

Research Article

An Interlinkage of macroeconomic Activities Among Advanced and Emerging Economies: An Empirical Analysis

Sanjay Kumar Rout

Centre for Development Studies, Prasanth Nagar, Ulloor, Thiruvananthapuram-695011, Kerala, India

Corresponding Author: Sanjay Kumar Rout, E-mail: sanjayrout1992@gmail.com

ARTICLE INFO

Article History

Received: June 12, 2020

Accepted: July 22, 2020

Volume: 2

Issue: 4

KEYWORDS

Advanced and emerging economies, GDP growth rate, macroeconomic activity, international economic interlinkage, impulse response function

ABSTRACT

Employing the generalized impulse response function of the VAR model, this paper attempts to evaluate the interlinkage of macroeconomic activities among advanced (the US, Japan and Germany) and emerging economies (China, India and Russia). We also developed two alternative models by adding some macroeconomic variables to check robustness of empirical findings. Study specifically attempts look at two questions; what extent both emerging and advanced economies are interlinked with each other? Whether interlinkage among them is positive or negative or both over time? The study finds that macroeconomic activities of both advanced and emerging countries are significantly interlinked at a higher extent. Further, the interlinked is positive and significant in the initial period but negative in the longer horizon. These empirical findings are robust.

Introduction

A debate on the international economic association in the light of globalization is dynamic in the 21st century than ever before. The economic policies based on hindsight of association of both emerging and advanced economies is unavoidable. For instance, policies for cross-border trade, flow of capital, movement of labour force etc. can never be neglected. These policies are based on welfare of both individual economies and global economy through optimizing their level of consumption. Therefore, according to An et al., (2016) understanding global interlinkage is important because it is central for formation of appropriate international trade agreements, propagation of business cycle and development of monetary union. More specifically, the emerging economies have become a relevant origin and host point of not only financial flows as world financial markets grow (Echeverri-Gent et al. 2015)² but also the flow of commodities. Thus, acknowledging the complexity of international interlinkage of macroeconomic activities among emerging and advanced economies would enable the policymakers to frame precise and reliable macroeconomic policies that enhance the level of welfare in the global economy.³

For the assessment of cross country interlinkage of macroeconomic activity, our sample includes both advanced and emerging economies viz. the US, Japan and Germany, China, India and Russia. These countries constitute the six largest economies in the world in terms of their purchasing power parity (PPP) adjusted GDP assess by World Economic Outlook (April 2018) of the International Monetary Fund. This is because the level of economic development is one of the important determinant of economic interlinkage/integration (Kone, 2012)⁴. The GDP share of these economies constitutes around 52%, while the share of China, India and Russia comprises 30% of world GDP.

² Echeverri-Gent, Herlevi and Ganczak (2015) Economic Interdependence and Strategic Interest: China, India, and the United States in the New Global Order

³ However, it is important to note that the concept economic interlinkage goes beyond the jurisdiction of economic phenomenon and we are also not making any semantic analysis.

⁴ Koné (2012) Is Economic Integration Between Developing Countries a Singular Process?

The GDP shares of China, India and Russia (emerging economies) increase substantially from 14% to around 30%, while the share of the US, Japan and Germany (advanced economies) declined sharply from 33% to 22% between 2000 and 2017 respectively. The share of emerging economies’ exports and imports in total world exports and imports of goods and services is varying from 6% and 5% in 2000 to 15% and 14% in 2017 while that of advanced countries have dramatically fallen from 28% and 32% to 20% and 21% during the same period respectively. The gap between them has been reducing gradually over time. Moreover, the share of FDI stock of advanced economies have been falling steadily from 31.39% to 27.34%, and that of emerging economies remained stable at around 12% of the world FDI stocks between 2010 and 2017⁵.

Some opined that globalisation is one of the most powerful platforms to insert emerging economies into the global economy (Arora and Vamvakidis, 2011)⁶. The interlinkage through bilateral trade and financial markets are quite relevant and conspicuous. It is also obvious from the statistics that there is a substantial magnitude of bilateral trade among the US, Japan, Germany, China, India and Russia. These economies are the top trading partners with each other. The bilateral trade ranking (both exports and imports ranking) among these countries presented in the Appendix (See Appendix table-A1 and table-A2).

Table-1 Correlation analysis on cross country GDP growth rate

	US	Japan	Germany	China	India	Russia
US	1					
Japan	0.791	1				
Germany	0.609	0.702	1			
China	0.146	0.187	0.218	1		
India	0.388	0.394	0.433	0.512	1	
Russia	0.591	0.551	0.542	0.598	0.243	1

Source: author’s own calculation based on GDP growth rate statistics⁷

Table-1 estimates the correlation among the macroeconomic activity of the US, Japan, Germany, China, India and Russia. It shows that there is a high correlation among the countries except for China, followed by India with others. China’s aggregate economic activity shows a low degree of correlation with other’s macroeconomic activity which reflects the resilient behaviour from external factors. Apart from China, the GDP growth rate of India has also relatively low correlation compared to the US, Japan, Germany and Russia. Thus, China and India represent the less possible synchronisation trend towards GDP growth rate across the countries. The overall pictures from the correlation table point out that there is still a higher correlation among them. One can therefore, predict that there would be significant economic interlinkage among these emerging and advanced economies with each other, given an increasing level of development and their bilateral trade, financial market integration, stock and flow of foreign capital, high correlation etc. Having such interactions among these economies, measuring empirically the extent of such economic interlinkage would constitute an important dimension to design desirable macroeconomic policy.

Finding the research gap from the previous studies (presented in section 3), the aim of this study is to appraise the international interlinkage of macroeconomic activity blended with both emerging and advanced economies. Besides the plethora of previous studies, a limited number of studies focused on bidirectional interlinkage of macroeconomic activities among the US, Japan, Germany, China, India and Russia altogether simultaneously. The present paper contributes to the literature in many aspects as well; (a) it considers both the advanced and emerging economies, (b) look at bidirectional interlinkage among them, (c) uses generalized impulse response function instead of orthogonal impulse response function used in the existing studies, (d) study incorporates both financial and non-financial variables in order to assess the robustness of the empirical findings etc. Specifically, our intention is to obtain some empirical idea on the international interlinkage of aggregate economic activity among advanced and emerging economies finally.

In this context, more specifically, this study addresses two questions; first, to what extent both emerging and advanced economies are interlinked with each other? And second, whether interlinkage of macroeconomic activities of advanced and emerging economies is positive or negative or both over time? The questions presented here are important and highly

⁵ Data mentioned in the text are extracted from World Development Indicators/ <http://databank.worldbank.org>

⁶ Arora and Vamvakidis (2011) China's economic growth: international spillovers

⁷ Data extracted from OECD.Stat database

significant in the context of international economic ingratiation. Further, we also framed two alternative models: one by running principal component analysis (PCA) of some important macroeconomic variables and second by considering the industrial production index to evaluate the robustness of empirical findings. Using the generalized impulse response function of the VAR model, our empirical results show that macroeconomic activity of both advanced and emerging countries are significantly interlinked. Our empirical findings are robust.

The remainders are organised as follows: Section 2 discusses the theoretical mechanism of international macroeconomic interlinkage. Section 3 briefly describes the previous studies. Section 4 presents the data description and descriptive statistics. Section 5 demonstrates the methodology for the empirical analysis. Section 6 describes in detail of the estimated results and its interpretation. Section 7 elaborates the robustness check. And finally section 8 concludes.

Theoretical mechanism of cross country economic interlinkage

There are various theoretical mechanisms through which one country interlinks with others found in the previous studies. Kumar et al. (2009)⁸ have emphasised on finance, export and exchange rate mechanism. Iacoviello and Navarro (2019)⁹ evaluated exchange rate, trade and the financial mechanism through which effects of interest rate transmit globally. Bayoumi and Swiston (2009)¹⁰ incorporated trade, commodity prices and financial mechanisms via GDP growth rate interact with each other. The previous studies based on mechanism are scanty despite the plethora of empirical investigation on international interlinkage of macroeconomic activities. Following are the theoretical mechanism that this study has addressed.

Broadly, we found three important theoretical mechanisms through which it ensures international interlinkage of macroeconomic activities. Firstly, the contribution of the exchange rate mechanism is dynamic and comprehensive. Considering two countries A and B, suppose there is a rise in the level of income of A due to economic expansion, may accelerate demand for foreign goods in A. Higher demand for foreign goods in A, leads to depreciate A's currency and appreciate country B's currency under a flexible exchange rate system. Thus, depreciation in A and appreciation in B makes the exports cheaper from A and imports dearer from B. In turn, there is a contraction of B's economic activities due to high import prices and expansion of country A's economic activities.

Secondly, apart from controlling the exchange rate mechanism, the contribution of international trade also plays a larger role in the context of cross country interlinkage. Trade mechanism based on the idea that higher the economic growth rate, larger is incomes and expenditures of the people in A. This high incomes and expenditures in A may accelerate the level of imports from B. In turn, it affects the economic activities of B. Therefore, higher the GDP growth rate in country A tends to raise economic activities in country B. The size of the interlinkage depends on the share of exports and imports of goods and services of B with A (Iacoviello and Navarro, 2019).

Thirdly and finally, financial mechanism manifest that higher the aggregate economic activity in A that indicates better economic performance alter the composition of financial assets held by the international economic players, thereby, prices of financial assets. This is because any deviation in macroeconomic performance brings the distortion in the prices of financial assets both in country A and B. The impact of the financial mechanism depends on the degree of globalisation and financial market integration. These are the important and significant mechanisms which provide a clear cut picture of international interlinkage between the countries and shows how theoretically macroeconomic activity interacts between countries.

Review the literature

This section directly reviews some of the empirical studies since there is limited formal analysis that attempts to provide a rigorous theoretical mechanism of international linkage of economic activities. In this context, Canova and Marrinan (1997) evaluated production and consumption interdependencies among the US, Japan and Germany. They pointed out that US output impact shapes international output cycle, while Japanese output shocks lead to modest international impacts. However, this study is limited to advanced economies. Extending the analysis to Latin America's GDP growth, Osterholm and Zettelmeyer (2007) argued that the external impact explains 50 to 60% of the variation in Latin American GDP growth. Further, Utlaut and Raye (2010) analysed the impact of external innovation on economic activities of emerging Asian economies. They argued that the external factors explained half of the variance decomposition in the real GDP growth rate of emerging Asian economies.

⁸ Kumar, Debroy, Ghosh, Mahajan, and Prabhu, (2009) Global Financial Crisis: Impact on India's Poor: Some Initial Perspectives.

⁹ Iacoviello and Navarro(2019) Foreign effects of higher US interest rates

¹⁰ Bayoumi and Swiston (2009) Foreign entanglements: estimating the source and size of spillovers across industrial countries.

Using Factor-Augmented VAR, Mumtaz and Surico (2009) examined the international transmission of structural innovation from the rest of the world to the UK. They argued that expansionary demand in the rest of the world has a positive impact on output growth of the UK. Some other study has examined the unidirectional international transmission of macroeconomic shocks. For instance, Erten (2012) analysed the impact of Eurozone and the US recession on the growth performance of China, emerging Asia and Latin America. He hypothesised that if there is a rise in economic growth in the US that in turn can lead to an increase in growth of emerging Asia, Latin America and China.

Apart from these studies which shed light on the impact of developed economies, some other studies have analysed the impact of emerging country like China on advanced economies. Thus, Arora and Vamvakidis (2010) argued that China's growth rate dominantly affects more Asian countries than the rest of the world. Similarly, Bataa et al. (2018) analysed the growth relationship over time and particularly, China's role in the US and Euro area. They illustrated that growth in China, just after 2007, is strongly associated with US and Euro area. The study by Bataa et al. (2018) and Arora and Vamvakid (2010) although showed the importance of emerging countries' impact on advanced economies' economic performance but these analyses are silent on the impact of a group of emerging economies.

Some of the studies that examine the mechanism/channels of international interlinkage, such as, Bayoumi and Swiston (2009) analysed the GDP growth spillover among four regions viz, the US, Euro Area, Japan and rest of the world through three different channels; trade, commodity prices and financial mechanism through which countries are interlinked. They pointed out that the US generates a larger magnitude of spillovers to other regions, particularly, to the euro area and the rest of the world. Their assessment has uniquely magnified the significance of the financial mechanism through which international macroeconomic activities are interlinked. Hanisch and Kempa (2017) measured the international spillover effects through various channels/mechanism in terms of supply and demand shocks of the US, spreading to G7 economies. They observed a positive response of growth rate to US demand shocks is short-lived while supply shock is long-lived from the US to G7 countries. The mechanism of trade, financial and confidence play a dynamic role in the international impact of the US output innovation.

Similarly, Poirson and Weber (2011) pointed out that the impact of the US's and Japan's output innovation on European countries remains significant. However, apart from the trade mechanism, they have ignored other mechanism in their study. Extending the analysis to emerging economies, Poshakwale and Ganguly (2015) examined the extent and channels of transmission of international shocks on the economic growth of emerging economies. They argued that with the intensification of globalisation over time, the emerging economies can't remain immune to external shocks.

Further, Samake and Yang (2014) expanded the investigation from BRICS to low-income countries through different possible channels such as trade, FDI, technology and exchange rate. They revealed that there is a significant direct transmission of the business cycle from BRICS to low-income countries along with the predominant role of trade mechanism in the transmission process. Surprisingly, there exist very few studies on the assessment of the growth rates transmission effects between emerging countries and their mutual interactions with the advanced economies. Ding and Masha (2012) estimated India's growth rate effects on other South Asian countries. They showed that India's growth impact on South Asian countries' growth was significant only in the post-reform period. Therefore, an increase in the growth rate of India by 1% led to a rise in the growth rate of South Asia (excluding India) by 0.37%. However, in spite of large number of previous studies (presented in section 3) on international interlinkage of macroeconomic activities, a limited number of studies focused on bidirectional interlinkage of macroeconomic activities among the US, Japan, Germany, China, India and Russia altogether simultaneously.

Data description and descriptive statistics

Data description

To examine the cross country interlinkage of macroeconomic activities, the data set includes viz. the seasonally adjusted quarterly real GDP growth rate, industrial production index, export and import of goods and services as a percentage of GDP, inflation rate based on consumer price index (CPI), real effective exchange rate, S & P global equity indices and net foreign investment (include both FDI and FPI). The real GDP growth rate and inflation (CPI) data are collected from the Organisation for Economic Cooperation and Development (OECD)¹¹ database with quarterly frequency. The industrial production index is drawn from the FRED¹² database and for China, it is from OECD. Stat (Monthly) and exchange rate data is taken also from FRED Database (monthly). Export and import, net foreign investment and S & P global equity indices data are drawn from World Bank's world development indicator¹³ (in annual frequency).

¹¹ Data extracted from OECD.Stat

¹² Link: <https://fred.stlouisfed.org>

¹³ Data extracted from World Development Indicators/ <http://databank.worldbank.org>

The annual frequency data are converted into quarterly data using cubic spline interpolation method as well as monthly frequency data are converted into quarterly frequency by taking three months average. The reason for not considering the annual data which is a low-frequency data do not perform as good as working with high-frequency data in the context of international interlinkage. This is also a fact that major data series based on quarterly frequency even very few data series is based on a monthly frequency. Thus, we have converted the annual and monthly frequency data into quarterly-frequency data. Finally, all the data used for the analysis are considered on quarterly frequency by covering the time period between 2000: Q1 to 2018: Q2 with 74 observations in each series.

Descriptive statistics

Table-3 Descriptive Statistics on GDP growth rates

	US	Japan	Germany	China	India	Russia
Mean	2.04	0.96	1.44	9.22	7.12	3.79
Median	2.21	1.35	1.75	8.8	7.36	4.58
Max.	5.29	5.47	5.33	15	13.52	11.00
Min.	-3.92	-8.70	-7.21	6.4	0.45	-9.39
Std. Dev.	1.64	2.18	2.29	2.19	2.43	4.25
Obser.	74	74	74	74	74	74

Source: author's own calculation based on GDP growth rate data

Table-3 elaborate the descriptive statistics of macroeconomic activity peroxid by GDP growth rate of the US, Japan, Germany, China, India and Russia. It reveals that the mean, as well as the median growth rate of China, India and Russia, are relatively much higher than Japan, Germany and the US which indicates the better macroeconomic performance of the former than the later. This manifests at least two ways for global economic interlinkage via emerging economies which provides an appropriate opportunity for international economic agents. First, a higher growth rate specifies the larger income and production of output. In turn, that would cause a higher demand for imported goods and services from foreign and also larger would be the level of exports due to higher production. And second, better and stable domestic macroeconomic performances attract foreign capital into the economies. Both ways play a significant role in the international interlinkage process of economic activities. Apart from the mean and median, standard deviation shows a higher variation in Russia's growth rate compared to other economies. This indicates the higher instability in Russia's macroeconomic activity relative to others.

Methodology

Some of the studies on international interlinkage of growth rate have used more advanced econometrics tools. Such studies are; Canova and Marrinan (1997) used multi-country general equilibrium model, Mumtaz and Surico (2009) used Factor Augmented VAR (FAVAR), Osterholm and Zettelmeyer (2007) and Erten (2012) employed Bayesian VAR (BVAR), Ding and Masha (2012) used fixed effect panel model, Bataa et al.,(2018) used iterative procedure in the VAR coefficient, Poshakwale and Ganguly (2015) applied block dynamic factor model, Samake and Yang (2014) used Global VAR model, Hanisch and Kempa (2017) used multi-country non-stationary dynamic factor model etc. However, these analytical methodologies missed out micro aspects of international interlinkage. For instance, grouping the countries like panel analysis or grouping the large number variables do not deal with micro aspects of individual economies.

Some other important studies have used more popular econometric tools whose application is numerous even in different fields. Such studies include; Bayoumi and Swiston (2009) used orthogonal impulse response function of VAR model, Arora and Vamvakidis (2010) employed both VAR and error correction model, Utlaut and Raye (2010) used orthogonal impulse response function (OIRF) of VAR model and forecast error variance decomposition model, Poirson and Weber (2011) used VAR model etc. However, these methodological frameworks much appropriate for uncover micro aspects of international interlinkage of aggregate economic activity. The present study attempts to address the micro aspects of international interlinkage in order to deal with individual economies. Therefore, we have employed the Generalised Impulse Response Function (GIRF) of Vector Autoregressive (VAR) framework for the analysis. We have used GIRF instead of OIRF, because OIRF is sensitive to variables ordering while GIRF is insensitive to ordering of variables, The VAR specification is also a natural tool for macroeconomic policy analysis as it captures both the contemporaneous association between variables (Luetkepohl,

2011) and captures the lagged information of the variables. Further, the VAR model is a widespread and popular choice among researchers given the uncertainty regarding the appropriate framework of international interlinkage (An et al., 2016). Thus, we used the general VAR model although previous studies have employed more advanced econometric tools. For the estimation of empirical model, one needs to understand the VAR specification introduced by Sims (1980). It can be represented with the following expression.

$$Z_t = \mathbf{b} + \mathbf{A}_1 Z_{t-1} + \mathbf{A}_2 Z_{t-2} + \dots + \mathbf{A}_p Z_{t-p} + \varepsilon_t, \quad t = 0, 1, 2, \dots \dots \dots (1)$$

Where $Z_t = (Z_{1t}, Z_{2t}, Z_{3t}, \dots, Z_{Kt})'$ is a $K \times 1$ random vector (here $K= 6$ variables). \mathbf{A}_i is the constant $K \times K$ coefficient matrix. $\mathbf{b} = (b_1, b_2, \dots, b_K)'$ is a constant $K \times 1$ vector of intercept. Finally, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \dots, \varepsilon_{Kt})'$ is a K - dimensional white noise where, $E(\varepsilon_t) = 0$, the variance covariance matrix at time t , $E(\varepsilon_t, \varepsilon_t') = \Sigma_\varepsilon$ is a positive definite matrix and $E(\varepsilon_t, \varepsilon_s') = 0$ for all $t \neq s$.

The model is said to be stable if all eigenvalues of \mathbf{A}_i should have less than 1 that is

$$\det(\mathbf{I}_K - \mathbf{A}_i \lambda) \neq 0 \quad \text{for } |\lambda| \leq 1$$

The model has been specified by considering six variables of six countries. Equation (1) can be represented as a Vector Moving Average of infinite order, (VMA (∞)) expression under the stability condition as:

$$Z_t = \mu + \sum_{i=0}^{\infty} \mathbf{A}_i^i \varepsilon_{t-i} \dots \dots \dots (2)$$

$$\text{Where, } \mu = (\mathbf{I}_6 - \mathbf{A}_i \mathbf{L})^{-1} \mathbf{b}$$

The sequence Z_t comprises of past and present error vectors (ε_t) in this VMA representation. Therefore, equation (2) can be rewritten as:

$$Z_t = \Phi(\mathbf{L}) \varepsilon_t \dots \dots \dots (3)$$

Where $\Phi(\mathbf{L})$ is a polynomial or the lag operator such that $\Phi(\mathbf{L}) = \sum_{i=0}^{\infty} \mathbf{A}_i^i \mathbf{L}^i$.

The coefficient (Φ) in equation (3) is the impulse responses of the system or $\phi_{jk,i}$ the jk^{th} element of Φ_i which represents the response of the j^{th} variable of the system to a unit shock of variable k , i^{th} period ago. However, due to the ordering problem (under orthogonal impulse response function) of six same type variables but separate variables representing for six countries, we have applied the Generalized impulse response function (GIRF) to estimate the extent of international integration among variables of interest. Now, using equation (4), GIRF can be written as:

$$GI_Z(h, \delta_j, \omega_{t-1}) = E(Z_{t+h} / \varepsilon_{jt} = \delta_j, \omega_{t-1}) - E(Z_{t+h} / \omega_{t-1}) \dots \dots \dots (4)$$

Where GI_X = Functional notation of generalized impulse of Z variable

h , = time horizon

δ_j = size of innovations

ω_{t-1} = Set of information available at time period $t-1$.

Equation (4) is the difference between two conditional expectations which are themselves random variables. Here, we assume that innovation given to the j^{th} element only, in spite of giving innovation to all elements in ε . The effects of other innovation are integrated out assuming an observed distribution of the errors. The $E(Z_{t+h} / \varepsilon_{jt} = \delta_j, \omega_{t-1})$ means that one is taking the expectation conditional to the information set ω_{t-1} and for a fixed value of the j^{th} shock at time "t", while integrating out all contemporaneous and future innovations. Now, assuming that the innovation term follows a multivariate normal distribution, it can be shown as:

$$\begin{aligned} E(\varepsilon_t / \varepsilon_{jt} = \delta_j) &= (\sigma_{1j}, \sigma_{2j}, \dots, \sigma_{kj})' \sigma_{jj}^{-1} \delta_j \\ &= \Sigma_\varepsilon e_j \sigma_{jj}^{-1} \delta_j \dots \dots \dots (5) \end{aligned}$$

Therefore, the GIR of the effect of innovation to j^{th} disturbance term at a time 't' on $t + h$ for the multivariate linear model is then given by:

$$\left(\frac{\Pi_h \Sigma_\varepsilon e_j}{\sqrt{\sigma_{jj}}}\right) \left(\frac{\delta_j}{\sqrt{\sigma_{jj}}}\right) \quad h = 0, 1, 2 \text{ ----- (6)}$$

Thus, by scaling the GIR by $\frac{\delta_j}{\sqrt{\sigma_{jj}}}$, one can obtain the effect of a unit shock to the j^{th} error term on Z_{t+h} which is given by

$$\Phi_j^g(h) = \sigma_{jj}^{-1/2} \Pi_h \Sigma_\varepsilon e_j \text{ ----- (7)}$$

The equation-7 measures the effect of one standard error innovation to the j^{th} equation at a time t on the expected value of Z at a time t+h. This will give us the international interlinkage of macroeconomic activities.

Finally, we have estimated three models employing above mentioned framework. One model for main analysis based on aim of this paper and other two models we estimated for the robustness check of the empirical findings. The variables in the first model includes real GDP growth rate of six countries. The variables used in the second model includes log industrial production index, log export and import of goods and services as a percentage of GDP, inflation rate peroxid by consumer price index (CPI), log real effective exchange rates, S & P global equity indices and net foreign investment (include both FDI and FPI) from each country separately. Then by running PCA for six countries, we get six variables and used theses six variables in the model to evaluate robustness. Finally, the variables employed for third model includes only log industrial production index of six countries.

Result and discussion

Fig-1 shows that there is no root lies outside the unit circle with optimum lag 3 as per the Akaike information criteria which satisfy the stability of the model of aggregate economic activity (GDP growth) of six countries.

Figure-1 stability test result for GDP growth based model estimation

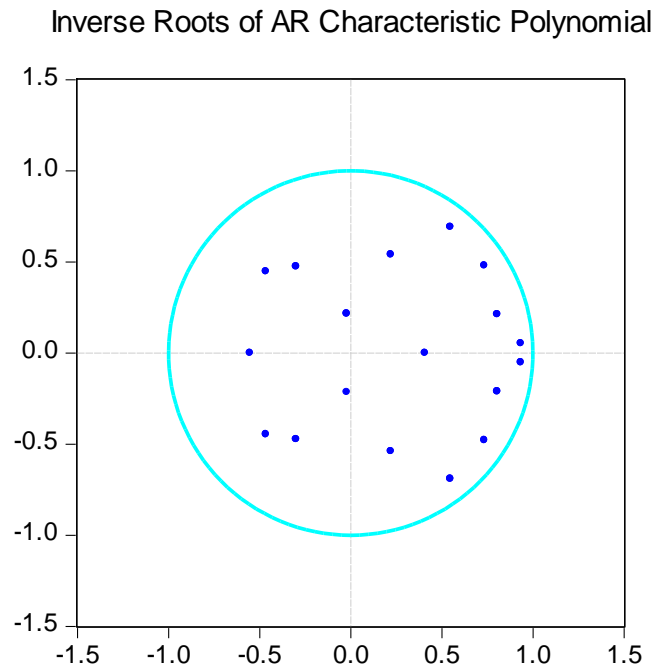
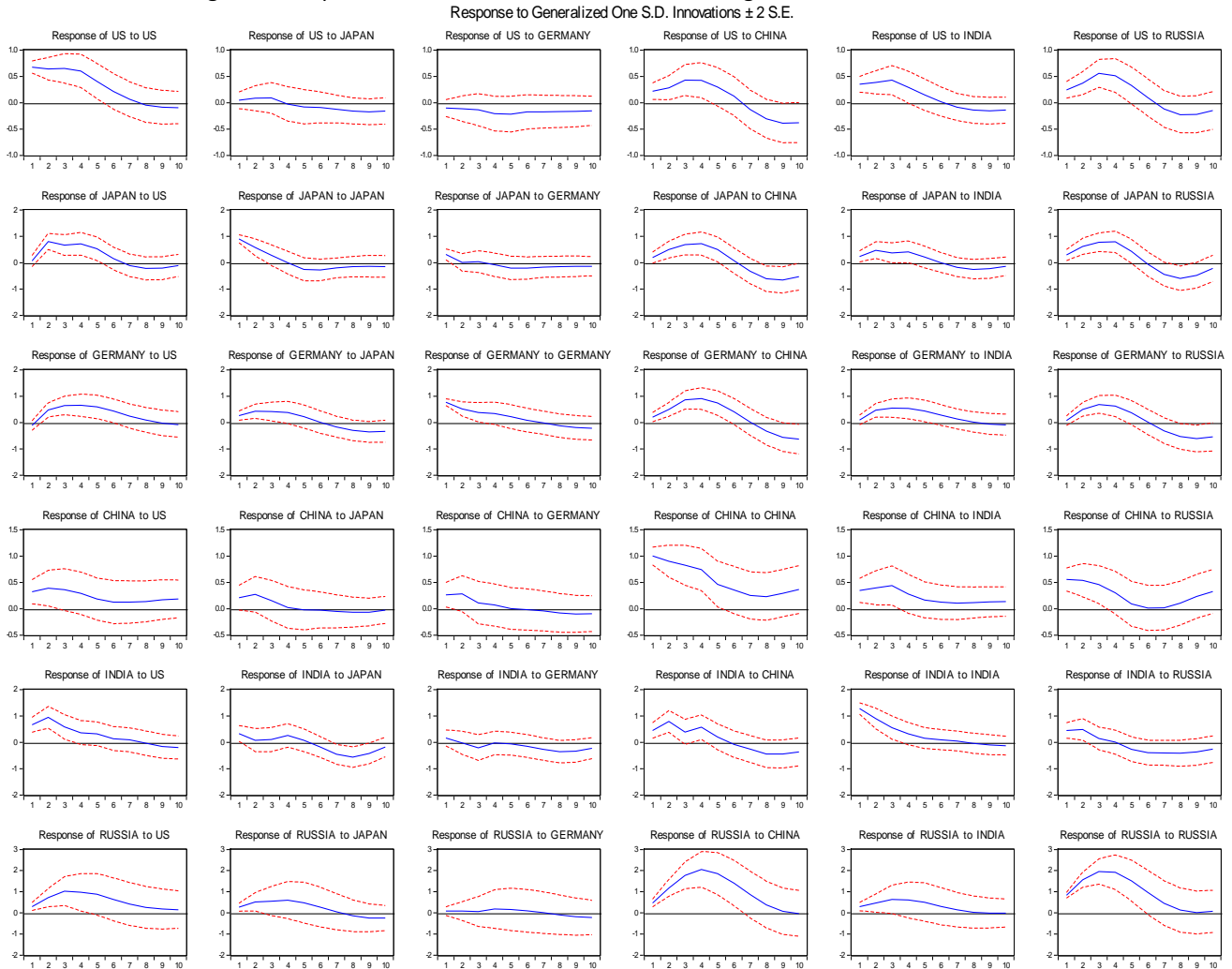


Fig.2 shows the responses of the US's, Japan's, Germany's, China's, India's and Russia's growth rate following generalized one standard deviation innovations in the growth rate of the same countries. The results manifest that the responses of macroeconomic activity of every individual countries to other economic activity is positive and significant in the initial periods barring responses of the US, Japan, India and Russia to Germany's growth rate which is close to zero and statistically insignificant.

Generally, given this positive and significant economic integration of macroeconomic activities among all major economies, signifies that the expansion of macroeconomic activities in any one economy has the potential of raising the level of income of other economies as well. With an increased income of people in one country, it gives rise to sources of demand generation for another country, implying higher imports from foreign markets leading to rising of macroeconomic activity abroad.

There are large numbers of studies whose findings support our results. Such studies are Canova and Marrinan (1997)¹⁴, Osterholm and Zettelmeyer (2007)¹⁵, Bayoumi and Swiston (2009)¹⁶, Utlaut and Raye (2010), Erten (2012), Arora and Vamvakidis (2010)¹⁷, Bataa et al. (2018)¹⁸ etc. These studies are arguing strongly that if there is an acceleration of macroeconomic activity in one economy lead to an increase in economic activity in other economies.

Figure-2: Responses to innovation in the six countries' growth rate over 10 Quarters



(Fig-2 portrays GIRF of the real growth rate of all countries in response to one standard deviation shocks in the growth rate of all countries. The fig. is based on GIRF of VAR estimated over 10 quarter horizon periods. Each graph produces the point estimation of GIRF with lower and upper bounds of 95% confidence interval. The blue solid line depicts the per cent response of growth rates of 6 countries in response to a unit standard deviation shock on all countries' growth rate, while the red dotted lines show 95% error bands. The vertical and horizontal axes represent the impulse responses of the real growth rate of different countries and time period respectively)

In contrast, the responses of individual economic activity to other economic activities are negative mostly in the longer horizon. This negative response manifests that due to high demand for imported goods and services from foreign countries in the initial horizon which lead to a rise in the exchange rate in the long horizon. The higher exchange rate means import becomes costly and export cheaply as the currency of domestic country depreciates and currency of foreign country appreciates. As a result, there is a contraction of economic activity in a foreign country on the long horizon. Therefore, the response of the foreign country to the domestic country's economic activity is negative on the long horizon. According to

¹⁴ See Canova and Marrinan (1998) Sources and propagation of international output cycles: common shocks or transmission

¹⁵ Osterholm and Zettelmeyer (2008) The effect of external conditions on growth in Latin America

¹⁶ Bayoumi and Swiston (2009) Foreign entanglements: estimating the source and size of spillovers across industrial countries.

¹⁷ Arora and Vamvakidis (2011) China's economic growth: international spillovers

¹⁸ Bataa, Osborn and Sensier (2018) China's increasing global influence: Changes in international growth linkages

Canova and Marrinan (1997) output innovation from the US, Japan and Germany reduce the foreign output in the medium term. The argument of Canova and Marrinan is very factual even in the case of China, India and Russia where it is clearly showing that output innovations decelerate foreign aggregate economic activity in the longer horizon.

Looking closely column-wise, the extent of responses of six countries' economic activity to the US's, China's, India's and Russia's economic activity are high compared to Japan's and Germany's economic activity. Mostly, the responses to Japan and Germany are statistically insignificant as well. This reflects that the degree of interlinkage of individual economic activity with Japan and Germany is insignificant. This finding also supported by the Canova and Marrinan (1997) study which pointed out that Japanese and German output innovation leads to modest international impact. Bayoumi and Swiston (2009) also claimed that the impact of Japan and the Euro area's economic activity on others like the US and the rest of the world are limited.

Specifically, from the fig.2, it shows that the interlinkage of the US's, macroeconomic activity to the economic activity of China, India and Russia are positive and significant in the initial periods but in the longer horizon, the interlinkage is negative and insignificant in one hand. On the other hand, the responses of foreign economic activity innovation to the US's economic activity innovation is significant and positive in the initial period but negative and insignificant in the longer horizon. All most all the economies under consideration are well interlinked with each other apart from Japan's and Germany's economic activity but the US is well and highly interlinked with emerging economies such as China, India and Russia compared to Japan and Germany. Therefore, according to Canova and Marrinan (1997), Erten (2012), Bayoumi and Swiston (2009) and Poirson and Weber (2011) the US output innovation shape international output cycle.

The saga of Japan and Germany is quite different. The macroeconomic activity of Japan and Germany are being influenced by the US, China, India and Russia but the influence of Japan and Germany on others are statistically insignificant in most of the cases. Undoubtedly, this reflects that Japan and Germany have a stronger degree of interlinkage with the world economy but the world economies are not. Thus, Canova and Marrinan (1997) and Bayoumi and Swiston (2009) Japan and the euro area's international impact is very modest.

Moreover, marching towards the evaluation of emerging economies like China, India and Russia, it shows from fig.2 that the interlinkage of aggregate economic activity of China to the US, India and Russia; India to the US, China and Russia; Russia to the US, China and India are significant in the initial horizon. The impact of China, India and Russia on all most all countries are remarkable but do not interlink to Japan and Germany. Eventually, emerging countries like China, India and Russia are well interlinked with other economies. Arora and Vamvakidis (2010) and Bataa et al. (2018) strongly argue that the growth rate of China is associated with the rest of the world. China has been able to strongly integrate with the global economy through its remarkable performance in terms of volumes of trade in goods and services, foreign investment and financial transactions with the global economy (Srinivasan, 2006; and Dimaranan et al. 2009). Hence, the growth of China has a significant influence on the world economy (Marelli and Signorelli, 2011). Marelli and Signorelli (2011) rightly mentioned that the continuous growth of India has a greater influence on the world economy. Thus, India has also been a major contributor to the international business and global economy. This confirms empirically to the point that the expansion of foreign macroeconomic activities contributes to the rising economic growth of India. Therefore, our empirical findings reinforce the evidence that India is highly integrated with the world economy. Given that India not only influences the world economy but the world economy in turn also greatly influences the Indian economy.

Further, it reflects that the mutual responses among emerging economies to each other are greater in magnitude. However, the responses of emerging economies in responses to shocks of advanced economies are not greater in magnitude comparing responses of other advanced economies, implying that there are greater linkages among all the major economies with some exceptions like where China's, India's and Russia's response to the US's growth rate. A similar principle also holds true for other economies under consideration given that they have a positive growth rate linkage with other economies. Finally, a very interesting result which sheds light as a whole is that the international linkage of economic growth rate remains positive and significant across the economies majorly for the initial horizon than over longer horizon.

Robustness check

We framed two alternative models; First, by running the PCA over some important macroeconomic variables of each economy separately. Such macroeconomic variables are log industrial production index, log export and import of goods and services as a percentage of GDP, inflation rate peroxid by consumer price index (CPI), log real effective exchange rates, S & P global equity indices and net foreign investment (include both FDI and FPI). These macroeconomic variables are very

sensitive in the context of cross country interlinkage. However, after getting one score series by running PCA for each respective country, we estimate the generalized impulse response function under the VAR framework. The estimated model is stable as there is no root lies outside the unit circle with optimum lag 3 as per the Akaike information criteria. This satisfies the stability of the model of some macroeconomic variables of six countries. The estimated generalized impulse response function result given and represented by figure-A1 in the Appendix. The figure-A1 in the appendix shows that both emerging and advanced countries are interlinked with each other.

And second, the model is based on only the industrial production index of respective countries and the estimated result presented by figure-A2 in the appendix. The industrial production index is also one of the significant macroeconomic variables that used to measure the level of production and an indicator of economic performance in the short period as well. It is also a relevant variable that gets affected by internal and external innovations. Fig-A2 in appendix reveals that all most all the advanced countries' (the US, Japan and Germany) industrial production interlink with each other among them and also interlink with emerging economies (China, India and Russia) positively and statistically significant. This reflects that the industrial output of advanced economies is more interlinked than emerging economies with the global economy. In contrast, the integration of industrial production of emerging economies like China, India and Russia to advanced economies (the US, Japan and Germany) are close to zero and statistically insignificant over 10 quarters barring the interlinkage of Russia to the US. Overall, our empirical findings are robust.

However, the recent studies by Ding and Masha (2012), Arora and Vamvakidis (2010) and Bataa et al. (2018) provide the evidence that the economic growth of one country positively affects the growth of another economy. The issues of international interlinkage of macroeconomic activity in these large markets have frequently been a significant policy concern to both monetary and fiscal authorities, portfolio managers or traders in stocks markets, Bankers, foreign and domestic investors, researchers, businessmen, labour force etc. As our study looks at the cross-country interlinkage effects, the external effects are realised with increasing cross movement of international physical and human capital, trade and financial flows which play significant roles for maintaining external sector balance and macroeconomic stability of economies.

Conclusion

This study attempts to evaluate the international interlinkage of aggregate economic activity proxied by GDP growth rate among the US, Japan, Germany, China, India and Russia. This study asked two relevant questions; what extent both emerging and advanced economies are interlinked with each other? Whether interlinkage of macroeconomic activity of advanced and emerging economies is positive or negative or both over time? Using the generalized impulse response of the VAR model, our empirical result shows:

(1) International interlinkage of macroeconomic activities of all individual economies to others is positive and significant in the initial period but negative in the longer horizon apart from the interlinkage of the US, Japan, India and Russia with Germany.

(3) The extent of international interlinkage of macroeconomic activities of six countries to the US's, China's, India's and Russia's economic activities are high and significant but to Japan's and Germany's economic activities are low and statistically insignificant.

(4) The growth rate of the US increases by 0.5%, 0.4%, and 0.4% following one standard deviation innovation in the growth of Russia, China and India respectively over initial horizons.

(5) The growth rate of Japan rises by 0.9%, 0.8%, 0.8% and 0.4% following one standard deviation innovation in the growth rate of the US, China, Russia and India respectively over initial horizons.

(6)The growth rate of Germany rises by 0.9%, 0.8%, 0.7%, 0.5%, and 0.4% following one standard deviation innovation in the growth rate of China, US, Russia, India and Japan respectively over initial horizons.

(7) The growth rate of China increases by 0.5% 0.4%, 0.3%, 0.2% and 0.2% following one standard deviation innovation in the growth rate of Russia, US, India, Japan and Germany respectively over initial horizons.

(8) The growth rate of India rises by 1%, 0.8%, and 0.4% following one standard deviation innovation in the growth rate of the US, China and Russia respectively over initial horizons.

(9) The growth rate of Russia rises by 1%, 0.5%, 0.4% and 0.2% following one standard deviation innovation in the growth rate of the US, Russia, Japan and China respectively over initial horizons. (See fig. 2 for all these findings in the main text)

We also framed two alternative models to evaluate the robustness of the empirical findings. Thus, our empirical findings are robust. Our empirical investigations have significant policy implication. Our empirical findings suggest that rigorous

macroeconomic policy is the need of the hour, because, the aggregate economic activity of each economy is strongly influenced by external macroeconomic activity. According to WESP (2019), external aspects expose domestic vulnerability. Therefore, a particular country should not be dependent on a single specific country; rather it should diversify its dependency in terms of import and exports of goods and services, foreign capital flow to other economies through its own policies to remain immune from severe crisis when felt only for a specific country on which it is mostly dependent upon. There are shortcomings of this analysis. First, this study does not address the contribution of the channels through which interaction takes place between the countries although we address theoretically. Second, the investigation based on only six countries. Third, this study has employed more general method although previous studies have used more advanced econometric tools. Further research can also be extended on basis of above shortcomings.

References

- [1] An, L., Kim, Y., & You, Y. (2016). Floating exchange rates and macroeconomic independence. *International Review of Economics & Finance*, 42, 23-35.
- [2] Arora, V., & Vamvakidis, A. (2011). China's economic growth: international spillovers. *China & World Economy*, 19(5), 31-46.
- [3] Bataa, E., Osborn, D. R., & Sensier, M. (2018). China's increasing global influence: Changes in international growth linkages. *Economic Modelling*, 74, 194-206.
- [4] Bayoumi, T., & Swiston, A. (2009). Foreign entanglements: estimating the source and size of spillovers across industrial countries. *IMF Staff Papers*, 56(2), 353-383.
- [5] Canova, F., & Marrinan, J. (1998). Sources and propagation of international output cycles: common shocks or transmission?. *Journal of International Economics*, 46(1), 133-166.
- [6] Choi, J. W. (2013). The 2007–2010 US financial crisis: Its origins, progressions, and solutions. *The Journal of Economic Asymmetries*, 10(2), 65-77.
- [7] Corsetti, G., Pesenti, P., & Roubini, N. (1998). *What caused the Asian currency and financial crisis? Part I: A macroeconomic overview* (No. w6833). National Bureau of Economic Research.
- [8] Dedola, L., Rivotto, G., & Stracca, L. (2017). If the Fed sneezes, who catches a cold?. *Journal of International Economics*, 108, S23-S41.
- [9] DeJong, D. N., Nankervis, J. C., Savin, N. E., & Whiteman, C. H. (1992). The power problems of unit root test in time series with autoregressive errors. *Journal of Econometrics*, 53(1-3), 323-343.
- [10] Diebold, F. X., & Yilmaz, K. (2015). *Financial and macroeconomic connectedness: A network approach to measurement and monitoring*. Oxford University Press, USA.
- [11] Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, 119(534), 158-171.
- [12] Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28(1), 57-66.
- [13] Diebold, F. X., & Yilmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics*, 182(1), 119-134.
- [14] Dimaranan, B., Ianchovichina, E., & Martin, W. (2009). How will growth in China and India affect the world economy?. *Review of World Economics*, 145(3), 551-571.
- [15] Ding, D., & Masha, I. (2012). India's Growth Spillovers to South Asia.
- [16] Echeverri-Gent, J., Herlevi, A., & Ganczak, K. (2015). Economic Interdependence and Strategic Interest: China, India, and the United States in the New Global Order. In San Francisco, California, Paper Prepared for the American Political Science Association Annual Meeting.
- [17] Erten, B. (2012). Macroeconomic transmission of Eurozone shocks to emerging economies. *International Economics*, 131, 43-70.
- [18] Hanisch, M., & Kempa, B. (2017). The international transmission channels of US supply and demand shocks: Evidence from a non-stationary dynamic factor model for the G7 countries. *The North American Journal of Economics and Finance*, 42, 70-88.
- [19] Ilzetzki, E., & Jin, K. (2013). The puzzling change in the international transmission of us macroeconomic policy shocks. *unpublished, London School of Economics.–2013*.
- [20] Koné, S. (2012). Is Economic Integration Between Developing Countries a Singular Process?. *Journal of Economic Integration*, 386-409.
- [21] Koop, G., Pesaran, M. H., & Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, 74(1), 119-147.
- [22] Lütkepohl, H. (2011). *Vector autoregressive models* (pp. 1645-1647). Springer Berlin Heidelberg.
- [23] Marelli, E., & Signorelli, M. (2011). China and India: Openness, trade and effects on economic growth. *The European Journal of Comparative Economics*, 8(1), 129.
- [24] Mitton, T. (2002). A cross-firm analysis of the impact of corporate governance on the East Asian financial crisis. *Journal of financial economics*, 64(2), 215-241.
- [25] Mumtaz, H., & Surico, P. (2009). The transmission of international shocks: a factor-augmented VAR approach. *Journal of Money, Credit and Banking*, 41, 71-100.
- [26] Nier, E. W., & Merrouche, O. (2010). What caused the global financial crisis? Evidence on the drivers of financial imbalances 1999-2007.
- [27] Österholm, P., & Zettelmeyer, J. (2008). The effect of external conditions on growth in Latin America. *IMF Staff Papers*, 55(4), 595-623.

[28] Poirson, H., & Weber, S. (2011). Growth spillover dynamics from crisis to recovery. *IMF Working Papers*, 1-50.
 [29] Poshakwale, S., & Ganguly, G. (2015). International shocks and growth in emerging markets. *Global Finance Journal*, 26, 29-46.
 [30] Robertson, D., & Wickens, M. R. (1997). Measuring real and nominal macroeconomic shocks and their international transmission under different monetary systems. *Oxford Bulletin of Economics and Statistics*, 59(1), 5-28.
 [31] Samake, I., & Yang, Y. (2014). Low-income countries' linkages to BRICS: Are there growth spillovers?. *Journal of Asian Economics*, 30, 1-14.
 [32] Sims, C. A. (1980). Macroeconomics and reality. *Econometrica: Journal of the Econometric Society*, 1-48.
 [33] Srinivasan, T. N. (2006). China, India and the world economy. *Economic and Political Weekly*, 3716-3727.
 [34] Utlaut, J., & Van Roye, B. (2010). *The effects of external shocks to business cycles in emerging Asia: A Bayesian-VAR approach*. Institute for the World Economy.
 [35] United Nation .(2019). world economic situation and prospects.

Appendix

There is remarkable bilateral trade among the US, Japan, Germany, China, India and Russia. These economies are the top trading partners with each other. The evidence presented below with the ranking and trade partner of each country in terms of export and imports in table A1 and A2 for 2010, 2015 and 2018.

Table-A1: Bilateral trade ranking of US, Japan and Germany respectively with others

Years	US		Japan		Germany	
	Exports	Imports	Exports	Imports	Exports	Imports
2010	(3) China	(1) China	(1) China	(1) China	(2) US	(2) China
	(4) Japan	(4) Japan	(2) US	(2) US	(6) China	(8) US
	(6) Germany	(5)Germany	(8) Germany	(12)Germany	(13) Russia	(11) Russia
	(17) India	(14) India	(18) India	(13) Russia	(18) Japan	(14) Japan
	(37) Russia	(17)Russia	(20) Russia	(27) India	(21) India	(26) India
2015	(3) China	(1) China	(1) US	(1) China	(1) US	(3) China
	(4) Japan	(4) Japan	(2) China	(2) US	(5) China	(7) US
	(6) Germany	(5)Germany	(8) Germany	(10)Germany	(16) Russia	(12) Russia
	(18) India	(9) India	(18) India	(13) Russia	(19) Japan	(18) Japan
	(36)Russia	(24)Russia	(23)Russia	(27) India	(27) India	(27) India
2018	(3) China	(1) China	(1) US	(1) China	(1) US	(2) China
	(4) Japan	(4) Japan	(2) China	(2) US	(3) China	(8) US
	(6) Germany	(5)Germany	(8) Germany	(8)Germany	(15) Russia	(13) Russia
	(13) India	(10) India	(17) India	(17) Russia	(16) Japan	(15) Japan
	(36)Russia	(23)Russia	(20)Russia	(27) India	(23) India	(27) India

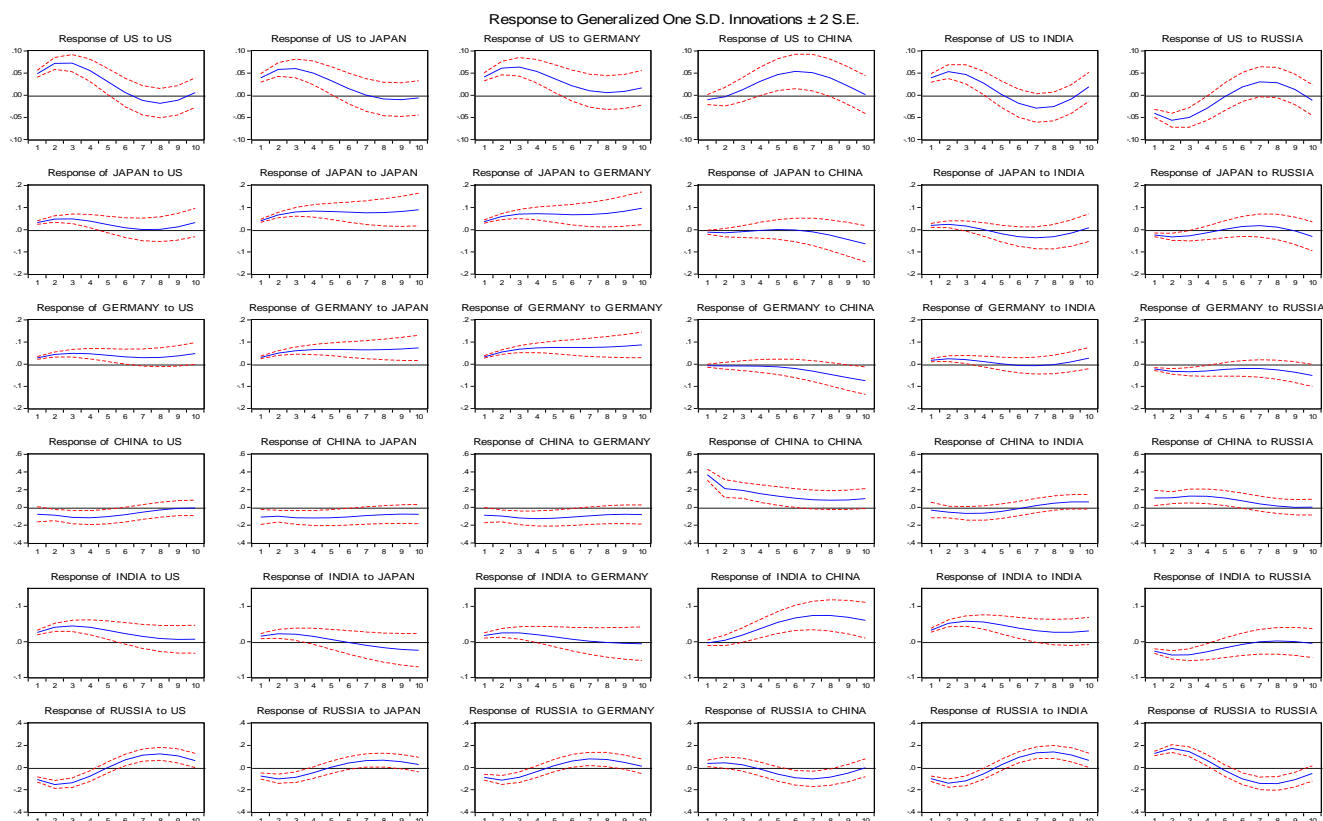
Source: IMF'S DOTS (International Monetary Fund's Direction of Trade Statistics), Note: the numeric in the bracket are the rank of the countries in terms of its export and import of goods and services with countries considered in the first row in both the table-A1 and A2 over time

Table-A2: Bilateral trade ranking of China, India and Russia respectively with others

Years	China		India		Russia	
	Exports	Imports	Exports	Imports	Exports	Imports
2010	(1) US	(1) Japan	(2) US	(1) China	(4) China	(1) China
	(3) Japan	(5) US	(3) China	(3) US	(5) Germany	(2) Germany
	(5) Germany	(6) Germany	(8) Germany	(7) Germany	(9) Japan	(4) Japan
	(7) India	(12) Russia	(11) Japan	(13) Japan	(10) US	(6) US
	(12) Russia	(15) India	(37) Russia	(29) Russia	(17) India	(26) India
2015	(1) US	(2) US	(1) US	(1) China	(2) China	(1) China
	(3) Japan	(5) Japan	(3) China	(3) US	(3) Germany	(2) Germany
	(5) Germany	(6) Germany	(7) Germany	(7) Germany	(7) Japan	(3) US
	(9) India	(11) Russia	(16) Japan	(13) Japan	(11) US	(6) Japan
	(16) Russia	(26) India	(38) Russia	(29) Russia	(18) India	(19) India
2018	(1) US	(2) Japan	(1) US	(1) China	(1) China	(1) China
	(3) Japan	(4) US	(3) China	(2) US	(3) Germany	(2) Germany
	(5) Germany	(6) Germany	(7) Germany	(13) Germany	(9) US	(3) US
	(7) India	(11) Russia	(20) Japan	(14) Japan	(11) Japan	(7) Japan
	(12) Russia	(26) India	(36) Russia	(24) Russia	(17) India	(19) India

Source: IMF'S DOTS (International Monetary Fund's Direction of Trade Statistics)

Figure-A1 Responses to innovation in the six countries' some macroeconomic variables including industrial production over 10 Quarters

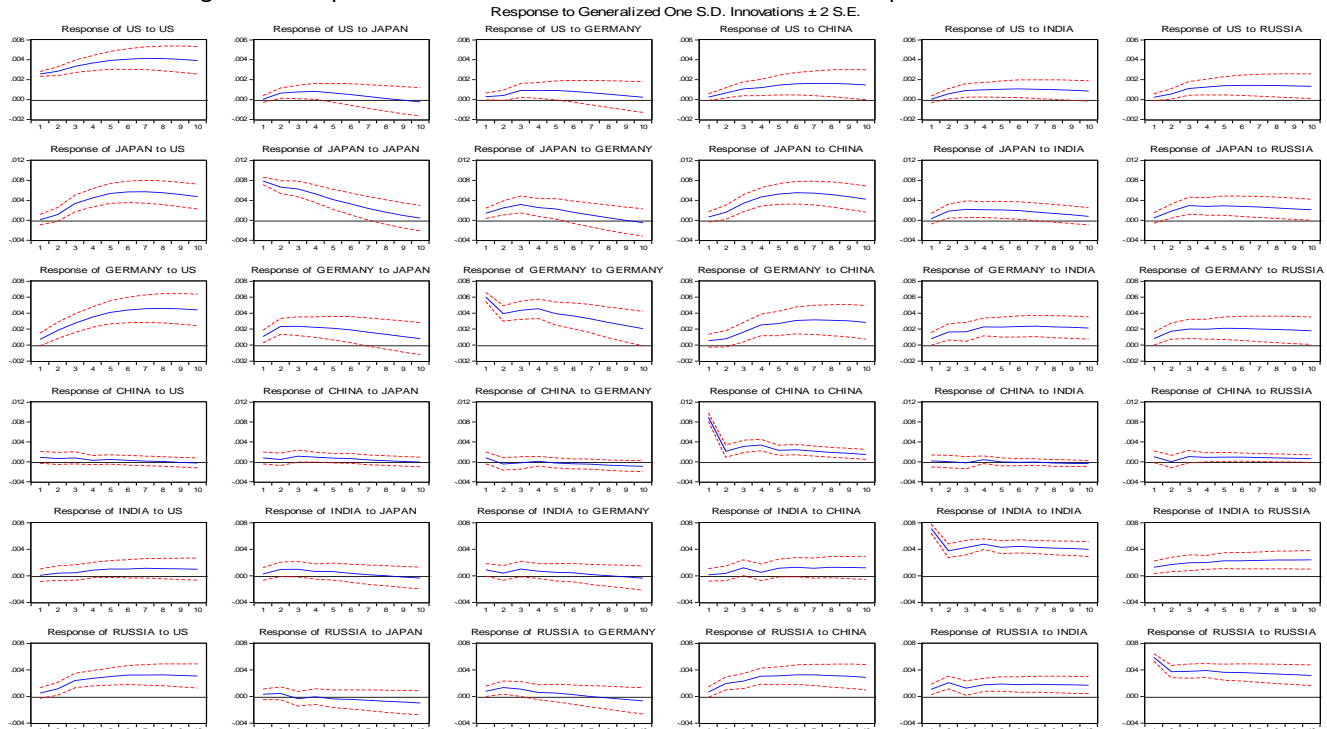


(Note: Fig-A1 portrays GIRF of some macroeconomic variables of all countries in response to one standard deviation shocks in some macroeconomic variables of all countries. The fig. is based on GIRF of VAR estimated over 10 quarter horizon periods.

The model is stable at optimum lag 2 selected as per the Akaike information criteria (AIC). For more detail, follow the footnote of figure-2 in the main text)

Note for the above figure (i.e. figure-A1), we frame the first alternative model by running principal component analysis (PCA) of some important macroeconomic variables to evaluate the robustness of the empirical findings. Such macroeconomic variables used in this model are log industrial production index, log export and import of goods and services as a percentage of GDP, inflation rate peroxid by consumer price index (CPI), log real effective exchange rates, S & P global equity indices and net foreign investment (include both FDI and FPI) from each country separately. These macroeconomic variables are very sensitive in the context of cross country integration among them. (Note that the model is stable and the result would be available on request for both figure-3 in the main text and figure-A1 presented above)

Figure-A2 Responses to innovation in the six countries' industrial production over 10 Quarters



(Note: Fig-A2 portrays GIRF of the log industrial production of all countries in response to one standard deviation shocks in the log industrial production of all countries. The fig. is based on GIRF of VAR estimated over 10 quarter horizon periods. The model is stable and the optimum lag is 3 selected as per Akaike information criteria (AIC) and here we have used monthly frequency data series. For more detail, follow the footnote of figure-2 in the main text)

From the figure-A2, the industrial output shows that the integration of emerging to advanced economies is lesser compared to the integration of advanced to emerging economies. Specifically, it reveals that all most all the advanced countries' industrial output integrate with each other among them and also integrates with emerging economies positively and significantly. As a whole, the economic integration through industrial production is relatively lower than integration through growth rate. This is because, GDP being an overall performance measure of the economy, it is connected with all other parameters of the economy broadly. It is also one of the relevant variables which get affected by internal and external shocks at a higher strength than industrial production.