

## INTERNATIONAL SPILLOVERS OF INTEREST RATE SHOCKS: AN EMPIRICAL ANALYSIS

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### ABSTRACT

This study attempts to empirically establish a comparative agreement of cross-country spillover of real overnight, short and long-term interest rates of US, Japan, Germany, China, India, and Russia. It examines whether the magnitude of international spillovers of real interest rate shocks do vary based on their maturity pattern? Employing Diebold and Yilmaz (DY) spillover methods, this study discovered that interest rate shock spillovers vary over their different maturities. Specifically, it finds that the total spillover through long-term interest rate is 44.8%, spillover through overnight interest rate is 41.10% and spillover through short-term interest rate is 37.50%. It indicates that spillover is marginally higher via long-term interest rate compared to overnight and short-term interest rates. This is because long-term interest rate takes a secular trend path based on the preferences of international investors and conditions of the global financial market. This has a significant policy bearing for monetary and fiscal authorities, portfolio managers (including traders in stock markets), foreign and domestic investors, etc.

**Contribution/Originality:** This study is one of the very few studies which has investigated the international spillovers of interest rates shocks over various maturities across developed and emerging market economies.

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## 1. INTRODUCTION

This study examines the cross country spillover of various real interest rates (based on their maturity pattern) shocks across six markets; the US, Japan, Germany, China, India, and Russia. Specifically, it tried to establish a comparative understanding of cross country spillovers viz. real overnight, short, and long-term interest rates. It asks some pertinent questions: do the real interest rates of varying maturities of different countries behave equally in terms of their magnitudes of cross-border spillovers? If not, then to what extent do they vary? Whether the magnitudes of spillovers are higher through overnight interest rates or short-term interest rates or long-term interest rates?

The real interest rates based on different maturity periods are subject to varying levels of risks of gains and losses of capital inflows and outflows for countries. This has a strong economic implication for the performance of monetary policy as this can alter the maturity pattern of interest rates and other capital assets upon which the policy

decisions are adopted (Holmes, Otero, & Panagiotidis, 2011). Therefore, it would be a significant analysis involving the assessment of international movement of various domestic interest rates across countries. The liberalization and globalization of world financial markets including the relaxation of various capital controls and other important barriers to international capital mobility provokes one's mind for an articulation of domestic interest rates at a global context in which foreign monetary policy and their interest rates eventually influence the domestic interest rates.

The countries under consideration have liberalized their financial markets and opened up their economies to a significant extent in the 21<sup>st</sup> century. These countries also have experienced drastic development in their financial markets including deregulation and introduction of innovative financial instruments, resulting in diminishing information and transaction cost. All these advancements imply that international real interest rates are likely to witness a greater degree of interactions now than ever before. Historically, many authors have documented that the international propagation of financial macroeconomic shocks can cause macroeconomic instability or financial vulnerability in economies. For example, the Asian Financial Crisis (1997-98), Global Financial Crisis (2007-09)<sup>1</sup> have affected negatively many economies (Choi, 2013; Nier & Merrouche, 2010). These cataclysms led to the deterioration of macroeconomic financial stability of many economies including high, medium, and low-income countries.

This explicitly shows that the crises originated from one specific region can subsequently spillover to another region, in which it can craft macroeconomic instability. Therefore, identifying the specific channels through which macroeconomic shocks can spillover across countries is crucial from the standpoint of policy. If policy actions are taken in desired directions, this can insulate the domestic economy from external impacts. The higher is the propagation of macroeconomic shocks stemming from deepening of globalization (Ilzetzki & Jin, 2013) larger will be disruption in the economy. Thus, in the era of globalization, a precise measurement of macroeconomic shocks spillover is quite important or ultimate for the successful implementation of macroeconomic policies (Diebold & Yilmaz, 2015)<sup>2</sup>.

Broadly, since various interest rates are prevailing in an economy depending on their maturity structure, analyzing the movement of various interest rates would help us to easily track the level of international spillover of real interest rate shocks emerging from one economy and transmitting to another economy. Mohan and Nandwa (2009) argued that interest rate is one of the relevant policy tools which is crucial not only in attracting foreign capital but also in maintaining macroeconomic stability. The policy outcomes arising from such analysis may help to perform better and thereby maintaining the required stability in the macroeconomic system that may insulate economies from external shocks.

For our exploration of cross-border interaction, the sample countries considered in the analysis include a few countries viz. the US, Japan, Germany, China, India, and Russia. These are six largest economies in the world in terms of their purchasing power parity (PPP) adjusted to real GDP. This is as per the estimation of World Economic Outlook (April 2018) of the International Monetary Fund for 2017. The real GDP share of these six economies constitutes around 52% in total world GDP. Since many studies have revealed the significant influence of only advanced economies on other economies but this study predicts that these six economies are so large which can influence each other's interest rate and thereby the macroeconomic policies of those economies. This is because; it is the size of the market of each of these economies which may crucially matter to influence each other's real interest rates.

It is also crucial to look into other macroeconomic variables which are sum and substance for evaluation of cross-border spillover of interest rate shocks. The trade shares of individual economies in total world exports and imports of goods and services constitute a significant chunk. The shares of exports and imports have remained stagnant at around 37% and 35% from 2000 to 2017, while the aggregate share of FDI stock varies from 40% to 44% during the same period. Given the emerging pattern in the movement of financial interaction underlying the changing international economic structure, we expect that there may be significant interactions of different terms of interest rates among six countries under consideration.

This study covers the period from 2000: Q1 to 2018: Q2. The countries and study periods are chosen based on the economies' size and data availability of concerned countries. This study uses money market rates viz. overnight and short-term interest rates and secondary market's 10-year government bond yield as they are less regulated over time and respond to international financial and money markets with increasing global integration of markets. Moreover, these interest rates are more relevant for international spillover analysis, since money and capital markets are integrating at a faster pace than any other markets. Therefore, it is considered to be more suitable and relevant for the exploration of cross country spillover of interest rates shocks.

Employing Diebold and Yilmaz (2012) spillover methods, it shows that the total spillovers through long term interest rate, overnight interest rate, and short term interest rate are 44.8%, 41.10%, and 37.50% respectively. It reflects that spillover is marginally higher via long-term interest rate compared to both overnight and short-term interest rates.

The rest of the paper is organized as follows: Section 2 discusses briefly the extant literature. Section 3 shortly describes the methodology. Section 4 presents primary data treatment including descriptive statistics and correlation analysis. Section 5 discusses the empirical results. Section 6 concludes.

<sup>1</sup>Asian Financial Crisis (1997-98) alternatively called as Asian Contagion defined as a sequence of currency devaluation and other follow up of economic events that started in 1997 and impacted many countries.

Global Financial Crisis (2007-09) began in 2007 from subprime mortgage market in the USA and took the turn of a great depression of 1930's. It advanced into full-blown global banking crisis with the collapse of the Lehman Brother's Investment Bank in 2008.

<sup>2</sup> Diebold and Yilmaz (2012); Diebold and Yilmaz (2015) rigorously analysed stocks, bond, exchange rate and commodities etc. volatility spillover across the U.S. assets markets.

## 2. REVIEW THE LITERATURE

Incorporating only advanced countries into the analysis, [Monadjemi \(1997\)](#) explained the cointegrating relationship of real overnight interest rate among five OECD countries. In an attempt to extend the analysis, [Anoruo, Ramchander, and Thiewes \(2002\)](#) examined the inter-market short-term interest rate linkages across seven newly industrialized markets and Japan and the US interest rates. They reasoned that interest rate within the Asian region responded well to each other and there is a substantial increase in interest rate linkages among these markets over time. [Mohan and Nandwa \(2009\)](#) also examined the interdependency between short-term nominal interest rates among ASEAN-5, China, and India. They came up with empirical evidence that there is Granger causality between interest rates of the ASEAN-5 countries with China and India. A study by [Ciner \(2011\)](#) focusing on short-term interest rates had analyzed the dynamic relations between the short-term euro currency interest rates for the US, German, UK, and Japan. He stated that monetary policy shocks originating in Europe were important for the US money markets at any frequency. In a separate study, [Edwards \(2010\)](#) raised the question about the extent and speed of cross-country interest rate transmission that encapsulated the impact of the US's interest rate on emerging countries. However, this study was limited to analyzing the unidirectional spillover of interest rates.

In an important study, [Hassler and Werkmann \(2012\)](#) investigated the short-term, medium-term, and long-term interest rates linkages for eleven OECD countries and the US. They found the evidence that German is having a strong association with the OECD countries. Another study by [Frankel, Schmukler, and Serven \(2004\)](#) considering the exchange rate, estimated the short-term interest rates sensitivity consisting of 18 industrial and 29 developing countries. They observed a stronger transmission of interest rates under fixed exchange rate regime than under a floating exchange rate regime. In contrast, [Căpraru and Ihnatov \(2012\)](#) evaluated the impact of the Euro short-term interest rate movements under different exchange rate regimes and argued that spillover was higher under floating, and then intermediate and then the fixed exchange rate systems respectively in an orderly manner.

Moreover, [Takáts and Vela \(2014\)](#) studied how monetary policy in advanced economies affects the financial conditions of emerging markets through different channels. They established that the US monetary condition transmits to most Emerging Market economies through short and long-term interest rates. [Chang and Su \(2015\)](#) attempted to revive the traditional real interest rate parity condition analysis by using modern tools such as sharp transition and smooth transition models. They showed that the movement of real interest rates mostly exhibited the real interest rate parity condition.

The study by [Sowmya, Prasanna, and Bhaduri \(2016\)](#) examined the magnitude and direction of linkages in sovereign bond yields across a spectrum of different maturities for industrialized countries and the Asian countries. They found that spillover is higher with long term rates than the short-term rates. It is because of this, the long-term rates are influenced by the preference of global investors and global financial conditions. Besides, [Feldkircher, Huber, Chantapacdepong, and Punzi \(2017\)](#) debated that the transmission occurs between the European economies and Asia under both positive and negative interest rates scenario of European economies. [Caporale, Carcel, and Gil-Alana \(2017\)](#) scrutinized the stochastic properties of interest rate series and its long-run interactions. They reasoned that the Australian interest rate was cointegrated with the Eurozone, and the UK, Canadian rates were cointegrated with the UK rate, and the US and Japanese were cointegrated with the UK rate. In a study, [Probst \(2019\)](#) questioned whether the international or domestic force that determines national short-term real interest rate for 17 advanced economies. He observed that the national real interest rate is highly approachable to global conditions during times of high international capital mobility.

Thus, a large number of scholars such as [Monadjemi \(1997\)](#); [Ciner \(2011\)](#); [Căpraru and Ihnatov \(2012\)](#); [Hassler and Werkmann \(2012\)](#); [Chang and Su \(2015\)](#), and [Caporale et al. \(2017\)](#) have focused on advanced economies and have ignored interest rate spillover between advanced and emerging countries. Their breakdown unified only short-term interest rate or single terms of interest rate in exploring the cross-country linkages except the studies by [Hassler and Werkmann \(2012\)](#) and [Sowmya et al. \(2016\)](#) who tried to analyze various maturities of interest rates. Only a few studies expanded the analysis from advanced economies to emerging economies or the relationship between them. These studies comprised of [Anoruo et al. \(2002\)](#); [Mohan and Nandwa \(2009\)](#); [Edwards \(2010\)](#); [Sowmya et al. \(2016\)](#) and [Feldkircher et al. \(2017\)](#).

In brief, all the extant literature are based on short-term interest rates ignoring other interest rates (i.e. overnight and long-term interest rates) in a country which needs much more consideration in the present global economic environment. Specifically, we intend to develop some empirical insights on real interest rates linkages among the countries. Nevertheless, this study contributes to the literature in many ways such as (i) it considers both advanced and emerging economies, (ii) it evaluates different maturities of real interest rate instead of examining single maturities of real interest rate, etc. Ultimately, this study is adding value to the existing knowledge in terms of cross-border spillovers of real interest rate shocks.

## 3. METHODOLOGY

To analyze the issue, this study employs [\(Diebold. & Yilmaz, 2012\)](#) spillover approach. It is based on generalized forecast error variance decomposition of h-step ahead forecast horizon corresponding to the structure of generalized impulse response of the system. The variance decomposition allows the forecast error variance of each variable into parts from aggregate shocks, i.e. it allows us to estimate the fraction of h-step ahead error variance for forecasting  $Z_i$  which is due to  $Z_j$ ,  $\forall j \neq i$  for each  $i$ .

The own variance share to be fractions of h-step ahead error variance in forecasting  $Z_j$  due to shocks to  $Z_j$ , for  $j = 1, 2, \dots, N$ , and cross variance share to be a fraction of h-step ahead error variances in forecasting  $Z_j$  due to shocks to  $Z_i$ , for  $i, j = 1, 2, \dots, N$  such that  $i \neq j$ .

Denoting the KPSS (Koop, Pesaran, & Potter, 1996) h-step ahead forecast error variance decomposition by  $\Theta_{ji}^g(h)$ , for  $h = 1, 2, \dots$

$$\Theta_{ji}^g(h) = \frac{\sigma_{jj}^{-1} \sum_{i=0}^{h-1} (e_j' \Pi_h \Sigma_\varepsilon e_i)^2}{\sum_{h=0}^{h-1} (e_j' \Pi_h \Sigma_\varepsilon \Pi_h' e_j)} \quad (1)^3$$

Where  $\Sigma$  is the variance matrix for error vector  $\varepsilon'$ ,  $\sigma_{jj}$  is the standard deviation of error term for  $j^{th}$  equation,  $e_j$  is the selection vector with one as the  $j^{th}$  element and zero otherwise in Eq. 1. It can be given as  $\sum_{i=1}^N \Theta_{ji}^g(h) \neq 1$  means the sum of elements of each row of variance decomposition is not Eq. 1 in Eq. 1. This is due to non-zero covariance between original shocks. Now, we can normalize  $\Theta_{ji}^g(h)$  in Eq. 1 by dividing it by row sum and reduced as Eq. 2:

$$\hat{\Theta}_{ji}^g(h) = \frac{\Theta_{ji}^g(h)}{\sum_{i=1}^N \Theta_{ji}^g(h)} \quad (2)$$

By construction  $\sum_{i=1}^N \hat{\Theta}_{ji}^g(h) = 1$  and  $\sum_{j=1}^N \hat{\Theta}_{ji}^g(h) = N$

The total spillover index is the cross-variance shares obtained from the above matrix which is represented as follows in Eq. 3:

$$S^g(h) = \frac{\sum_{j \neq i}^N \hat{\Theta}_{ji}^g(h)}{\sum_{j=1}^N \hat{\Theta}_{ji}^g(h)} \times 100 = \frac{\sum_{j \neq i}^N \hat{\Theta}_{ji}^g(h)}{N} \times 100 \quad (3)$$

This is analogous to the Cholesky factor-based measure of KPSS used in Diebold and Yilmaz (2012). The total spillover index in our empirical exercise measures the contribution of spillover of shocks across countries to their total forecast error variance.

The total spillovers received by market  $j$  from all other markets  $i$  can be expressed in terms of Eq. 4.

$$S_{j*}^g(h) = \frac{\sum_{i=1}^N \hat{\Theta}_{ji}^g(h)}{\sum_{i=1}^N \hat{\Theta}_{ji}^g(h)} \times 100 \quad (4)$$

Similarly, total spillover transmitted by market  $j$  to all other markets  $i$ , can be expressed in terms of Eq. 5.

$$S_{*j}^g(h) = \frac{\sum_{i=1}^N \hat{\Theta}_{ij}^g(h)}{\sum_{i=1}^N \hat{\Theta}_{ij}^g(h)} \times 100 \quad (5)$$

It is also important that total spillover is decomposed into those coming from (or to) a particular source (Diebold & Yilmaz, 2012).

It involves a simple exercise to estimate the net spillover from market  $j$  to all other markets  $i$  as revealed in Equation 6:

$$S_j^g(h) = S_{ij}^g(h) - S_{ji}^g(h) \quad (6)$$

The net transmission of spillover is just the difference between gross innovations transmitted to (explained by Eq. 5) and gross innovations received from all other markets (explained by Eq. 4).

## 4. DATA DESCRIPTION, DESCRIPTIVE STATISTICS, AND CORRELATION ANALYSIS

### 4.1. Data Description

The data set included for the present empirical analysis includes viz. overnight, short term and long-term interest rates<sup>4</sup>. The statistics on overnight, short-term, and long-term interest rates for most of the economies are drawn from the OECD<sup>5</sup> database except for India's short-run interest rate, which is taken from the International Financial Statistics of IMF<sup>6</sup> and long-term interest rate of China, India, and Russia are extracted from "Investing.com"<sup>7</sup> with a daily frequency. The data on all the terms of interest rates are drawn in the form of nominal

<sup>3</sup> The Equation 1 is derived from generalised impulse response function. For details, one can follow Koop et al. (1996) and Pesaran and Shin (1998) papers. The study examines the properties of the time series of all the data set by conducting the seasonality test, unit root test and structural break test which are presented in the appendix.

<sup>4</sup> The overnight interest rate defined as the rate of interest charged on less than 24-hour call money or interbank lending rate for all the countries. The short-term interest rates refer to 3-month money market rates. Long term interest rates include the quarterly yield on 10 years Government bond/securities.

<sup>5</sup> Data extracted on 18 Oct 2018 10:48 UTC (GMT) from OECD. Stat

<sup>6</sup> Data extracted from "international financial statistics" of international monetary fund

<sup>7</sup> Data extracted from "Investing.com"

value and then converted into real values by subtracting the inflation rates based on the consumer price index (CPI)<sup>8</sup> of respective countries. All the data series with a daily frequency are converted into quarterly frequency by simply taking their averages over three months. This is done due to the unavailability of all data series with a monthly frequency and thereby it considers a larger data set with a quarterly frequency covering the period from 2000Q1 to 2018Q2.

The study also looked at seasonality, unit root, and structural break tests in data series. This is because taking care of properties of time series would provide us appropriate estimated parameters rather than providing us misleading results. Firstly, to take care of presence of seasonality, the study plots the pattern of Correlogram. If it is found there is a presence of seasonality in the data series, then the series is seasonally adjusted by using the X-12-ARIMA model. Secondly, to address the stationarity issue, the study employs the Augmented Dickey-Fuller (ADF) test. The number of lags (n) augmented is determined by the Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) and lags are dropped out until they are found to be insignificant. The maximum 3 lags are chosen for the model estimation. Since the model estimated requires the data to be stationary, therefore, finally, all non-stationary data series are converted into stationarity after taking their first differences to use them in the estimation.

#### 4.2. Descriptive Analysis

Table 1 provides a comparative description of real overnight interest rate (ROIR), real short-term interest rate (RSTIR), and real long-term interest rates (RLTIR) for all 6 countries selected for the study. Based on averages, it is apparent that the level of ROIR, RSTIR, and RLTIR are reasonably higher in China, India, and Russia compared to the US, Japan, and Germany, indicating the isolated predominance of three nations in managing different maturities of interest rate. This may provide a sense of idea about the inflow of capital due to higher returns in these countries and the integration of these markets with the global market, and thereby drawing the attention of global investors from the international markets. It can be seen that the range of variation remains exclusively high for emerging economies as compared to advanced nations. Considering the median, some of the variables depict a negatively skewed distribution and some others depict a positively skewed distribution. These features undoubtedly serve towards making a cautionary remark on the fluctuation of the value of various series. Also, when one considers the variability of different variables, it is evident that this goes counter to the levels of variables considered in terms of their averages.

Table-1. Descriptive Statistics of ROIR, RSTIR, and RLTIR.

Variables	Countries	Mean	Median	Max.	Min.	Std. Dev.	Observations
ROIR	US	-0.441	-0.831	3.279	-3.685	1.641	74
	Japan	0.028	0.241	2.315	-3.531	1.015	74
	Germany	0.169	0.159	3.248	-2.361	1.492	74
	China	0.923	1.271	4.347	-3.948	1.867	74
	India	0.473	1.637	5.028	-9.311	3.078	74
	Russia	1.623	1.402	13.169	-4.696	3.551	74
RSTIR	US	-0.225	-0.721	3.386	-3.469	1.627	74
	Japan	0.432	0.329	3.295	-3.391	1.332	74
	Germany	0.401	0.342	3.338	-2.323	1.509	74
	China	1.247	1.773	3.833	-3.608	1.738	74
	India	3.801	3.807	9.472	-3.639	3.595	74
	Russia	-1.937	-2.039	7.415	-14.443	4.783	74
RLTIR	US	1.328	1.357	5.141	-1.439	1.274	74
	Japan	0.966	1.316	3.532	-3.031	1.336	74
	Germany	1.372	1.579	4.116	-1.612	1.559	74
	China	1.348	1.729	4.728	-3.751	1.723	74
	India	1.341	1.863	7.901	-7.304	3.045	74
	Russia	-0.079	-0.681	24.755	-7.881	5.199	74

#### 4.3. Correlation Analysis

The correlation coefficients produced in Table 2(a) and 2 (b) show that the extent of association between relative movements of real overnight interest rate, and real short-term interest rate among different countries are moderate

<sup>8</sup> The consumer price index (CPI) is taken from the OECD data source with quarterly frequency. The consumer price index (CPI) is considered as to represent the price level for all the countries and the intuition behind using CPI as a measure of the price level is that it covers prices of both goods and services comprehensively than any other measurement indicators representing the prices.

except the correlation coefficient between the US and Germany (based on overnight and short-term interest rates) where correlation is higher. Table 2(c) shows the association between the US-Germany, US-China, and Japan-Germany are larger compared to other pairs of countries in terms of long-term interest rate. Among the three maturities of interest rates, the extent of correlations between real long-term interest rates is higher relative to overnight and short-term rates.

Table-2(a). ROIR correlation matrix.

Variable	US	Japan	Germany	China	India	Russia
US	1					
Japan	0.333	1				
Germany	0.673	0.351	1			
China	0.491	0.213	0.286	1		
India	0.267	-0.279	0.181	0.273	1	
Russia	0.418	0.146	0.317	0.473	0.484	1

Table-2(b). RSTIR correlation matrix.

Variable	US	Japan	Germany	China	India	Russia
US	1					
Japan	0.448	1				
Germany	0.675	0.505	1			
China	0.120	-0.044	-0.220	1		
India	0.484	0.260	0.710	-0.135	1	
Russia	-0.297	-0.495	-0.695	0.330	-0.605	1

Table-2(c). RLTIIR correlation matrix.

Variable	US	Japan	Germany	China	India	Russia
US	1					
Japan	0.489	1				
Germany	0.706	0.698	1			
China	0.619	0.157	0.333	1		
India	0.067	-0.081	0.137	0.222	1	
Russia	0.062	0.037	-0.055	0.245	0.272	1

Source: Tables 2 (a), (b), and (c) are the author's own calculation based on extracted data.

Note: ROIR is the real overnight interest rate, RSTIR is the real short-term interest rate, and RLTIIR is the real long-term interest rate.

## 5. RESULTS AND DISCUSSION

Employing Diebold and Yilmaz (2012) spillover methods, it shows that the total spillover through long-term interest rate is 44.8%, through overnight interest rate is 41.10% and through short term interest rate is 37.50% respectively as shown in Tables 3(c), (a) and (b). It indicates that spillover is marginally higher via long-term interest rate as compared to overnight and short-term interest rates. This is because the long-term interest rate takes its secular trend path based on the preferences of international investors and global financial market conditions. This result is also supported by the study of Sowmya et al. (2016). They argued that the magnitude of spillover is larger with long-term interest rate than short-term interest rate. They also strongly argued that international investors and global financial conditions go in favour of long-term interest rate than that of short-term rate.

Table-3(a). Spillover through ROIR.

Variable	US	Japan	Germany	China	India	Russia	From Others
US	34.3	18.9	15.5	16.4	12.9	2	65.7
Japan	13.1	54.1	6.4	10.6	8.1	7.7	45.9
Germany	12.3	7.3	63	1.3	12.6	3.4	37
China	8.7	10.1	0.4	77.1	2.6	1.1	22.9
India	12.6	12.7	11.3	6.8	47	9.5	53
Russia	2.9	7.1	1.2	3.1	7.6	78.1	21.9
To others	49.6	56.1	34.9	38.2	43.9	23.7	Total spillover
Net	-16.1	10.2	-2.1	15.3	-9.1	1.8	41.10%

Table-3(b). Spillover of RSTIR.

Variable	US	Japan	Germany	China	India	Russia	From Others
US	46.6	3.4	23.4	7.4	10.2	9.1	53.4
Japan	13.2	70.1	2.5	4.7	7.4	2.1	29.9
Germany	26.2	3.6	58.4	1.6	4.1	6.1	41.6
China	17.1	2.1	4.2	68	4.8	3.9	32
India	8	10.4	9.6	7.1	62.9	2	37.1
Russia	9.5	1.8	4.3	12.5	2.9	69.1	30.9
to others	74	21.3	43.9	33.2	29.3	23.2	Total spillover
Net	20.6	-8.6	2.3	1.2	-7.8	-7.7	37.50%

Table-3(c). Spillover of RLTIR.

Variable	US	Japan	Germany	China	India	Russia	From Others
US	32.1	8.1	12.8	15.8	19.8	11.3	67.9
Japan	16.4	43.4	0.6	4.9	23.1	11.5	56.6
Germany	23.7	6	49.7	7.8	8.3	4.4	50.3
China	6.9	16.3	1.3	69.3	3.4	2.8	30.7
India	11.5	10.2	7.3	7.7	60	3.2	40
Russia	2.7	6	5.2	4.7	5	76.3	23.7
to others	61.3	46.7	27.2	40.8	59.7	33.3	Total spillover
Net	-6.6	-9.9	-26.1	10.1	19.7	9.6	44.80%

Note: Tables 3(a), (b), and (c) show the spillover magnitude of ROIR, RSTIR, and RLTIR respectively based on Diebold and Yilmaz (2012) method over the period 2000Q1 to 2018Q2. It is estimated based on the generalized forecast error variance decomposition of 10 steps ahead with optimum lag 3. The columns demonstrate the fraction of forecast error variance that the headline country transmits to all the economies. The rows demonstrate the fraction of forecast error variance that the headline economy imports from all economies. The row Net indicates the difference between "To Other" and "From Others". The total spillover is the average of all off-diagonal elements.

In aggregate, more than two-fifth of total interest rate forecast errors for these economies is explained by the spillover of innovations, and roughly three-fifths of this variance is then explained by country-specific interest rate shocks. The country-specific innovations are elucidated and represented in diagonal elements in all of the Tables 3(a), (b), and (c). In the context of ROIR, the country-specific interest rate shocks appear to be larger for all countries except for the US and India. It indicates that the US and India are importing larger innovations from other countries compared to their own innovations. The US only receives higher innovations from other countries through short-term interest rates. Interestingly, advanced countries like the US, Japan, and Germany are receiving a higher degree of shocks through long-terms rates from other countries compared to their own innovations. In contrast, the scenario is just reverse for the emerging countries like China, India, and Russia who receives lesser shocks from others through long-term interest rate.

The total spillover of interest rate shocks received from external sources is higher for the US, followed by Japan and Germany. Among the emerging economies, India imports the larger external shocks and then followed by China and Russia. In the context of propagation of shocks spillovers to others, the US dominates both in short and long-term interest rates, while Japan dominates through overnight interest rate.

In terms of overnight interest rate, it shows the net total spillover (generate "to others" minus receipt "from others") of China, Japan, and Russia are positive constituting 15.3%, 10.2%, and 1.8% respectively and for other countries it is negative. The highest net negative shock is for the US followed by India. It indicates that higher transmission of overnight interest rate shocks comes to the US and India compared to what they generate for others. In contrast, Germany has a negative net spillover of shocks signifying that the propagation of ROIR shocks from Germany is comparatively lesser than what it received from others.

In the context of short-term rate, it shows that the US, Germany, and China have positive shocks, while Japan, India, and Russia (-7.7%) have negative values in their net spillover of interest rate shocks. In the case of RLTIR, it shows that the emerging economies such as India (19.7%), China (10.1%), and Russia (9.6%) have positive spillovers. In contrast, the US (-6.6%), Japan (-9.9%), and Germany (-26.1%) have negative net spillover of interest rate shocks. Thus, the long-term interest rate shock spillover reflects that the emerging economies propagate more shocks to other economies than what they receive from other countries, while the advanced countries receive higher magnitude of interest rate shocks from others compared to what they transmit to others.

## 6. CONCLUSION

This study attempts to establish a comparative understanding of cross-country interlinkage of real overnight, short and long-term interest rates of the US, Japan, Germany, China, India, and Russia. It investigates whether the magnitude of international spillover of real interest rate shocks do vary based on their maturity patterns. Employing (Diebold & Yilmaz, 2012) spillover methods, it shows that the interest rate shocks spillovers vary according to their maturity. Specifically, the study observed that spillover through long-term interest rate is 44.8%, spillover through overnight interest rate is 41.10% and spillover through short-term interest rate is 37.50%. It indicates that spillover is marginally higher via long-term interest rate compared to both overnight and short-term interest rates. This is because the long-term interest rate takes its secular trend path based on the preferences of international investors and global financial market conditions. This has significant policy concerns to both monetary and fiscal authorities of economies, portfolio managers including the traders/investors from both foreign and domestic markets.

Therefore, the study suggests that all the stakeholders including the policymakers should take into account of the magnitude of spillover of long-term, short-term, and overnight interest rates while predicting, deciding, and framing up of macroeconomic policies to maintain macroeconomic stability in their respective economies. The policymakers in the US, Japan, Germany, China, India, and Russia may regularly design and update appropriate macro policies considering the results based on our illustrative empirical findings to maintain macroeconomic stability in response to the stronger interactions of economies with each other in a two-dimensional way in this integrated world.

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