approximated as a TVP model based on the White theorem. He also suggests that in a TVP model, the estimates can be better interpreted and the predictions are more straightforward. Additionally, a time-varying specification for parameters 'lets the data speak' freely and allows us to explore the time-varying role of uncertainty shocks in different years (Benati, 2014). More importantly, the TVP model can capture any temporal shifts in the impacts of economic uncertainty, which were confirmed by Mumtaz and Theodoridis (2018), who find the impacts of uncertainty

[1] For the purpose of elaboration, we will use Korea's and Korean, also China's and Chinese interchangeably throughout our paper.

shocks on real activity and financial variables systematically decline over time. With these considerations, we employ a time-varying parameters vector autoregressive (TVP-VAR) model to examine the effects of China's economic uncertainty on Korea's exports.

The TVP-VAR model is an extension of the linear VAR model that allows the model's coefficients to change over time. However, a time-varying specification introduces too many parameters to be estimated, reducing model's degree of freedom. For small samples, the reliability of the estimation and the accuracy of the impulse response functions could decrease. Thus, we introduce an indicator in a stochastic model specification search (SMSS) framework developed by Eisenstat, Chan and Strachan (2016), which allows the model to automatically and endogenously determine the time-variation of each VAR coefficient to reduce the problem of overparameterization in a stylized TVP-VAR model.

Economic uncertainty is an obscure theoretical concept. To inspect its impacts, we need a proper proxy. In the literature, economic policy uncertainty (EPU) index and macroeconomic uncertainty (MU) index, developed by Baker, Bloom and Davis (2016) and Jurado, Ludvigson and Ng (2015) respectively, are two most common measures of economic uncertainty and both corroborated to have detrimental effects on real economic activities (Claeys, 2017; Colombo, 2013; Huang et al., 2018; Trung, 2019). However, Shin Min-Chul et al. (2017) argue that Korea's EPU and MU indexes show a different dynamic, and the two indicators are negatively correlated.[2] Actually, the EPU index is a real-time indicator that reflects media focus or sentiment on economic conditions and policy stance, whilst the MU index, according to Jurado, Ludvigson and Ng (2015), is an ex-post indicator defined as the common volatility in the unforecastable component of a large number of economic and financial variables. Moreover, as documented in Shin Min-Chul et al. (2017), the EPU index is more relevant to uncertainties in trade activities and captures more uncertainties in international affairs than the MU index. As we intend to evaluate the impacts of China's economic uncertainty on Korean exports, the EPU index is a more suitable proxy for us.

We model China's economic policy uncertainty and Korean exports in a TVP-VAR model with an SMSS structure. Moreover, we design several model specifications to check the robustness and validate the role of China's economic policy uncertainty. Our results suggest that China's economic policy uncertainty shocks have little impact on Korea's aggregate exports but have significant adverse effects on Korea's exports to China. In addition, China's investment is found to be a crucial intermediary in transmitting China's economic uncertainty shocks to China's imports from Korea after 2010. Notably, we also find the spillovers of China's economic policy uncertainty are more severe during the global financial crisis (GFC) and verify the time-variations in the impacts of China's economic policy uncertainty on Korea's exports to China, which are attributed to changes in China's foreign trade policies, global economic conditions, and China's degree of economic freedom (marketization).

To the best of our knowledge, we are the first to analyze the spillover effects of China's economic policy uncertainty on Korea's exports through a time-varying parameters VAR model with an SMSS structure. The remainder of this paper is organized as follows. Section 2 describes the empirical SMSS framework embedded in a stylized TVP-VAR model and the data used. The empirical findings, discussions, and policy implications are presented in Section 3. The last section concludes.

[2] The negative correlation between the EPU and MU indexes is also found for China, see Liu (2020), for example.

2. Methodology and Data

Here, we illustrate the stylized TVP-VAR model with stochastic volatility (SV) as used by Cogley and Sargent (2005) and Primiceri (2005) and the SMSS structure developed by Eisenstat, Chan and Strachan (2016). We also report our data and the basic specifications for the model estimation.

2.1. Baseline Model

We borrow partly from Eisenstat, Chan and Strachan (2016) to describe the model. Consider a generic state-space model with SV,

$$\mathbf{B}_{0t}\mathbf{y}_t = \mathbf{X}_t\boldsymbol{\beta}_t + \boldsymbol{\epsilon}_t, \boldsymbol{\epsilon}_t \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_t), \tag{1}$$

$$\boldsymbol{\beta}_t = \boldsymbol{\beta}_{t-1} + \boldsymbol{\eta}_t, \boldsymbol{\eta}_t \sim \mathbf{N}\left(\mathbf{0}, \widetilde{\boldsymbol{\Omega}}\right), \tag{2}$$

where $\mathbf{y}_t$, in our context, is a nine-dimensional vector containing economic policy uncertainty indices for China and Korea, and the variables refer to Korea's macroeconomy: private consumption, aggregate exports and imports, economic output, price level, interest rate, and exchange rate. $\mathbf{X}_t$ is the regressor matrix consisting of an intercept and lagged $\mathbf{y}_t$, that is, $\mathbf{I}_t \otimes \left(\mathbf{1}, \boldsymbol{y}'_{t-1}, \ldots, \boldsymbol{y}'_{t-p}\right)$ and p is the VAR lag length. $\mathbf{B}_{0t}$ is a lower unitriangular matrix of contemporary relations. The VAR coefficients vector $\boldsymbol{\beta}_t$ is assumed to evolve with time and follow a random walk process, in which the initial value $\boldsymbol{\beta}_0 = \boldsymbol{\alpha}$, where $\boldsymbol{\alpha}$ follows a normal distribution $\boldsymbol{N}(\boldsymbol{\alpha_0}, \mathbf{A}_0^{-1})$.

The residuals $\boldsymbol{\epsilon}$ and $\boldsymbol{\eta}$ are also assumed to be normally distributed and independent of each other for leads and lags, where the covariance matrix of $\boldsymbol{\epsilon}$ is set to be time-variant. More specifically, $\boldsymbol{\Sigma}_t$ is a diagonal matrix with elements $(\exp(h_{1,t}), \ldots, \exp(h_{9,t}))$, where the log stochastic volatility $\mathbf{h}_t = (h_{1,t}, \ldots, h_{9,t})'$ follows a random walk process,

$$\mathbf{h}_t = \mathbf{h}_{t-1} + \mathbf{e}_t^h, \mathbf{e}_t^h \sim \boldsymbol{N}(\mathbf{0}, \boldsymbol{\Sigma}_h), \tag{3}$$

where the initial value $\mathbf{h}_0$ follows a normal distribution $\boldsymbol{N}(\mathbf{0}, \mathbf{V}_0^h)$, and the transition covariance follows an inverse Wishart distribution, that is, $\boldsymbol{\Sigma}_h \sim IW(\boldsymbol{\nu}_0, \boldsymbol{\Sigma}_0)$.

Re-parameterizing $\gamma_{i,t} = (\beta_{i,t} - \alpha_i)/\omega_i$ for $i = 1, \ldots, 81p + 45$, and applying the decomposition of the error covariance matrix $\widetilde{\boldsymbol{\Omega}} = \boldsymbol{\Omega}^{\frac{1}{2}}\boldsymbol{\Phi}\boldsymbol{\Phi}'\boldsymbol{\Omega}^{\frac{1}{2}}$, (1)-(2) becomes,

$$\mathbf{y}_t = \mathbf{X}_t\boldsymbol{\alpha} + \mathbf{X}_t\boldsymbol{\Omega}^{\frac{1}{2}}\boldsymbol{\Phi}\boldsymbol{\gamma}_t + \boldsymbol{\epsilon}_t, \tag{4}$$

$$\boldsymbol{\gamma}_t = \boldsymbol{\gamma}_{t-1} + \widetilde{\boldsymbol{\eta}}_t, \widetilde{\boldsymbol{\eta}}_t \sim \boldsymbol{N}(\mathbf{0}, \mathbf{I}_{81p+45}), \tag{5}$$

where $\boldsymbol{\Omega}^{\frac{1}{2}} = diag\left(\omega_1, \ldots, \omega_{81p+45}\right)$, and $\boldsymbol{\Phi}$ is a lower unitriangular matrix. (4)-(5) is a stylized vector autoregressive model featuring SV and time-varying parameters, which might be prone to overparameterization. Several recent studies have discussed this issue and proposed measures to deal with it, see Bitto and Frühwirth-Schnatter (2019), Eisenstat, Chan and Strachan (2016), Huber, Kastner and Feldkircher (2019), and among others. Eisenstat, Chan and Strachan (2016) introduce a Tobit prior and let the time-variant properties of VAR coefficients be determined in an internally consistent SMSS framework to reduce the model dimension. Practically, their approach is more efficient, flexible, and easy to implement than

other methods, such as the latent threshold approach proposed by Huber, Kastner and Feldkircher (2019). Consequently, in this paper, we will employ their approach but with a slight difference[3].

For each VAR coefficient, the corresponding Tobit prior is a latent variable ω_i^* ($i = 1, \ldots, 81p + 45$), which follows a normal distribution $N(\mu_i, \tau_i^2)$. The value of ω_i is given as an indicator function,

$$\omega_i = \begin{cases} 0, if\ \omega_i^* \leq 0 \\ \omega_i^*, if\ \omega_i^* > 0 \end{cases}. \tag{6}$$

Additionally, it is assumed that τ_i^2 and λ^2 follow an Exponential distribution $E(\lambda^2/2)$ and a Gamma distribution $G(\lambda_{01}, \lambda_{02})$, respectively, to incorporate a lasso structure. As shown in (6), the Tobit prior automatically restricts the value of ω_i from being negative, and determines the time-varying property of each VAR coefficient. Most importantly, this prior setting leads to a straightforward implementation of hierarchical shrinkage by a fast Gibbs sampler, which effectively reduces the model dimension but has sufficient capability to capture nonlinear shifts.

To end the model, we apply a Gibbs sampler to estimate the model in which the following hyperparameters on the above priors are set in line with Eisenstat, Chan and Strachan (2016)[4].

$$\boldsymbol{\alpha}_0 = \mathbf{0}, \mathbf{A}_0 = \mathbf{I}_{81p+45}, \mathbf{h}_0 = \mathbf{0}, \mathbf{V}_0^h = \mathbf{I}_9, \boldsymbol{\nu}_0 = 20, \boldsymbol{\Sigma}_0 = 0.001\mathbf{I}_9,$$
$$\lambda_{01} = \lambda_{02} = 0.1, \mu_i = 0.$$

2.2. Data and Model Specification

Based on data availability, we use quarterly data starting from 1990Q1 to 2019Q1 for our empirical investigation. We proxy the Korean macroeconomic variables in $\mathbf{y}_t$ by private consumption, aggregate exports, aggregate imports, GDP, GDP deflator, money market rate, and the exchange rate of the Korean won against the US dollar[5]. We also replace aggregate exports and imports with the bilateral exports and imports with China retrieved from the WIND Economic Database to check our baseline model's robustness.

There are three EPU indexes for China, all utilizing the methodology of Baker, Bloom and Davis (2016) but using varying number of newspapers for the textual analysis. Baker, Bloom and Davis (2016) use only one English newspaper published in Hong Kong, while Davis, Liu and Sheng (2019) collect from two influential newspapers in mainland China. Recently, Huang and Luk (2020) retrieve from ten newspapers in mainland China. Three (log) EPU indexes for China from Jan 2000 to Apr 2020 are plotted in Fig. 1. It is clear that Baker, Bloom and Davis 's (2016) and Davis, Liu and Sheng's (2019) EPU indexes are more volatile than Huang and Luk's (2020). Certainly, Baker, Bloom and Davis's (2016) EPU index may be

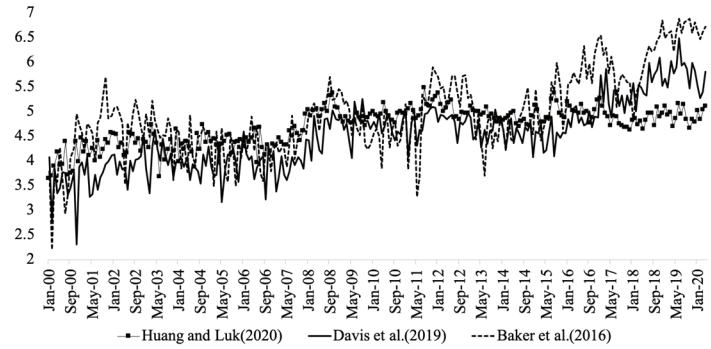
[3] Unlike Eisenstat, Chan and Strachan (2016), we will not impose any restrictions but use Cholesky decomposition to identify structural shocks.

[4] We only change the value of ν_0 in accordance with the number of endogenous variables. Others are directly borrowed from Eisenstat, Chan and Strachan (2016) because all data are standardized before estimation. The detailed procedure of the Gibbs sampler can be found in Eisenstat, Chan and Strachan (2016).

[5] For an exchange rate proxy, the literature suggests using the effective exchange rate when investigating aggregate economic topics. However, we use the bilateral exchange rate of the Korean won against the US dollar since the effective exchange rate before 1994 is not available and Korean exports are mostly priced in the US dollar (Cheng, 2017).

biased because of idiosyncrasies in an individual newspaper. With broader media coverage, Huang and Luk's (2020) EPU index is the best choice for us. However, Huang and Luk (2020) only provide an EPU index from Jan 2000, which cannot meet our sample size requirement. Hence, we rely on the EPU index provided by Davis, Liu and Sheng (2019), even though it might be subject to media control. However, two newspapers, *Renmin Daily* and *Guangming Daily*, used by Davis, Liu and Sheng (2019), are very influential in China and could give a somewhat accurate reflection of policymakers' concerns and real economic policy uncertainty, which might otherwise be averaged out when using too many non-financial newspapers. In addition, we also include Korea's EPU index into our models on account of international spillovers among EPU indexes highlighted in the literature, see Antonakakis et al. (2018), Klößner and Sekkel (2014), Liow, Liao and Huang (2018), Yin and Han (2014), and among others. We use the Korean EPU index constructed by Baker, Bloom and Davis (2016), who use five newspapers published in Korea.

Fig. 1. Log EPU Indexes for China



Source: Authors' calculation using data downloaded from the internet. The EPU indexes constructed by Baker, Bloom and Davis (2016) and Davis, Liu and Sheng (2019) are downloaded from http://www.policyuncertainty.com, while Huang and Luk's (2020) EPU index is retrieved from https://economicpolicyuncertaintyinchina.weebly.com.

All data in the baseline model are collected from International Financial Statistics (IFS) except the EPU indexes, which are downloaded from the *Economic Policy Uncertainty* website[6] (http://www.policyuncertainty.com). To rule out seasonality and ensure stationary, these data are seasonally adjusted using the X12 method, where necessary, and transformed into non-annualized quarter-on-quarter rates of growth by taking the log-differences except for the money market rate which enters as level.

Apart from the baseline model, we construct two models to test for robustness. The Korean EPU index is ordered last in the first model, and aggregate trade is replaced by bilateral trade with China in the second one. For convenience, these two models are denoted as "KOEPU last" and "Bilateral trade", respectively.

Following Bahmani-Oskooee and Baek Jung-Ho (2016) and Iyke and Ho Sin-Yu (2019) who both focus on the Korean economy, four lags are included in our three models - a natural choice for quarterly data (Bayoumi and Swiston, 2008) - that can adequately capture model

[6] Because the website only provides monthly EPU indexes, we average monthly EPU indexes to obtain quarterly ones.

and underlying economic dynamics. We confirm this lag choice using the deviance information criteria (DIC), a most commonly-used information criterion in Bayesian models proposed by Spiegelhalter et al. (2002)[7].

To estimate the models, following Eisenstat, Chan and Strachan (2016), we standardize the data to match the naive priors for hyperparameters. We estimate the model using a Markov chain Monte Carlo (MCMC) Gibbs sampler with 45000 replications, where the initial 15000 are discarded as burn-in and the remaining are retained 1 in every 10 simulations, producing 3000 effective draws.

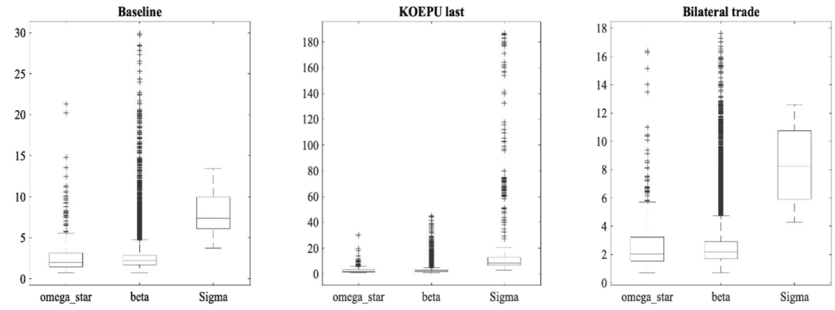
3. Results

Here, we present our results from the three models and include more variables to explore primary drivers of Korean exports. We analyze the transmitting channels and the rationales for the time-varying effects of China's economic policy uncertainty on Korean exports to China, as well. Additionally, some policy implications are provided according to our empirical findings.

3.1. Convergence of MCMC draws

Fig. 2 shows the boxplots of the inefficiency factors of MCMC draws of ω^*, β and Σ for the three models. As we can see, the majority of the estimated parameters' inefficiency factors are less than 10, indicating the good performance of our MCMC draws.

Fig. 2. Inefficiency Factors of the Estimated Parameters



3.2. Impulse Response Functions

Building on the retained draws, we examine the dynamics of Korea's exports after an unexpected rise in China's EPU. We compute time-averaged and time-varying cumulative impulse response functions (IRFs) using Cholesky decomposition[8].

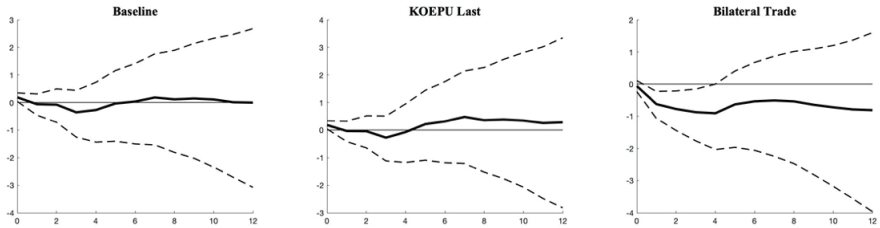
Fig. 3 depicts the time-averaged responses after a one-unit increase shock in China's EPU for the three models. In each, we set a 12-quarter (3 years) response horizon, which is

[7] Centered on our baseline model, we employ the approach in Chan and Eisenstat (2018) to compute the DICs for models with different lag lengths (allowing a maximum lag at six). The models with four to six lags have DICs of 3847.46, 4110.60, and 4289.20, respectively. The results suggest that setting a lag length greater than four makes the model more complicated, producing higher DICs.

[8] As discussed above, the models are estimated with data after standardization, but we don't intend to recover the estimates of IRFs. The positive matrix of scale adjustment restricts the differences between the rescaled IRFs and the non-rescaled IRFs only in magnitude.

sufficient to describe the convergence of IRFs. In general, the IRFs in the baseline model and the KOEPU last model are similar in pattern and significance. The responses are positive at the point when shock takes place but fluctuate into the negative region gradually before the fifth quarter, and revert to positive after that. However, the responses in these two models are insignificant because of the wide highest posterior density (HPD) intervals containing zero during the entire horizon. Remarkably, the IRFs in the Bilateral trade model differ in sign, magnitude and significance. In the Bilateral trade model, Korean exports to China respond adversely and persistently to an increase in China's EPU over the response horizon and significantly in the first year after the shock.

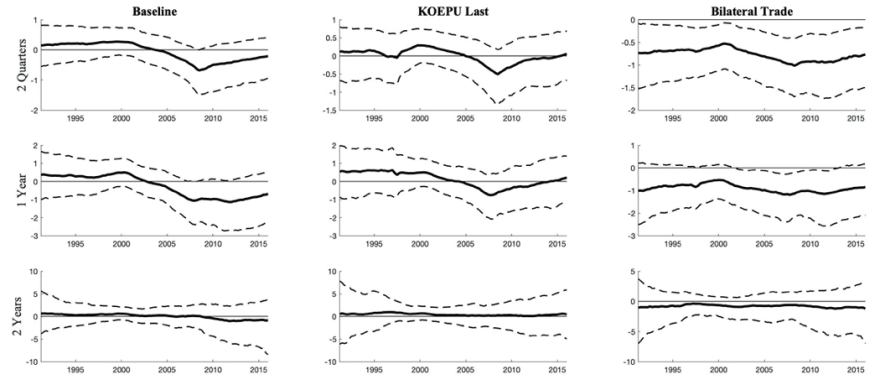
Fig. 3. Time-Averaged Responses of Korean Exports to a One-Unit Positive Shock in China's EPU.



Note: The solid lines represent the estimated median responses, while the dash lines stand for 84% HPD intervals.[9]

As shown in Fig. 3, the averaged IRFs generally converge at eight quarters after the shock. To understand the time-varying effects of China's EPU on Korean exports, we estimate the cumulative IRFs at horizons of two quarters, one year and two years, respectively, after the shock throughout our sample period. Fig. 4 shows the estimated time-varying IRFs.

Fig. 4. Time-Varying Responses of Korean Exports to an Unexpected Rise in China's EPU at Horizons of Two Quarters, One Year and Two Years after the Shock, Respectively



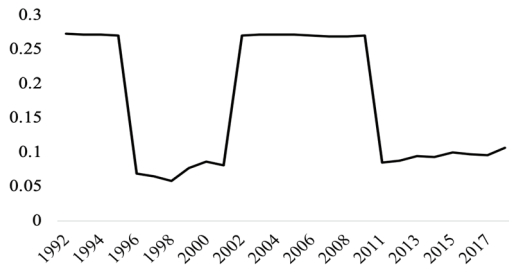
Note: The solid lines are posterior medians, whereas the dash lines are 84% HPD intervals.

[9] As discussed in Chen and Shao (1999) and Julious (2004), the 84% HPD intervals correspond to a statistical significance level of 5%. It is common in the literature to use 84% HPD intervals to diagnose the significance of parameters of interest, see Eisenstat, Chan and Strachan (2016) and Mandalinci and Mumtaz (2018), for example.

Obviously, the time-varying IRFs in the Baseline and KOEPU last models share some commonalities, including trends, magnitudes, and significances, where the responses are positive at all horizons before 2005, then become negative and reach the lowest level during the GFC. In addition, since the HPD intervals contain zero, the responses in all time points and horizons in the two models tend to be insignificant. However, the IRFs in the Bilateral trade model show a lot of differences; an increase in China's EPU deteriorates the exports to China persistently in all horizons at each time point across the sample. Moreover, the corresponding HPD intervals show that the responses at two-quarter horizon are significant over the sample period, whilst the reactions at one-year horizon only show the significance from 2002 to 2013. That is, the impacts of China's EPU on Korean exports to China last only one year at most. More importantly, the IRFs at the horizons of two quarters and one year all reach their nadir during the GFC, corroborating the results of previous studies, such as Fontaine, Didier and Razafindravaosolonirina (2017), who find that China's EPU is more influential during the US' recession periods.

So far, we find that China's economic policy uncertainty plays a significant role in Korean exports to China but not in the aggregate exports, even though China is Korea's biggest export destination. For aggregate exports, the potential dampening effects of China's economic policy uncertainty shocks might have been mitigated by the diversification of Korea's export destinations. During 1990-2018, on average, the exports to China and the US were about 40%, with each accounting for about 20% of Korea's aggregate exports, whereas other countries together accounted for 60%, with each of them having a share of less than 10%. Following Massell (1964), we compute the Gini coefficients (displayed in Fig. 5) to measure Korean exports' geographical concentration. The formula is given by $G_t = \Sigma(X_{it}/X_t)^2$, where X_{it} is the exports to country *i* in year *t*, and X_t is the aggregate exports in year *t*. From 1992 to 2018, the Gini coefficients range from 0.069 to 0.273, with an average of 0.17, indicating a high regional diversification of Korean exports. High concentration levels are often taken as an indication of the vulnerability of exports to trade partners' economic changes (Hastiadi, 2016). Therefore, a low geographical concentration would help Korean aggregate exports be less prone to China's economic policy uncertainty shocks.

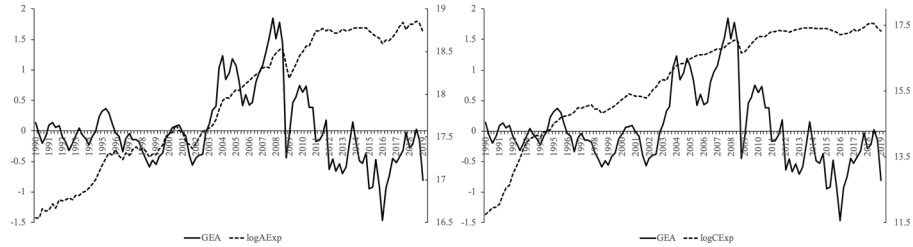
Fig. 5. Gini Coefficients of Korean Aggregate Exports (1992-2018)



Note: Authors' calculation using UN Comtrade data on Korea's country-specific exports.

Interestingly, one may wonder that if China's economic policy uncertainty is not the driving factor behind changes in Korean aggregate exports, what would explain the observed sharp declines in Korea's exports (shown in Fig. 6)? Additionally, why do Korea's exports to China respond over time to China's EPU shocks? To answer these questions, we include more variables into our model in the next subsection.

Fig. 6. Korea's Exports and Global Economic Activity



Note: logAExp, logCExp, and GEA stand for the natural logarithm of aggregate exports and bilateral exports to China, and the global economic activity index constructed by Kilian (2009).

3.3. Roles of Global Demand and Logic of Time-varying Responses

As global trade primarily reflects global demand (Ollivaud and Schwellnus, 2015), changes in global demand are common shocks that cannot be avoided, even though Korean exports have a high regional diversification. Therefore, global demand may play a crucial part in determining Korea's exports. Moreover, China has emerged as an investment-driven economy in the last few decades since its reform and opening up in 1978. As China's domestic investment falls, partly because of rising shocks in its uncertainty (Trung, 2019), so does its demand for imports. In this sense, China's EPU shocks could be transmitted to its imports through investment. To evaluate the effects of global demand and China's investment, we include the global economic activity index (GEA) constructed by Killian (2009) into our baseline model, and include GEA and China's fixed assets investment (FAI) variables into our Bilateral trade model and estimate the two models using the same procedure utilized previously[10].

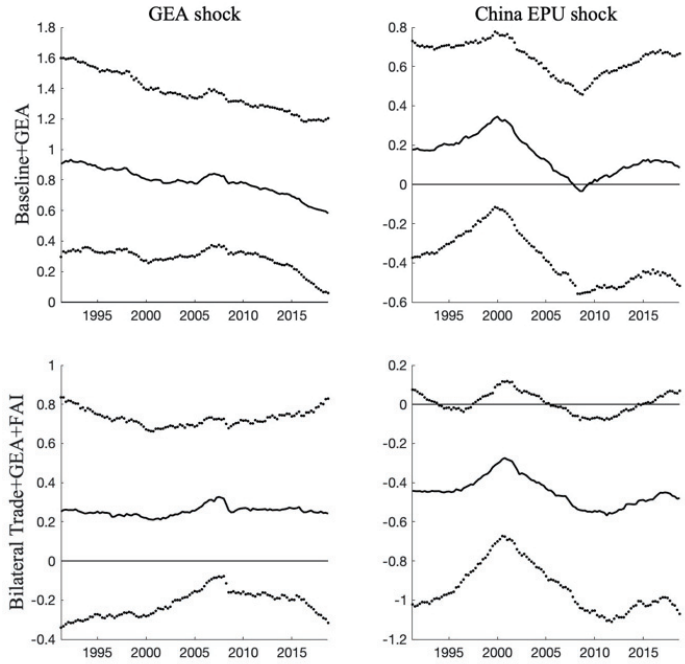
Fig. 7 shows the estimated time-varying responses of Korea's exports to an unexpected rise in GEA and China's EPU. As revealed in the top left panel, a surge in global economic activity leads to a significant increase in Korean aggregate exports, which is in line with theoretical view that exports fluctuate synchronously with global demand. Although the magnitude of impacts has declined persistently with a slight leap during the GFC, GEA is still an important determinant of Korea's aggregate exports. Accordingly, the abrupt drops observed in Korean exports might be a result of plunges in global demand (see Fig. 6). However, the results suggest GEA has no significant role in determining the bilateral exports to China on account of large HPD intervals containing zero (shown in the bottom left panel of Fig. 7).

The effects of China's EPU on exports are similar to our earlier findings. Importantly, the logic for the time-variant impacts of China's EPU on Korea's exports to China needs to be explored more in detail. As shown in Fig. 4 and Fig. 7, the median responses of Korea's exports to China have approximately five phases according to the time-varying characteristics.

[10] Kilian's GEA index is constructed using percentage changes in representative single-voyage ocean shipping freight rates based on various bulk dry cargoes. The index accurately captures the timing and magnitude of shifts in demand for global commodities and changes in latent global real output (Kilian and Zhou, 2018). For more information on the index, refer to Kilian (2009) and Kilian and Zhou (2018). The index is downloaded from Kilian's webpage, https://sites.google.com/site/lkilian2019/research/data-sets. China's investment is proxied by nominal fixed assets investment (consisting of government and private investments) collected from Chang et al.'s (2016) China's macroeconomy database.

Intuitively, the time-varying characteristics of the responses are associated with variations in China's foreign trade strategy, global demand (International Monetary Fund, 2016), and policies adopted during that time.

Fig. 7. Time-Varying Responses of Korean Exports at Two-Quarter Horizon after an Unexpected Rise in GEA and China's EPU, Respectively



Note: The solid lines are median estimates, and the dotted lines are 84% HPD intervals. IRFs in the "Baseline + GEA" model and the "Bilateral trade + GEA +FAI" model are shown in the top and bottom panels, respectively.

In the first phase during the early 1990s (before 1996), China adopted an opening up policy and embarked on an export-oriented economic growth. Diplomatic relations with South Korea were established in 1992. However, strict controls and restrictions on imports, together with an immature economic system and political concerns, made imports from Korea sensitive to changes and uncertainties in economic policies. Therefore, the responses of Korea's exports to China's EPU shocks are relatively large and stable during this period.

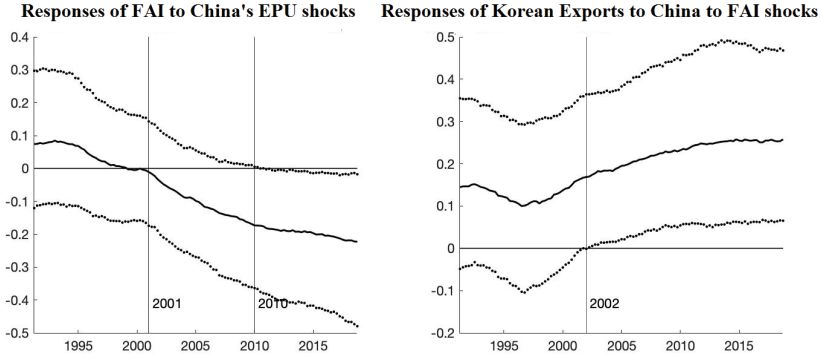
The unfavorable effects of China's EPU on Korea's exports to China decreased in the second stage from 1996 to 2001. During this period, China underwent dramatic institutional changes to build a socialistic market economic system towards marketization and decentralization. It also continued to remove controls and restrictions on imports to satisfy the requirements of WTO accession (Qiu and Xue,2014). In particular, the Chinese yuan became freely convertible on the current account since the end of 1996. All these policy changes might have helped to alleviate the impacts of China's EPU on the imports from its trade partners, including South Korea.

After joining WTO in 2001, China's market economy improved even more in many aspects;

trade rights were fully liberalized (Qiu and Xue, 2014), import quotas were abolished, reforms on the exchange rate system and the domestic stock market were driven in 2005. Along with the improving market system, China's investment became an important channel through which its EPU affected the imports from Korea (see Fig. 8). China's investment may have declined due to rising shocks in its EPU, followed by a significant decrease in the demand for Korea's goods and commodities. Therefore, for China, the increasing degree of marketization[11] may have enhanced the efficiency of the investment channel and, hence, the magnitude of the impacts of domestic EPU on the imports from Korea. Additionally, the GFC in 2008 and the subsequent European debt crisis around 2010 suppressed global demand and further magnified the adverse effects of China's economic policy uncertainty. However, a bold fiscal policy, called the 'Four billion economic stimulus plan', launched at the end of 2008 gave a significant boost to China's investment and shielded its domestic economy from foreign shocks, and thus stabilized the impacts of economic policy uncertainty on the imports from Korea during the twin crises.

As we can see from Fig. 7, the responses changed gradually from 2012 till the first half of 2018. Shrinkages in global demand starting from 2013 onwards caused a rapid buildup of excess capacity (and a reduction in capacity utilization) in China's industrial sectors (Chen, Ding and Rui, 2018), which consequently resulted in a decreased China's demand for the imports from Korea (shown in Fig. 6). However, several policies adopted in this period, such as supply-side reforms, a more proactive import policy, the One Belt and One Road initiative (BRI), the free trade agreements (FTA) between China and South Korea, the agreements on currency swaps between the renminbi and the Korean won, and so on., could have mitigated the effects of China's EPU on Korean exports to China. During the second half of 2018, nevertheless, the estimated increases in the impacts of China's EPU might be due to the trade disputes between China and the US.

Fig. 8. Time-Varying Immediate Responses of FAI to a Positive Shock in China's EPU, and Time-Varying Immediate Responses of Korean Exports to China to a Positive Shock in FAI under the "Bilateral trade + GEA +FAI" Model



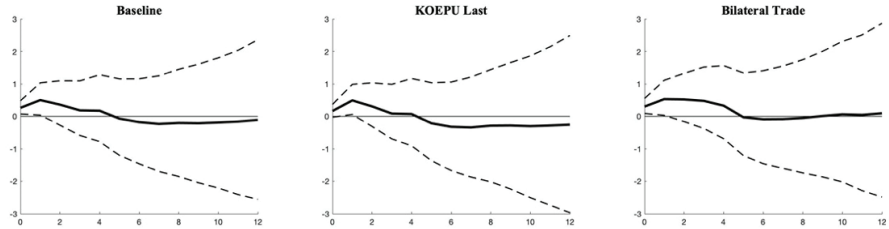
Note: The solid lines are median estimates, while the dotted lines are 84% HPD intervals.

[11] The statistics, retrieved from the WIND Economic database, reveal that China's degree of marketization has substantially improved since 1996.

3.4. Summary and Policy Implications

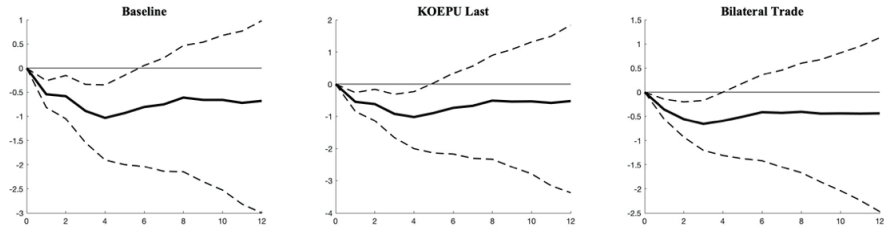
In sum, we find that China's economic policy uncertainty has little impact on Korea's aggregate exports, while it has significant adverse effects on its bilateral imports from Korea. Furthermore, Korean aggregate exports comove significantly with global demand. As we stated in the Introduction section, external economic uncertainty shocks can exert an influence on the host country's exports through two main channels: demand channel and exchange rate channel. In our models, a rising shock in China's EPU indeed causes the Korean exchange rate to depreciate in the short-run (shown in Fig. 9), whereas a devaluation in the won would dampen Korean exports significantly (shown in Fig. 10)[12], which corroborates the results of Reinhart and Calvo (2000). Cheng (2017) and Cook and Devereux (2006) highlight that as Korea's exports are mostly priced in the US dollar, a depreciation in the won might not make its exports more competitive. More importantly, South Korea is a developing economy focusing on processing trade (Oh Han-Nah, Lee Sung-Woo and Seo Young-Joon, 2018) and highly dependent on external energy supply, such as oil and gas. A devaluation in the Korean won against the US dollar inevitably raises the cost of imported inputs (including energy products) and the prices of exported commodities (Cheng, 2017), leading to inflation (Khan et al., 2018), which finally results in a decline in exports. Similar findings are also reported for China by Xing (2012); an appreciation in the renminbi reduces imports as well,

Fig. 9. Time-Averaged Responses of the Exchange Rate to a Rising Shock in China's EPU



Note: The solid lines and dash lines represent posterior median estimates and 84% HPD intervals, respectively.

Fig. 10. Time-Averaged Responses of Exports to a Rising Shock in the Exchange Rate



Note: The solid lines and dash lines represent posterior median estimates and 84% HPD intervals, respectively.

[12] The responses of the exchange rate to EPU shocks and exports to exchange rate shocks in models included GEA and FAI are similar to those depicted in Fig. 9 and Fig. 10. The IRFs are not reported here but available upon request.

which is in contrast with the conventional wisdom. Apart from the transmission through the exchange rate, China's EPU shocks might have reduce the demand for Korea's goods and commodities through its investment, especially after 2010 (shown in Fig. 8). As a result, these two channels would make Korean exports to China sensitive to China's EPU shocks.

Our empirical results have the following policy implications. First, given the significant detrimental impacts of China's economic policy uncertainty on Korean exports to China, Korea must consolidate and deepen its economic and trade cooperation with China under the current FTA and BRI frameworks. Second, since China's economic policy uncertainty shocks are transmitted through its domestic investment and the exchange rate, Korean policymakers should focus on changes in China's macroeconomy and aim to stabilize their foreign exchange market. Third, South Korea should continue to optimize the structure of its exports and encourage industries with a greater comparative advantage over China, such as machinery and electrical equipment and optical components, to enhance their core competence. Finally, Korean authorities should pay more attention to the possible effects of the declines in global demand because of the recent global COVID-19 pandemic on Korean exports, and enforce effective countermeasures to shield its domestic economy.

4. Conclusions

We contribute to the growing literature on international spillovers of economic uncertainty by explicitly investigating the dynamic effects of China's economic policy uncertainty on Korea's exports through a TVP-VAR model. In particular, we employ a new approach in a stochastic model specification search framework developed by Eisenstat, Chan and Strachan (2016) to control overparameterization, which has been recognized in recent econometrics literature. Using quarterly data from 1990Q1 to 2019Q1, we highlight significant adverse effects of China's economic policy uncertainty on Korea's exports to China, providing empirical evidence to demonstrate that economic uncertainty acts as a demand shock. Additionally, China's economic policy uncertainty could affect Korea's exports to China through the exchange rate. Moreover, Korea's aggregate exports are mainly driven by global demand, and are less influenced by China's economic policy uncertainty shocks on account of the high regional diversification in export destinations. Additionally, with the time-varying IRFs, our results support the findings of previous studies, which pointed out that international spillovers of economic uncertainty were more severe during the global financial crisis. Importantly, we attribute the time-varying features in the adverse effects of China's economic policy uncertainty on Korea's exports to China to changes in China's foreign trade policies, global economic conditions, and China's degree of economic freedom (marketization).

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