Policy Research Working Paper 10225

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Evidence from a GVAR Model

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WORLD BANK GROUP
Macroeconomics, Trade and Investment Global Practice
November 2022

Policy Research Working Paper 10225

Abstract

The paper uses a global vector autoregression model with quarterly time series data from 1994 to 2016 to investigate the spillover effects of Chinese trade and growth shocks on 10 Association of Southeast Asian Nations countries. Time varying trade weights are used to construct the foreign variables in individual country models and structural generalized impulse response functions are used to conduct the dynamic analysis. The results show that a positive shock to Chinese trade and growth has a positive effect on the growth of Brunei, Malaysia, the Philippines, Singapore and Thailand. The effect is much weaker and statistically insignificant for other countries.

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Spillover Effects of China's Trade and Growth Shocks on ASEAN Countries: Evidence from a GVAR Model

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Keywords: ASEAN countries, Chinese trade shocks, GVAR, Economic integration

JEL classification: C32, F43, O47

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1 Introduction

Economic relations between China and the Association of Southeast Asian Nations (ASEAN) countries have expanded dramatically in the last two decades despite occasional political tensions. China's economic reforms in 1992 and entry to the World Trade Organization (WTO) in 2001 helped these countries to come even closer economically. A year after joining the WTO, China signed a Framework Agreement on Comprehensive Economic Cooperation with the ASEAN countries. This ultimately led to the creation of China's first free trade agreement and the largest free trade area in the world in terms of population, the ASEAN-China Free Trade Area (ACFTA). To further boost the economic ties, both sides signed a protocol in 2015, which took effect in mid-2016. China has been the biggest trading partner for the ASEAN countries since 2010. Trade between them increased from less than $40 billion in 2000 to more than $500 billion in 2017[1].

The economic integration between China and ASEAN countries has helped the participating countries to gain access to each other's growing markets. Higher economic integration also means countries have increasingly become more interdependent to pursue their own stability and development. Rapid growth of the Chinese economy has made it the engine of economic growth in Asia. Despite the subdued growth in the developed West after the financial crisis, the Chinese demand has kept the export led growth prospects of the ASEAN countries alive. Under these circumstances, it has become increasingly important to understand the inter dependencies of these nations in order to take the correct policy measures.

The aim of this paper is to investigate the impact of Chinese trade and growth on the ten ASEAN economies using a global vector autoregression (GVAR) model. In doing so, it will control for other macroeconomic variables like the real effective exchange rate and short term interest which can potentially affect the transmission mechanism. Examining the potential effects of China on East Asian countries is not new in the literature. Different

[1]Source: Ministry of Commerce, China.

versions of Computable General Equilibrium (CGE) model were used by some papers. Chirathivat (2002) predicted economic growth in China and ASEAN countries due to further economic integration using a CGE model. He also examined the possible effects on different sectoral products. Park and Fuller (1995) also estimated a CGE model to identify the effect of ACFTA on trade creation and overall welfare gain. Though he found overall positive outcomes in the region, his estimation showed higher welfare gains for more advanced countries like Singapore and Malaysia compared to other less advanced countries. Using similar methodology, Estrada et al. (2011) concluded that trade liberalization and FTA between ASEAN and three large Asian economies (China, Japan and the Republic of Korea) will have greater positive effect in the region compared to bilateral trade deals. Using partial equilibrium approaches with disaggregated data Ahearne et al. (2006) and Roland-Holst and Weiss (2004) found the possibilities of increasing trade competitiveness in the region by further reduction of tariffs. There are some studies that used gravity models to analyze the effects. Using a gravity model with panel data, Yang and Matinez-Zarzoso (2014) found substantial trade creation due to ACFTA. Zhou (2007) also used a gravity model to conclude that being a member of the WTO positively affected bilateral trade between China and the ASEAN countries. Using a similar gravity approach, Robert (2004) examined the validity of the Linder Hypothesis in the ACFTA region. Ahuja and Nabar (2012b) and Ahuja and Nabar (2012a) used a factor augmented vector autoregression (FAVAR) model to analyze the spillover effects of a Chinese growth slowdown. There are some other studies (e.g. Rong and Yang (2006), Qiu et al. (2007), Ferrianta et al. (2012)) which focus exclusively on agricultural products.

This paper contributes to the literature in several ways. First of all, it uses a global vector autoregression (GVAR) model to investigate the effect of Chinese trade and growth shock on ASEAN countries. Gravity models often fail to take into account the dynamic nature of the global economy involving many variables. While CGE models do take care of this issue by incorporating a large number of equations, they are more grounded in theory.

The GVAR models are primarily data-driven models and can incorporate today's interconnected economies in a convenient manner and can take into account the dynamic nature of the global economy involving many variables better than the gravity and CGE models. It gives a very practical global modeling framework for empirical analysis of different shocks and transmission mechanism of macroeconomic variables. GVAR models tackle the 'curse of dimensionality' problem by imposing restrictions directly on the parameters of the model. In particular, all foreign economies are typically approximated by one representative economy constructed as a (trade-)weighted average of foreign economies. Compared to factor augmented VAR (FAVAR) models, as used by Ahuja and Nabar (2012a,b) in the context of spillover effects of Chinese macroeconomic shocks, the GVAR approach can combine different macroeconomic variables of a large number of countries in a much more efficient manner. Here, individual country models are added by means of a consistent econometric approach to get a global model where cointegration is allowed for variables within and across countries. On the other hand, FAVAR models capture country-specific dynamics only through the idiosyncratic components (i.e. the residuals). Also, unlike other data driven models, GVAR allows data to be used in levels and thus the long run information in the data is retained. Cross country studies on spillover effects of macroeconomic shocks using GVAR models have flourished in recent times due to its convenient features. However, only few (e.g. Han and Ng (2012), Feldkircher and Korhonen (2012) and Osorio and Unsal (2013)) concentrated on China and its effect on other countries.While Han and Ng (2012) used it mostly for forecasting and Osorio and Unsal (2013) used it to detect spillover effects of inflation, Feldkircher and Korhonen (2012) focused on the effect of Chinese growth shocks on Central and Eastern European countries.

Secondly, this study uses a time varying weight matrix in order to construct the foreign variables in individual country models. Though use of time varying weights is gaining popularity in GVAR analysis, most of them still use a fixed weight matrix. Since the data coverage in this paper includes the Asian crisis of 1997 and the global financial crisis of

2007, a time varying weight matrix is better able to capture the varying trade relationships between the countries over the sample period. Also, in terms of dynamic analysis, structural generalized impulse response functions (SGIRFs) are used instead of the more commonly used generalized impulse response functions (GIRFs) in the GVAR literature. Use of SGIRF partially helps to overcome the criticisms of GIRFs.[2] Thirdly, this paper covers a larger time period (1994-2016) than any other related studies. This helps to understand the overall effect of Chinese trade shocks across the business cycle and the effect of ACFTA.

2 The GVAR model

The GVAR approach introduced by Pesaran et al. (2004) gives a relatively simple yet effective way to model today's global economy where each country and different macroeconomic factors within countries are related with each other. The GVAR model used here consists of two different stages. First of all, a separate VARX model is estimated for each country separately. If some of the variables have unit roots and they are cointegrated, the model is estimated in their error correcting form. In these individual VARX (or VECMX) models, each country has two different types of variables: domestic and foreign. Domestic variables are endogenous in the model while the foreign variables are exogenous. Each domestic variable has its corresponding foreign variables. These foreign variables are constructed using a weight matrix so that the relative importance of different countries is reflected properly. They provide a connection between the evolution of the domestic economy and the rest of the world. These foreign variables need to be weakly exogenous, an assumption that needs to be tested. In the second step, these individual VARX (or VECMX) models are combined together in a consistent manner with the help of a link matrix to build a global model.

- **Individual country models**

[2] See section 4 for more deatil.

Let there be $N+1$ countries in the model, indexed by $i = 0, 1, 2, \ldots..N$, where country 0 is considered the reference country. Each country i then follows the $VARX(p,q)$ model:

$$y_{i,t} = a_{i,0} + a_{i,1}t + \sum_{j=1}^{p} \alpha_{i,j} y_{i,t-j} + \sum_{j=1}^{q} \beta_{i,j} y^*_{i,t-j} + u_{i,t} \tag{1}$$

for $t = 1, 2, ..., T$. Here, $k_i \times 1$ matrix $y_{i,t}$ represents the endogenous domestic variables and $k_i^* \times 1$ matrix $y^*_{i,t}$ represents the corresponding (weakly) exogenous foreign variables. k and k^* are the numbers of domestic and foreign variables respectively, $a_{i,0}$ is a $k_i^* \times 1$ vector of fixed intercepts and $a_{i,1}$ is a $k_i^* \times 1$ vector of coefficients on the deterministic time trends. p and q are the lag lengths of the domestic and foreign variables respectively. They are selected according to the Schwartz Baysian (SB) criterion. Finally, $u_{i,t}$~iid $(0, \sum u_i)$.

Foreign variables are calculated as the weighted average of the rest of the countries' values of that variable. More specifically,

$$y^*_{i,t} = \sum_{j=1}^{N} w_{i,j,t} y_{j,t} \tag{2}$$

where $w_{i,j,t}$ is a weighting factor that captures the importance of country j for country i, with $\sum_{j=0}^{N} w_{i,j,t} = 1$ and $w_{i,i,t} = 0$. Most of the GVAR literature use fixed trade weights based on bilateral trade volumes. However, these may be subject to temporal changes, particularly for the time period considered in this paper as it contains the periods of financial crisis of 2007-08 and the Asian financial crisis of 1997. As a result, using a fixed weight might mislead the results. In order to take account of these changes during the sample period, time-varying weights are used to construct the foreign variables in the country-specific models. These are constructed as three-year moving averages to smooth out short-run business-cycle effects in the bilateral trade flows.

More compactly, setting $p_i = max(p,q)$, equation 1 can be written as:

$$A_{i,0} z_{i,t} = a_{i,0} + a_{i,1}t + \sum_{j=1}^{p_i} A_{i,j} z_{i,t-j} + u_{i,t} \tag{3}$$

where vector $z_{i,t} = (x_{i,t}{'}, x^*_{i,t}{'})'$ represents both domestic and foreign variables and coefficient matrices are $A_{i,0} = (I_{k,i}, -\beta_{i,0})$ and $A_{i,j} = (\alpha_{i,j}, \beta_{i,j})$.

Because of the characteristics of the macroeconomic variables and to allow for the cointegrating relationship within and between countries, the country specific VARX models are estimated in the following error correction form (VECMX):

$$\Delta y_{i,t} = c_{i,0} - \alpha_i \beta_i{'}(z_{i,t-1} - a_{1,t}(t-1)) + \beta_{i,0}\Delta y^*_{i,t} + \sum_{j=1}^{p_i - 1} \phi_{i,j}\Delta z_{i,t-j} + u_{i,t} (4)$$

Here, α_i is a $k_i \times r_i$ matrix of rank r_i and β_i is a $(k_i + k^*_i) \times r_i$ matrix of rank r_i. The country specific VECMX models are estimated using reduced rank regression conditional on the weakly exogenous foreign variables. This takes into account the possibility of cointegration within domestic variables and across domestic and foreign variables. This way estimates for r_i, β_i and α_i are obtained. The other parameters are estimated by OLS from this equation:

$$\Delta y_{i,t} = c_{i,0} + \delta ECM_{i,t-1} + \beta_{i,0}\Delta y^*_{i,t} + \phi_i \Delta z_{i,t-1} + u_{i,t} \qquad (5)$$

where $ECM_{i,t-1}$ is the error correction term referring to the r_i cointegrating relations of the ith country model.

•The global model

The next step is to combine the individual country specific parameter estimates into a single global model. All country specific variables are considered as a single $k \times 1$ global vector $y_t = (y'_{0t}, y'_{01}, ..., y'_{Nt})'$ where $k = \sum_{i=0}^{N} k_i$, so that all the variables are endogenous in the system as a whole. For each country, the corresponding VARX model is obtained from the VECMX model that was estimated. The link matrix W_i, which is the $(k_i + k^*_i) \times k$ matrix collecting the trade weights w_{ij}, $\forall i, j = 0, 1, 2, ..., N$ is used to obtain the identity $z_{i,t} = W_i y_t$. From equation (3), it follows that:

$$A_{i,0} W_i y_t = a_{i,0} + a_{i,1} t + \sum_{j=1}^{p_i} A_{i,j} W_i y_{t-j} + u_{i,t} \qquad (6)$$

for $i = 0, 1, ..., N$. Then the $N + 1$ systems in (6) are combined to get the global model in levels:

$$G_0 y_t = a_0 + a_1 t + \sum_{i=1}^{p} G_i y_{t-i} + u_t \tag{7}$$

Here, $G_0 = (A_{00}W_0, A_{10}W_1, ..., A_{N0}W_N)'$ is a known non singular $k \times k$ matrix that depends on the trade weights and parameter estimates $G_i = (A_{0i}W_0, A_{1i}W_0, ..., A_{Ni}W_N)'$ for $i = 1, 2, .., p$, $a_0 = (a_{00}, a_{10}, ..., a_{N0})'$, $a_1 = (a_{01}, a_{11}, ..., a_{N1})'$, $u_t = (u_{0t}, u_{1t}, ..., u_{Nt})$ and $p = max(p_i)$ across all i. Premultiplying (7) by G_0^{-1}, the GVAR (p) model is obtained as

$$y_t = b_0 + b_1 t + \sum_{i=1}^{p} F_i y_{t-i} + \varepsilon_t \tag{8}$$

where, $b_0 = G_0^{-1} a_0$, $b_1 = G_0^{-1} a_1$, $F_i = G_0^{-1} G_i$ for $i = 1, 2, ..., p$ and $\varepsilon_t = G_0^{-1} u_t$.

The dynamic properties of the GVAR model in (8) can then be examined using Structural Generalized Impulse Response Functions (SGIRFs).

3 Data and relevant tests

This section describes the data, model specification, the results of the weak exogeneity test, time varying weights and the contemporaneous effects.

3.1 Data and model specification

I use quarterly data from 1994Q1 to 2016Q4 for China, Japan and ten ASEAN countries (i.e. Brunei, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam). The model is estimated with data on total trade (TRADE), real GDP growth (GROWTH), real effective exchange rate (REER) and short term interest rate (SIRT). If the data were not available in seasonally adjusted form, they were adjusted using the census X-12 method. Though the main objective of this study is to investigate the effects of trade and growth shocks, the short term interest rate is included to control for monetary policy and exchange rate is included to better understand the transmission process of the trade shocks. It was not possible to add more variables due to data unavailability for many of the ASEAN countries.

GDP growth and trade data were collected from Oxford Economics and the IMF's IFS dataset respectively. Since this paper investigates the spillover effects via the trade channel, it is important to define the trade variable correctly. Trade data for each country is the sum of the value of exports and imports of that country with other countries in the sample. Rather than using total trade data with all the countries of the world, using data specific to the countries in the sample helps to isolate the effects of trade within this region. Many analysts focus on the value of the trade balance (difference between exports and imports) of a country rather than using total trade (sum of exports and imports). However, the trade balance can be a poor indicator of the overall economic prosperity in the region. Trade, whether it is exports or imports, allows each nation to concentrate its labor, capital, and other resources on the economic pursuits at which it is most productive relative to other countries. This helps to generate greater output in the region which is shared by its participants, even though the effect on the trade balance might be negative in some countries. This is why total trade is used in this paper instead of the trade balance.

Real effective exchange rate data for China, Japan, Indonesia, Malaysia, the Philippines, Singapore and Thailand are taken from IMF's IFS dataset. For other countries, exchange rate in terms of the US dollar is used as a proxy of the real effective exchange rate due to data unavailability. The source of short term interest data is OECD and Oxford Economics for China, Japan, Indonesia, Malaysia, the Philippines, Singapore and Thailand. For others the lending rate is used as a proxy for the short term interest rate and they are collected from the IMF's IFS data set[3].

In the individual VARX country models, all the four variables are included both as en-

[3]Except Brunei, Lao PDR and Vietnam, for which data were not available.

dogenous domestic variables and exogenous foreign variables. Next, the order of the country specific VARX (p_i, q_i) model is selected using the Schwarz Bayesian (SB) criterion. While selecting the lag order, p_i and q_i were not allowed to be greater than 2 because of the short sample size compared to the large number of parameters to be estimated. Stationarity is checked for all the country specific domestic variables and their corresponding foreign variables using the Augmented Dickey Fuller (ADF) test and the Weighted-Symmetric Dickey Fuller (WS) test. Given that some of the variables are non-stationary, Johansen's cointegration test is conducted next in order to determine the number of cointegrating relations for each country. Here, the specifications consider case IV according to Pesaran et al. (2000), where a linear deterministic trend is implicitly allowed for the cointegration space but can be eliminated in the dynamic part of VEC models. Next, individual country specific VECMX models are estimated subject to the reduced rank restrictions and the corresponding error correcting terms were derived. These ECM's were subsequently used to conduct the weak exogeneity test.

3.2 Weak exogeneity test

As mentioned earlier, one of the main assumptions of the GVAR model is the weak exogeneity of the country specific foreign variables $y^*_{i,t}$. In general, a variable in a VARX model is considered weakly exogenous if it is not dependent on the contemporaneous values of the endogenous variables but is likely to depend on the lagged values of these endogenous variables. More formally, $y^*_{i,t}$ is considered weakly exogenous if $y_{i,t}$ does not affect $y^*_{i,t}$ in the long run but $y^*_{i,t}$ is said to be 'long run forcing' for $y_{i,t}$. As shown in Johansen (1992), this assumption allows proper identification of the cointegration relations. In the formal test, joint significance of the estimated error correction terms in auxiliary equations for the country specific foreign variables $y^*_{i,t}$ is tested. Specifically, for each lth element of $y^*_{i,t}$ a regression of the following form in conducted:

$$\Delta y^*_{i,t,l} = a_{i,l} + \sum_{j=1}^{r_i} \delta_{i,j,l}\widehat{ECM}_{i,j,t-1} + \sum_{s=1}^{p_i^*} \phi'_{i,s,l}\Delta y_{i,t-s} + \sum_{s=1}^{q_i^*} \Psi_{i,s,l}\Delta \widetilde{y}^*_{i,t-s} + \eta_{i,t,l} (9)$$

where $\widehat{ECM}_{i,j,t-1}$, for $j = 1, 2, ..., r_i$ are the estimated error correction terms corresponding to the r_i cointegrating relations found for the i th country, and p_i^* and q_i^* are the orders of the lagged changes for the domestic and foreign variables respectively. The test for the weak exogeneity is an F-test of the joint hypothesis that $\delta_{i,j,l} = 0$ for $j = 1, 2, ..., r_i$ in the above equation. It is not necessary that lag orders of p_i^* and q_i^* are the same for the underlying country specific model. They are selected using the SB criterion.

Table 1: Weak Exogeneity Test at the 5% significance level

Country	F test	Fcrit_0.05	GROWTH	TRADE	REER	SIRT
Brunei	F(1,75)	3,96	0,11	0,28	0,02	4,84
Cambodia	F(1,73)	3,97	0,57	0,90	2,02	0,66
China	F(3,70)	2,73	1,92	7,01	1,44	0,45
Indonesia	F(2,72)	3,12	3,2	6,03	1,49	1,86
Japan	F(2,72)	3,12	1,23	0,95	2,39	0,17
Lao PDR	F(2,74)	3,12	6,81	0,12	0,10	0,10
Malaysia	F(2,72)	3,14	3,76	3,50	3,86	2,19
Myanmar	F(1,73)	3,97	0,04	0,006	0,28	0,27
Philippines	F(2,72)	3,12	0,33	0,72	0,60	1,32
Singapore	F(3,71)	2,73	0,49	1,54	0,46	0,33
Thailand	F(1,73)	3,97	4,61	0,03	0,01	0,07
Vietnam	F(1,75)	3,96	2,42	2,67	1,62	1,41

The results are shown in table (1). As can be seen, almost all the variables pass the weak exogeneity test as the assumption of exogeneity can not be rejected at 5% level. Only exceptions are the short term interest rate for Brunei, trade for China and Indonesia, GDP growth for Lao PDR and Thailand, real effective exchange rate for Malaysia. This is a very desirable result as it confirms the suitability of a GVAR model for this region. Based on the eigenvalues[4], the model is also found to be stable.

3.3 Time varying weights

As mentioned in section 2, trade weights are calculated for each country in order to create the country specific foreign variables. These trade weights reflect the proportion of a country's trade with other countries in the sample. Yearly bilateral trade flow data among each of the countries are used in order to create these weights. Use of time varying trade weights (instead of fixed trade weights) in this GVAR model means there are trade weights for each country for each year in the sample. This large trade weight matrix gives insights on how trade flow fluctuated between countries over the years. Figure(1) shows the trade weights of China for the 10 ASEAN countries over the sample period (1994-2016). Trade weights here represent the relative importance of China in terms of trade for these countries compared to other countries in the sample (i.e. rest of the ASEAN countries + Japan).

It is evident from the figure that for almost all the ASEAN countries, the importance of China as a trading partner has increased over the time. While the trade weights of China increased most sharply for Vietnam, the weakest increase is displayed by Brunei. As a trading partner, China's importance is greatest for Vietnam, Cambodia and Myanmar at the end of the sample period. Myanmar shows the most fluctuation in terms trading relation with China. In 1994, China was their most important trading partner among all the ASEAN countries, but the weight decreased until 2000 and started to rise again after the creation for ACFTA in 2010. In short, the graphs in general show an upward trend of the weights of China as a trading partner for the ASEAN countries and it is likely that they will continue

[4]The results are available on request

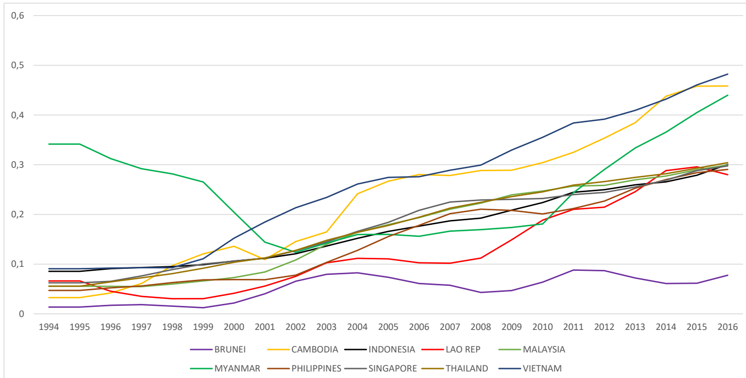

Figure 1: Time varying weights between China and the ASEAN countries

to move upward in the near future.

3.4 Contemporaneous effects

Contemporaneous effects show how variables of each country are affected contemporaneously by the combined effect of the same variables of the rest of the countries. These results are presented in table (2). Values of the coefficients show the response of the domestic country variables to a 1% change in their foreign counterparts. For example, in Indonesia, a 1% increase in trade in the rest of the countries (foreign trade variable) brings 0.63% increase in growth in the domestic economy. These results can also be interpreted as impact elasticity and they give a good indication of how interconnected the countries are.

In table (2), coefficients are also presented with their corresponding Newey-West heteroskedasticity and autocorrelation consistent t- ratios. Values in bold font indicates they are statistically significant at the 5% level. Results show a high degree of contemporaneous

Table 2: Contemporaneous effects

		GROWTH	TRADE	REER	SIRT
Brunei	Coefficient	0,10	0,01	-1,9E-05	
	t-ratio	0,44	**3,16**	-0,42	
Cambodia	Coefficient	-0,03	0,01	-0,04	0,02
	t-ratio	-1,32	**3,67**	-1,40	0,30
China	Coefficient	0,20	0,92	-0,001	-0,27
	t-ratio	0,31	**10,21**	-0,87	-1,89
Indonesia	Coefficient	-1,34	0,63	-0,002	-0,95
	t-ratio	-2,55	**7,64**	-0,088	-1,31
Japan	Coefficient	0,02	0,75	-0,02	-0,02
	t-ratio	1,22	**10,38**	-0,94	-0,84
Lao PDR	Coefficient	-0,04	-0,001	0,22	
	t-ratio	-2,57	-0,06	1,08	
Malaysia	Coefficient	0,73	0,57	0,03	0,84
	t-ratio	**5,01**	**8,80**	1,72	**6,06**
Myanmar	Coefficient	0,01	0,02	0,45	0,17
	t-ratio	1,35	2,64	0,68	1,38
Philippines	Coefficient	0,07	0,22	-0,01	2,80
	t-ratio	1,47	**6,50**	-0,63	**3,26**
Singapore	Coefficient	0,35	0,99	-0,005	0,68
	t-ratio	3,57	**8,85**	-0,73	**4,92**
Thailand	Coefficient	-0,75	0,99	-0,002	0,37
	t-ratio	**-8,45**	**10,71**	-0,30	0,49
Vietnam	Coefficient	0,014	0,32	2,21	
	t-ratio	1,39	**7,82**	0,93	

co-movements among the countries for trade. Trade is statistically significant for all the countries except Lao PDR and Myanmar. For Singapore and Thailand the impact elasticity for trade is almost 1, which indicates a 1% increase in trade in the rest of the countries brings about a 1% increase in trade in the same quarter for these countries. This also indicates that these countries are more sensitive to foreign trade shocks. Among other variables, growth is significant for Malaysia and Thailand and short term interest rate is significant for Malaysia, Philippines and Singapore. On the other hand, real effective exchange rates do not show any statistically significant contemporaneous movement to a foreign shock of the same variables. In general, these contemporaneous coefficients depict strong interconnections among the countries through trade.

4 Dynamic analysis: Structural generalized impulse response function (SGIRF) analysis of China's trade and growth shock

This section discusses the effects of a trade and GDP growth shock to China on GDP growth, trade, real effective exchange rate and short term interest rate of all the countries by the means of structural generalized impulse response function (SGIRF) analysis. Identification of shocks has been a major issue in GVAR models. In order to conduct dynamic analysis, the vast majority of the research papers using GVAR models rely on the generalized impulse response function (GIRF) proposed by Koop et al. (1996) and further developed by Pesaran and Shin (1998). Identification of shocks in a GVAR model is complicated due to the cross country interactions and high dimensionality of the model. Identification in traditional VAR analysis is usually achieved by using the orthogonalized impulse response functions (OIRFs) which require certain ordering of variables. This approach is often not suitable for GVAR models as it requires ordering not only of the variables but also the countries. As a result, when a large number of variables and countries are included in the model, it becomes difficult to justify such ordering based on economic theory and empirical findings. The reason why GIRFs are popular in GVAR models is that they are invariant to the ordering of the countries and variables, thus making them suitable for models that involve many countries and variables. However, it comes at a cost. Critiques often argue that in GIRFs the error terms are not orthogonal and thus it allows correlation among them. This, in turn makes economic interpretation of shocks difficult.

I take this into account in this paper by using structural generalized impulse response functions (SGIRFs) instead of GIRFs. SGIRF allows the most dominant economy in the model to be ordered first and also its variables to have certain ordering. It becomes difficult to use SGIRFs in GVAR models if all the economies are of similar size and significance. However, since China is significantly larger than the other countries in the sample, use of SGIRFs is well justified. As a consequence, China and its variables are ordered first. This means the identifying scheme for the model of China is based on a lower-triangular Cholesky decomposition and it has the following ordering: [Growth, Trade, REER, SIRT]'. So for China, GDP growth is ordered first and it is followed by trade. This assumes GDP growth affects the trade contemporaneously but not the other way round.[5] Trade is then followed by real effective exchange rate and short term interest rate. Other countries and their variables are kept unrestricted. More about the GIRFs and SGIRFs are discussed in the appendix.

Since the main objective of this paper is to see the effects of the Chinese trade shock on itself and the spillover effects on other countries, this result is depicted in Figure(2). It shows the SGIRFs for China, Japan and the ten ASEAN countries to a 1 standard deviation (SD) positive trade shock to China. For each country, reactions of GROWTH, TRADE, REER and SIRT are depicted for up to 20 quarters. The associated 90% bootstrap confidence bands, computed on the basis of 1000 replications, are also displayed by the broken lines.

[5] The results were also checked by ordering trade first, however there were no major changes

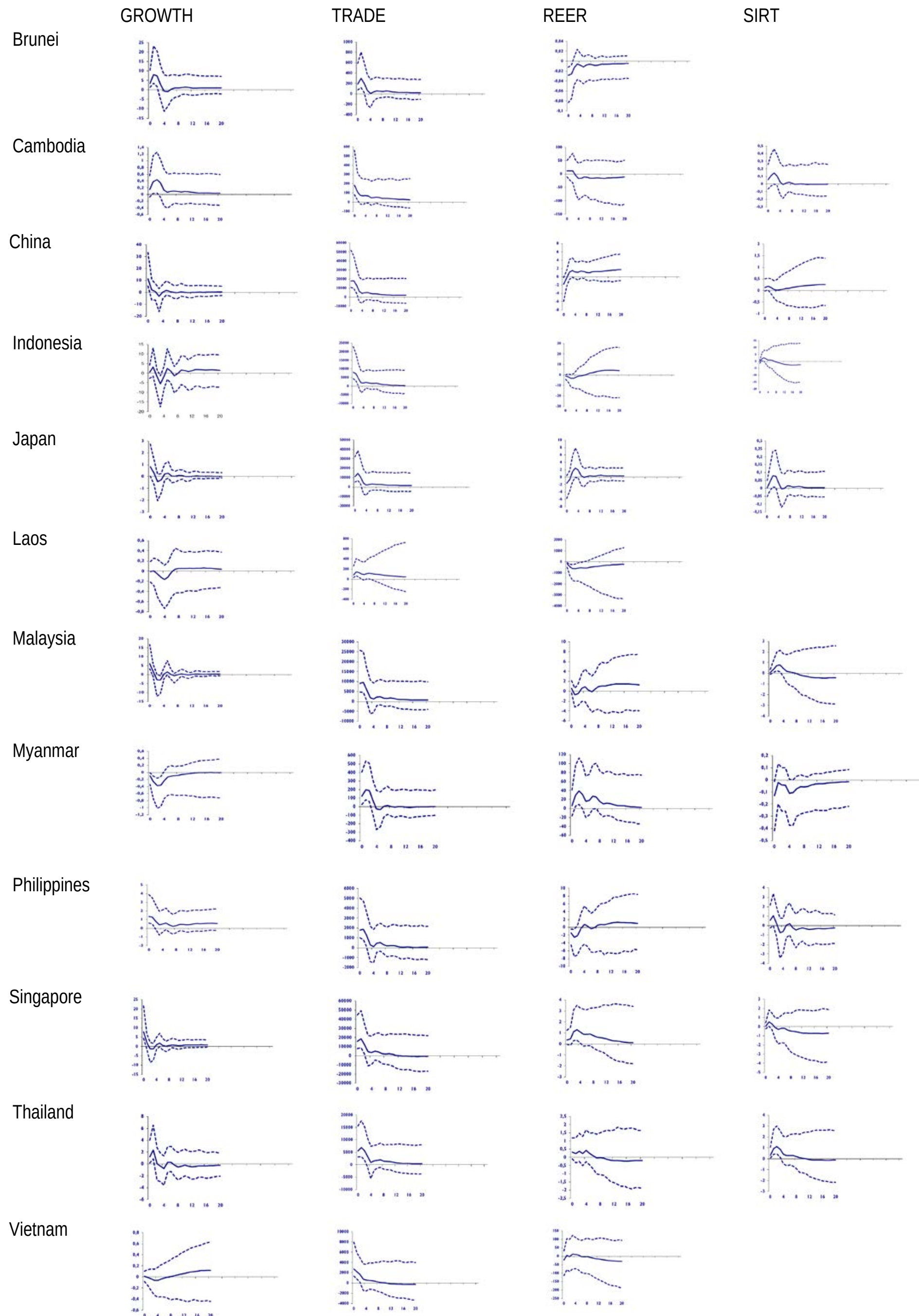

Figure 2: Impulse response functions for an expansionary 1 SD shock to China Trade *Notes:* The figure reports structural generalized impulse response functions (SGIRFs) for the GDP growth (GDP), total trade (TRADE), real effective exchange rate (REER) and short term interest rate (SIRT). The graphs show bootstrap median estimates with the associated 90% bootstrap confidence bands computed on the basis of 1000 replications of the SGIRFs, where the forecast horizon extends up to 20 quarters and is recorded along the horizontal axis.

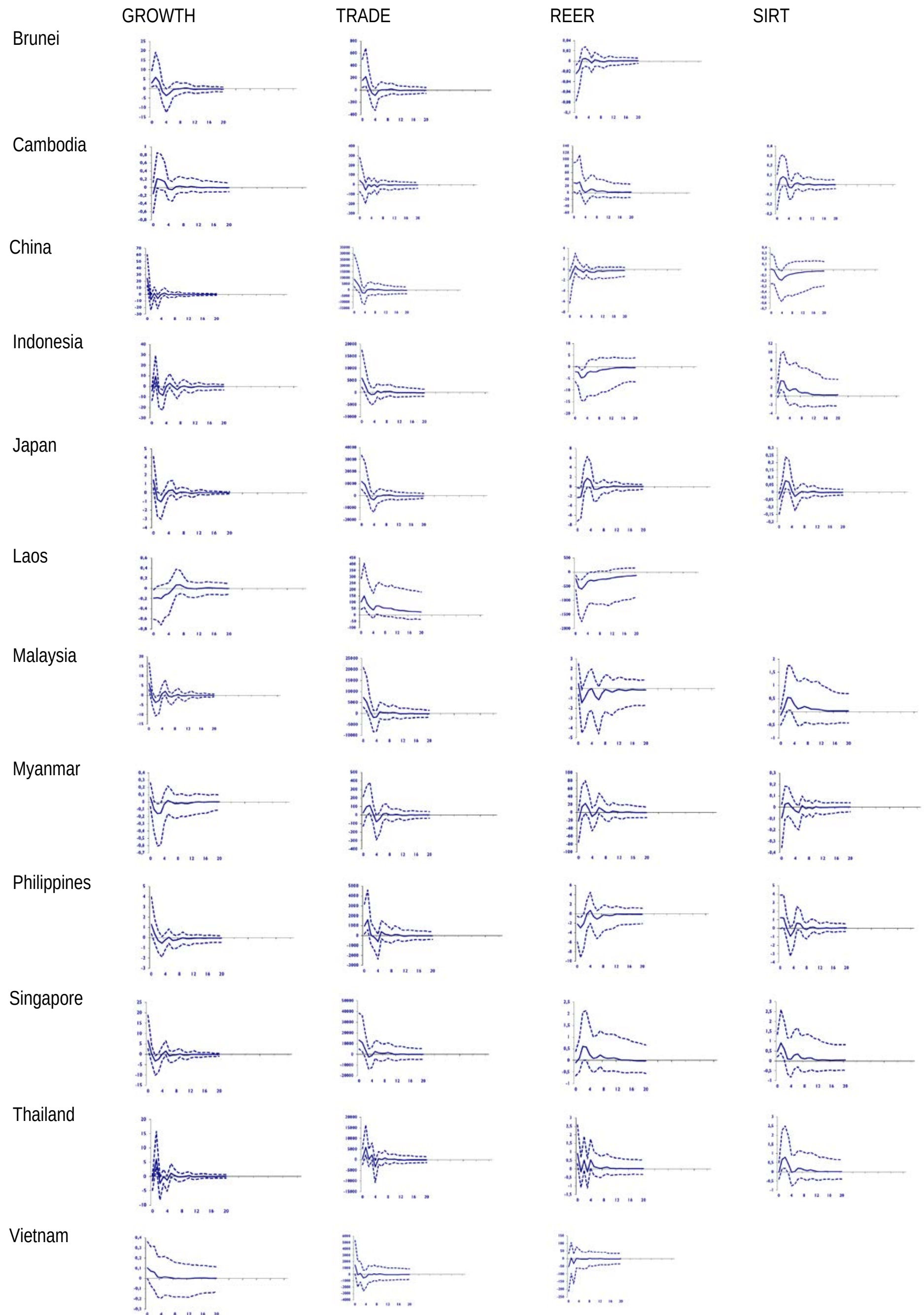

Figure 3: Impulse response functions for an expansionary 1 SD shock to China GDP growth
Notes: see Fig.(2)

The figure shows mixed results for growth. A positive Chinese trade shock is followed by a positive and significant reaction in growth for most of the countries. These countries include Brunei, China, Japan, Malaysia, the Philippines, Singapore and Thailand. For all of these countries, the effect is very short lived and becomes insignificant after a few quarters. Reaction on impact is highest for Singapore, confirming the strong business ties between these two countries. Cambodia, Indonesia, the Lao PDR and Vietnam do not show any significant reaction in growth after the shock. Myanmar is the only country to show a negative reaction. These results are surprising particularly for countries like Vietnam and Myanmar for which China is the largest trading partner both in terms of exports and imports. These results reveal that an increase in Chinese trade with ASEAN countries has different effects on GDP growth of different ASEAN countries and trade does not translate into growth for all the countries. As depicted in the second column of the figure, a positive trade shock in China, on the other hand, does have a positive effect on total trade of other countries. This effect is again short lived and significant for only a few quarters. The effect on the real exchange rate is insignificant for most of the countries. Only Brunei, Lao PDR and Philippines show slight depreciation of currency immediately after the shock. The only country to show some appreciation of currency is Singapore. Short term interest mostly shows a statistically insignificant outcome, with the only exception of Thailand showing some rise in the rates following a Chinese trade shock.

Figure(3) shows the reactions of the variables after a GDP growth shock to China. A 1 SD shock to Chinese growth increases the GDP of Brunei, Japan, Malaysia, the Philippines, Singapore and Thailand in the short term. These are the same countries that reacted positively to a trade shock, implying their strong connections with China. Again these reactions are not very persistent and become insignificant after a few quarters. For other countries the reactions are insignificant. A growth shock in China also increases the amount of trade of the ASEAN countries. The only exceptions are Cambodia and Myanmar, showing insignificant responses after a growth shock to China. Real effective exchange rates and short term interest rates mostly show statistically significant reactions.

5 Policy implications and concluding remarks

China and the ASEAN countries are increasingly becoming more important in global trade. In 1980, China's share of global GDP was less than 2 percent, but it is now in line to increase to 20.3 percent by 2025 (IMF (2020)). China's trading ties with ASEAN countries are growing at a faster pace than any of its major trading partners, with trade more than doubling since 2010. The findings of this paper show that this trade has a significant positive spillover effect, helping the region to grow together. The policy implications could be many:

- The FTA provides China and the ASEAN countries convenient access to their mutual markets, investment destinations, and resources. The outcome of this paper also complements the findings of Huang (2019) that argues China and ASEAN countries should further deepen intra-industry trade through industrial structure upgrading and FDI. A positive macroeconomic impact in ASEAN countries to a positive shock to China should motivate the ASEAN countries to investigate further the diverse elements of the economy that makes this result possible. The export and investment policies of these countries should be prepared accordingly.

- The findings of this paper support the argument that the Chinese policy of conducting FTAs with other emerging Asian countries has paid off. China is increasingly able to obtain economic benefits from the regional network of FTAs while intensifying its economic and, by extension, political relations with its partners (Lei and Sui (2022)). The China-ASEAN collaboration has reduced the regional trade policy uncertainty significantly, positively affecting outward foreign direct investments and economic growth (Sun et al. (2013)). Policies adopted by other major trading partners of the regions (i.e., the United States, the European Union, and Japan, among others) will likely take this into consideration while making their own trade policies with these countries going forward.

- The results of this study show that a positive Chinese trade and growth shock has a positive effect on most, but not all, ASEAN countries. The magnitudes of the positive effects are also different. This indicates that the channels through which trade translates into growth are different for different ASEAN countries. The policymakers of the respective countries could take this into consideration for conducting negotiations under different trade agreements involving these countries, including the Regional Comprehensive Economic Partnership Agreement (RCEP) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP). The development of these trade policies will remain critical for the China-ASEAN relationship in the future.

- Finally, more dependence on trade with China may also indicate greater vulnerability of the ASEAN countries to a negative Chinese economic shock. For some countries where the spillover effects are larger (i.e., Singapore), the risks associated with a negative macroeconomic shock are also larger. The heightened geo-political tensions due to the Russian Federation-Ukraine war and any possible future trade war between the United States and China could magnify the economic woes of the ASEAN countries due to the existing (and often difficult to replace) value chain system with China.

The outcome of this paper also sheds light on the direction of future research involving this region. In conducting econometric analysis with time series data of ASEAN countries, researchers often consider them as one group. The results of this study indicate that heterogeneity among countries should be considered more seriously while conducting empirical research. This creates the need for more research on the interaction between these countries to better understand the economic integration process. Finally, due to limitations involving such large-scale multi-country models, investigating the transmission mechanism of shocks in individual countries was beyond the scope of this study. Future studies should focus more on this topic.

References

Ahearne, A., Fernald, J., Loungani, P., and Schindler, J. (2006). Flying geese or sitting ducks: China's impact on the trading fortunes of other Asian economies. *International Finance Discussion Papers*, 887.

Ahuja, A. and Nabar, M. (2012a). Investment-led growth in China: Global spillovers. *IMF Working Paper*, 267.

Ahuja, A. and Nabar, M. (2012b). The spillover effects of a downturn in china's real estate investment. *IMF Working Paper*, 266.

Chirathivat, S. (2002). ASEAN-China Free Trade Area: Background, implications, and future. *Journal of Asia Economics*, 13(5):671–86.

Estrada, G., Park, D., Park, I., and Park, S. (2011). ASEAN's Free Trade Agreements with the People's Republic of China, Japan, and the Republic of Korea: A qualitative and quantitative analysis. *ADB Working Paper Series on Regional Economic Integration*, 75.

Feldkircher, M. and Korhonen, I. (2012). The rise of China and its implications for emerging markets -evidence from a GVAR model. *BOFIT Discussion Papers*, 20.

Ferrianta, Y., Hanani, N., Setiawan, B., and Muhaimin, W. (2012). Impact of trade liberalization ASEAN-China free trade area (ACFTA) on the performance of Indonesia Maize economy. *Journal of Basic and Applied Scientific*, 2(7):6801–6809.

Han, F. and Ng, H. (2012). ASEAN-5 Macroeconomic Forecasting using a GVAR model. *ADB Working Paper Series on Regional Economic Integration*, 76.

Huang, Y. (2019). The Impact of China-ASEAN Free Trade Area on Bilateral Trade and its Enlightenment. *2019 9th International Conference on Education and Social Science (ICESS 2019).*

IMF (2020). World Economic Outlook: A long and difficult ascent. Washington D.C.

Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of Econometrics*, 52:231–254.

Koop, G., Perasan, H., and Potter, S. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, 74(1):119–147.

Lei, Y. and Sui, S. (2022). China's strategy of free trade area and economic regionalism. *Journal of International Development.*, https://doi.org/10.1002/jid.3658.

Osorio, C. and Unsal, D. (2013). Inflation dynamics in Asia: Causes, changes, and spillovers from China. *Journal of Asian Economics*, 24:26–40.

Park, H. and Fuller, W. (1995). Alternative estimators and unit root tests for the autoregressive process. *Journal of Time Series Analysis*, 16:415–429.

Pesaran, M. H., Schuermann, T., and Weiner, S. M. (2004). Modelling regional interdependencies using a global error-correcting macroeconometric model. *Journal of Business & Economic Statistics*, 22:129–162.

Pesaran, M. H. and Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economic Letters*, 58(1):17–29.

Pesaran, M. H., Shin, Y., and Smith, R. J. (2000). Structural analysis of vector error correction models with exogenous i(1) variables. *Journal of Econometrics*, 97:293–343.

Qiu, H., Yang, J., Huang, J., and Chen, R. (2007). Impact of China-ASEAN Free Trade Area on China's international agricultural trade and its regional development. *China World Economy*, 15(4):77–90.

Rong, J. and Yang, C. (2006). Empirical study on competitiveness and complementarity of China and ASEAN's agricultural products. *International Trade Problems*, 8:45–50.

Sun, Y. F., Heinz, F., and Ho, G. (2013). Cross-country linkages in europe: A global var analysis. *IMF Working Papers*, (13/194).

Zhou, X. (2007). Endogeneity of wto in the gravity model: China and ASEAN. *Chinese Business Review*, 6(6):23–39.

Appendix

GIRF and SGIRF

The generalized impulse response function (GIRF) was introduced by Koop et al. (1996) and further developed by Pesaran and Shin (1998). Let consider the model obtained during the solution of the GVAR expressed in terms of the country specific errors given by equation (7). The GIRFs are based on the definition:

$$GIRF(y_t; u_{i,l,t}; h) = E(y_{t+h}|u_{i,l,t} = \sqrt{\sigma_{ii,ll}}, I_{t-1}) - E(y_{t+h}|I_{t-1}) \tag{10}$$

where I_{t-1} is the information set at time $t-1$, $\sigma_{ii,ll}$ is the diagonal element of the variance co-variance matrix Σ_u corresponding to the l^{th} equation in the i^{th} country, and h is the horizon. GIRF's are invariant to the ordering of the variables and they allow for correlation of the error terms (the error terms are not orthogonal).

The structural generalized impulse response functions (SGIRFs) used in this paper allow ordering of variables to one country. As the United States is the largest and the most dominant economy in this model, it is ordered first and its variables are ordered in the way mentioned in section 4.1. The SGIRF's are invariant to the ordering of other countries and their variables. Let consider the $VARX^*(p_1, q_1)$ model for the United States

$$y_{1,t} = a_{1,0} + a_{1,1}t + \sum_{j=1}^{p} \alpha_{1,j} y_{1,t-j} + \sum_{j=1}^{q} \beta_{1,j} y^*_{1,t-j} + u_{1,t} \tag{11}$$

Let $V_{1,t}$ be the structural shocks given by $V_{1,t} = P_1 u_{1,t}$, where P_1 is a $k_1 \times k_1$ matrix of coefficients to be identified. The identification conditions using the triangular approach of Sims (1980) require $\Sigma_{v,1} = Cov(v_{1,t})$ be diagonal and P_1 to be lower triangular. Let Q_1 be the upper Cholesky factor of $Cov(u_{1,t}) = \Sigma_{u,1} = Q_1^{'} Q_1$ so that $\Sigma_{v,1} = P_1 \Sigma_{u,1} P_1^{'}$ with $P_1 = (Q_1^{'})^{-1}$ Under this orthogonalization scheme $Cov(v_{i,t}) = I_{k_0}$

Pre-multiplying the GVAR model in equation(7) by

$$P^1_{G_1} = \begin{bmatrix} \mathrm{P}_0 & 0 & 0 & 0 \\ 0 & \mathrm{I}_{k_1} & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & \mathrm{I}_{k_n} \end{bmatrix}$$

it follows that

$$P^1_{G_1} G_1 y_t = P^1_{G_1} G_1 y_{t-1} + ... + P^1_{G_1} G_p y_{t-p} + v_t \tag{12}$$

where $v_t = (v'_{1t}, u'_{1t}, ..., u'_{Nt})$ and

$$\Sigma_v = Cov(v_t) = \begin{bmatrix} \mathrm{V}(\mathrm{v}_{1t}) & \mathrm{Cov}(\mathrm{v}_{1t}, u_{1t}) & . \; . \; . & \mathrm{Cov}(\mathrm{v}_{1t},\ u_{Nt}) \\ \mathrm{Cov}(\mathrm{u}_{1t}, v_{1t}) & \mathrm{V}(\mathrm{u}_{1t}) & . \; . \; . & \mathrm{Cov}(\mathrm{u}_{1t}, u_{Nt}) \\ \vdots & \vdots & & \vdots \\ \mathrm{Cov}(\mathrm{u}_{Nt}, v_{1t}) & \mathrm{Cov}(\mathrm{u}_{Nt}, u_{1t}) & . \; . \; . & \mathrm{V}(\mathrm{u}_{Nt}) \end{bmatrix}$$

with

$V(v_{1t}) = \Sigma_{v,11} = P_1 \Sigma_{u,11} P^1_1$ and $Cov(v_{1t}, u_{jt}) = Cov(P_1 u_{1t}, u_{jt}) = P_0 \Sigma_{u_{1j}}$

By using the definition of the generalized impulse responses with respect to the structural shocks given by

$$SGIRF(y_t; v_{l,t}; h) = E(y_{t+h} | I_{t-1} \varrho'_l v_t = \sqrt{\varrho'_l \Sigma_v \varrho_l},) - E(y_{t+h} | I_{t-1}) \tag{13}$$

it follows that for a structurally identified shock, v_{lt} such as a US trade shock the SGIRF is given by

$$SGIRF(y_t; v_{l,t}; h) = \frac{\varrho'_j A_n (P'_{G_1} G_1)^{-1} \Sigma_v \varrho_l}{\sqrt{\varrho'_l \Sigma_v \varrho_l}},\ h = 0, 1, 2, ...; j = 1, 2, ...k]$$

where $\varrho_l = (0, 0, ..., 0, 1, 0, ...0)'$ is a selection vector with unity as the l^{th} element in the case of a country-specific shock, Σ_v is the covariance matrix of the structural shocks and $P'_{G_1} G_1$ is defined by the identification scheme used to identify the shocks.