Emerging Markets Review 37 (2018) 1–16

Contents lists available at ScienceDirect

Emerging Markets Review

journal homepage: www.elsevier.com/locate/emr

Financial connectedness of BRICS and global sovereign bond markets

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ARTICLE INFO

Article history:
Received 2 June 2017
Received in revised form 20 February 2018
Accepted 22 February 2018
Available online 27 February 2018

JEL classification:
C53
E44
F36
G15

Keywords:
BRICS
Emerging markets
Sovereign bond markets
Market linkages
Volatility spillover
Vector autoregression
Variance decomposition

ABSTRACT

The paper examines the financial connectedness via return and volatility spillovers between Brazil, Russia, India, China and South Africa (BRICS) and three global bond market indices represented by the United States of America (USA), European Monetary Union (EMU) and Japan for the period 01 January 1997 to 27 July 2016 (weekly data). We find that Russia followed by South Africa is the net transmitter of shocks within BRICS, implying that the risk arising from these markets may have an adverse impact on others in BRICS. However, China and India exhibit weak connectedness, suggesting that these markets may be useful for hedging and diversification opportunities in BRICS. The networks of pairwise spillover results further confirm this. Among global indices, China appears as highly interconnected with the USA. USA is the strongest transmitter of shocks to BRICS bond indices. The panel data results further confirm the significant determinants of net directional spillover. Thus, we can conclude that BRICS is a heterogeneous asset class even in the case of the bond market. India and China are the markets to look for better risk management strategies.

1. Introduction

This study examines the financial connectedness via return and volatility spillovers of dollar-denominated sovereign bond indices for a group of selected emerging markets represented by BRICS (Brazil, Russia, India, China and South Africa) and three major global and regional sovereign bond indices viz., United States of America (USA), European Monetary Union (EMU) and Japan. The primary purpose of this research is to investigate the direction and extent of connectedness of BRICS countries with global and regional bond markets. The extant literature on sovereign bond emerging markets can be divided into three broad categories. Preliminary research within the context of bond market contagion focused on an examination of the major determinants of bond markets using structural, financial, institutional and macroeconomic factors which explain the movements of sovereign bond yields. In this regard, prominent studies include those by Eichengreen and Luengnaruemitchai (2004) and Burger and Warnock (2006) for Asian and developed countries; Eichengreen et al. (2008) for Latin American countries; Adelegan and Radzewicz-Bak (2009), Bae (2012) and Mu et al. (2013) for African countries. These

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https://doi.org/10.1016/j.ememar.2018.02.006

studies conclude that exchange rate volatility and fiscal factors typically constrain the development of sovereign and corporate bond markets across emerging markets, whereas, institutional and structural factors such as trade openness and bureaucratic quality provide a positive influence for the growth of sovereign and corporate bond markets. A second line of enquiry into the development of bond markets is provided from the perspective of a stock-bond interdependence framework, these studies consider themes such as the comovement between equity and bond markets across emerging economies with a major focus on segmentation of risk premia (Panchenko and Wu, 2009), the impact of sovereign credit risk rating on equity-bond relationship (Christopher et al., 2012), considerations of bond with equity within a portfolio (Kolluri et al., 2015), how interest rate shocks affects bond markets (Cenedese and Mallucci, 2016) and the effect of the global financial crisis on the co-movement between equity and bond markets (Sakemoto, 2018).[1] In the case of BRIC countries, Bianconi et al. (2013) find that the bond markets of BRIC countries exhibit high comovement in the short-term with the exception of India. Zhang et al. (2013) examine the volatility spillovers of equity and bond markets of BRICS with G7 countries and report bidirectional causality-in-variance dependence for Brazil and South Africa. In the third category of these studies, the research focus turns to the investment performance of combining emerging bond indices with those of developed markets where researchers examine co-movements in bond markets focused on defined geographical regions and between emerging and developed markets. In this context, notable studies include those by Cifarelli and Paladino (2006), Bunda et al. (2009), Piljak (2013) and Piljak and Swinkels (2017). Results from these studies suggest that conditional covariances increased during turbulent times but failed to reveal the dominance of one market over another *op cit* Cifarelli and Paladino (2006). Related studies by Piljak (2013), Miyajima et al. (2015) and Piljak and Swinkels (2017) examine the co-movement and diversification dynamics of emerging markets with the US government bond market. While, there is ample evidence of bond market integration, what is missing in the existing literature is a systematic analysis of emerging economies with the US, the EMU and Japan's bond markets.

The primary aim of this study is to increase our understanding of the relationships between the bond markets of BRICS cointries and those of the developed bond markets in the USA and the EMU. This information will be valuable to both domestic and international private and public fund managers given that the sovereign bond markets of China, Brazil, and India alone account for 50% of the outstanding local currency debt (see Klingebiel, 2014). In terms of local currency denomination of these bonds Arslanalp and Tsuda (2014) find that the local currency sovereign debt holdings for China equates to (1340.27 billion USD), Brazil (859.48 billion USD) and India (680.49 billion USD). It is important therefore that one examine these markets from the point of view of their segmented nature and their relationship to the broader global markets for bonds. For example, large investors prefer to diversify their risk by investing a part of their portfolio in bonds issued by different countries rather than solely investing in their own country's government bonds. Spillover analysis would therefore inform investors' regards optimal asset allocation decisions. From the perspective of informing sovereign policymakers, spillover analysis can provide an important direction in undertaking timely bond issues (see Clare and Lekkos, 2000).

In the light of above discussion, the format of this study takes on two stages. In stage one, we employ a directional spillover method which allows us to determine the extent of interdependence between BRICS and global bond indices via return and volatility spillovers. Specifically, we apply the directional connectedness method developed by Diebold and Yilmaz (2012, 2014) (henceforth, DY), whose study examined the directional spillover emanating from one bond index to another under both, static and dynamic settings.[2] The strength of connectedness is further magnified by the use of networks that help trace the magnitude and strength of directional spillover across sample indices.[3] These results include identification of the major turning points during the estimation period which are further re-confirmed by the dynamic equicorrelation (DECO) model of Engle and Kelly (2012). It is noteworthy that the GARCH-DECO model is a special case of dynamic conditional correlation model of Engle (2002). The GARCH-DECO model assumes that the correlations are constant across pairs, but the common equicorrelation is time-varying. Conditioned to deal with curse of dimensionality, the GARCH-DECO creates better comparable scenarios with DY results than normal GARCH-DCC model.[4] In the second stage, we examine the possible determinants of bond market directional connectedness by considering a large number of macroeconomic and financial variables. This information is expected to sharpen our understanding about yield development over time and anticipation of the sovereign debt crisis (see Hartman et al., 2004).

The remainder of this study is organized as follows: Section 2 provides a brief literature review on the volatility spillovers. Section 3 explains data. Section 4 provides the details about the econometric framework. Section 5 reports empirical results followed by conclusion in Section 6.

[1] Some of the relevant studies in the context of equity market integration and contagion effect of emerging equity markets with developed markets include Bekaert (1995), Bekaert and Urias (1996), Jong and Roon (2005), Tai (2007), Ahmad et al. (2013), Cakici et al. (2013), Bhuyan et al. (2016), Chiang and Chen (2016), Mensi et al. (2017) and Bouri et al. (2017).

[2] For further details, please refer Diebold and Yilmaz (2014).

[3] Several studies have used this method to examine different markets interactions including foreign exchange rates, equity markets, sovereign bond yield spreads, commodity derivatives, energy and other financial/real assets spillovers (see Antonakakis and Vergos, 2013; Cronin, 2014; Sehgal et al., 2014, 2015; Antonakakis and Kizys, 2015; Ahmad, 2017; Ahmad et al., 2017).

[4] The GARCH-DECO model has also practical advantages over GARCH-DCC. According to Engle and Kelly (2012), in case of DCC, as the sample size grows, estimation becomes increasingly tiring and even sometime it breaks down completely, whereas in case of DECO, because of simplicity of equicorrelated matrices, it is easier to calculate the inverse and determinants and even optimization becomes feasible.

2. Related literature

An overview of existing literature on bond market reveals that there are a few early studies on the interdependence of international bond markets (Ilmanen, 1995; Clare and Lekkos, 2000; Driessen et al., 2003; Laopodis, 2004; Dewachter et al., 2004, among others). Ilmanen (1995) examines the predictable variation in long-maturity government bond returns in six countries using a linear regression model with local and global instruments. Clare and Lekkos (2000) decompose the relationship between the government bond markets of Germany, the United Kingdom, and the United States. They find that global factors influence the yield curves for each of these markets and the impact of these factors increases significantly during times of financial stress. Driessen et al. (2003) estimate and interpret the factors that jointly determine bond returns of different maturities in the US, Germany, and Japan. They find that the positive correlation between bond markets is driven by the term structure levels, not by term structure slopes. Dewachter et al. (2004) develop a benchmark against which the effects of ECB (European Central Bank) monetary policy on the German bond market can be evaluated. They find that yield spreads increased substantially during the EMU (European Monetary Union) period. Laopodis (2004) examines the monetary policy implications of the greater integration of the capital markets using long-term interest rates. He finds greater convergence among countries in the EU (European Union) as Germany still retains its hegemonic status.

There are papers on sovereign yield spreads (Balli, 2009; Favero and Missale, 2012; Antonakakis and Vergos, 2013; Costantini et al., 2014). Balli (2009) examines the time-varying nature of European government bond market integration by employing multivariate GARCH models. He states that global factors are sufficient for the volatility of yield differentials among euro government bonds. Favero and Missale (2012) provide new evidence on the determinants of sovereign yield spreads and market sentiment effects in the Eurozone to evaluate the rationale for a common Eurobond jointly guaranteed by Eurozone member states. Antonakakis and Vergos (2013) examine sovereign bond yield spread spillovers between Eurozone countries using the VAR-based spillover index model of Diebold and Yilmaz (2012) and impulse response analyses. Their findings highlight the increased vulnerability of the Eurozone from the destabilizing shocks originating mostly from the Eurozone countries in the periphery and to a lesser extent from the Eurozone core. Costantini et al. (2014) find that fiscal imbalances – namely expected government debt-to-GDP differentials – are the primary long-run drivers of sovereign spreads.

The literature on volatility spillovers in bond markets is scanty. Skintzi and Refenes (2006) examine dynamic linkages among the European bond markets. They find that significant volatility spillovers exist from both the aggregate Euro and US bond markets to the individual European markets. They also conclude that the introduction of the Euro has strengthened the volatility spillover effects and the cross-correlations for most European bond markets. Christiansen (2007) examines volatility spillover from the US and aggregate European bond markets into individual European bond markets using a GARCH volatility-spillover model. Results indicate that for EMU countries, the US volatility spillover effects are rather weak (in economic terms) whereas the European volatility spillover effects are substantial. The bond markets of EMU countries exhibit high integration after the introduction of the euro. The post-Euro period has further strengthened the integration process. They find interest rate convergence as one of the primary drivers of bond market integration. Gómez-Puig et al. (2014) apply the Granger-causality approach and endogenous breakpoint test to offer an operational definition of contagion to examine (EMU) countries public debt behaviour. A database of yields on 10-year government bonds issued by 11 EMU countries covering fourteen years of monetary union is used. The main results suggest that the 41 new causality patterns, which appeared for the first time in the crisis period, and the intensification of causality recorded in 70% of the cases provide clear evidence of contagion in the aftermath of the current euro debt crisis. Sibbertsen et al. (2014) study tests for a break in the persistence of EMU government bond yield spreads examining data from France, Italy and Spain and using German interest rates as a kind of benchmark. Their results provide evidence for breaks between 2006 and 2008. The persistence of the yield spreads against German government bonds has increased significantly after this period.

Besides this, few studies have also examined volatility spillovers in bond markets using Diebold and Yilmaz (2009, 2012) methodology. Claeys and Vašíček (2014) measure direction and extent of sovereign bond markets linkages among sixteen EU (European Union) using a factor-augmented version of the VAR model in Diebold and Yilmaz (2009). Fernández-Rodríguez et al. (2015) examine volatility spillovers in EMU sovereign bond markets. They find that slightly more than half of the total variance of the forecast errors is explained by shocks across countries rather than by idiosyncratic shocks. They also report that during the pre-crisis period, most of the triggers in the volatility spillovers were central EMU countries – peripheral countries imported credibility from them – while during the crisis, peripheral countries became the dominant transmitters. Fernández-Rodríguez et al. (2016) examine the time-varying behavior of net pair-wise directional connectedness at different stages of the recent sovereign debt crisis.

Under emerging market setting, a limited number of studies have responded to the need of bond market making in emerging economies. Kim et al. (2006) examine the time-varying bond market integration in case of European emerging countries and report the evidence of weak bond market integration. Examining the bond markets of Asian countries with USA and Australia, Vo (2009) reports moderate level of interdependence because of the different institutional structure. Cifarelli and Paladino (2006) examines the volatility comovement between spreads for ten selected emerging economies. The study reports that volatility comovements between spreads are higher for within countries than across spatially distributed countries. Bunda et al. (2009) assess comovements in emerging markets bond returns and disentangles roles of external and domestic factors during episodes of heightened market volatility. Piljak (2013) investigates the time-varying dependence of bond markets of emerging including frontier economies with the USA and also examines the major factors that determine the comovement. The study finds that the impact of domestic factors are higher than the factors on the bond market integration of these countries. Piljak and Swinkels (2017) examine the dynamic interdependence of sovereign debt markets of frontier economies with US bond markets. The study reports that there is a limited interdependence between frontier and US bond markets because of the limited diversification opportunities.

3. Data

We use the Monday closed weekly data on Brazil, Russia, India, China and South Africa that are constituents of the JPM GBI-Emerging Markets Broad Index (EMBI).[5,6] To see the integration of BRICS with USA, Eurozone, and Japan, we have also considered J.P. Morgan United States Government Bond Index for the USA, J.P. Morgan Economic and Monetary Union (EMU) Government Bond Index for all maturities for Eurozone and J.P. Benchmark 10 Year Government Bond Index for Japan. All the bond indices are denominated in US dollars and are downloaded from *Thomson DataStream*. We use the data available from 01 January 1997 to 27 July 2016 (yielding 1018 observations). Following Christiansen (2007) and Piljak (2013), we transform the data into logarithmic differences to calculate bond returns.

Table 1 provides an overview of EMBI Global for BRICS. As these important constituents of EMBI Global, we find that CHN has the highest number of issues followed by BRZ and Russia. However, on total value (market capitalization), BRZ appears to have the largest value followed by CHN and SAF. IND has the lowest market value in BRICS. Based on effective interest rate duration (EIR) which measures the change in the value of bond prices due to change in yield. We can see that the EIR durations of SAF and BRZ are highest within BRICS followed by CHN and RUS. In a generic sense, we can say that BRZ and SAF bond markets are relatively more volatile than others in BRICS though it also depends upon the number of years to maturity.

Table 2 provides the details of descriptive statistics. In general, it appears that bond returns are higher in emerging countries compared to EMU, USA, and Japan and this corresponds to a higher standard deviation in BRICS countries due to their economic, political and credit related risk transfers. Among BRICS, Russia reports the maximum and minimum weekly returns of 31% and −40%, respectively. Also, we find that the distributions of these bond markets returns are non-normal. It is noteworthy that except India and China, all sample bond markets exhibit negative skewness, indicating the severe impact of crisis event on these countries' bond markets. The Jarque-Bera (JB) statistics report the case of non-normality for each bond market. All the sample bond index returns exhibit no serial correlation in the first moment except India, EMU, and the USA. However, all bond indices show a significant serial correlation in the second moments, indicating to check for possible clustering effect. It is further substantiated by the Autoregressive Conditional Heteroscedasticity (ARCH) test which shows statistically significant clustering effect for each bond indices. We have also checked for possible outlier effect with Augmented Dickey and Fuller (ADF) test which suggests that all the bond returns series are stationary at level.

4. Econometric modelling framework

4.1. Directional spillover model

The directional spillover model is proposed by Diebold and Yilmaz (2009, 2012). The model is based on a vector autoregression (VAR) with a major focus on the calculation of forecast-error-variance-decomposition (FEVD). FEVDs are used to examine the spillovers between different assets/markets. The specification of the model begins with a covariance-stationary VAR model. Under generalized VAR framework, let us consider a covariance-stationary VAR (p) model with N-variable i.e. $Y_t = \sum_{t=1}^{p} \psi_i Y_{t-i} + e_t$, where $e_t \sim i.\ i.\ d(0,\Sigma)$ is a $N \times 1$ vector of residuals. The moving average representation of VAR model takes the form of $Y_t = \sum_{j=0}^{\infty} A_j e_{t-j}$, where the $N \times N$ is coefficient matrix. A_j follows recursive pattern as $A_j = \psi_1 A_{j-1} + \psi_2 A_{j-2} + \ldots + \psi_p A_{j-p}$, A_0 is an identity matrix and $A_j = 0$ for $j < 0$. Diebold and Yilmaz (2012) apply generalized framework of VAR model to calculate the H-step-ahead generalized forecast error decompositions

$$\theta_{ij}(H) = \frac{\sigma_{ii}{}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \sum e_j \right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \sum A_i' e_j \right)} \tag{1}$$

where σ_{ii} is the i element on the principal diagonal of $\sum$. Since the sum of each row of$\theta_{ij}(H)$ is not equal to 1, each element of the matrix is normalized by summing the row as $\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{j=1}^{N}(\theta_{ij}(H))}$ so that the decomposition including shocks in each market equals to unity, i.e., $\sum_{j=1}^{N}(\theta_{ij}(H)) = 1$ and total decomposition of all variables sums to N i.e.$\sum_{i,\,j=1}^{N}(\theta_{ij}(H)) = N$. The total spillover index is computed as

$$S(H) = \frac{\sum_{\substack{i,\,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{N} \times 100 \tag{2}$$

[5] The JP Morgan GBI-EMBI includes 18 emerging market economies consisting of Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Nigeria, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, and Turkey (see Fong et al., 2016). It is considered as one of the major benchmarks of bond market investment instrument.

[6] For more details about EMBI, please refer https://www.jpmorgan.com/country/US/EN/jpmorgan/investbk/solutions/research/indices/product and also Piljak (2013) for empirical analysis of EMBI and also why we should use logarithmic returns in case of bond indices.

Table 1
Bond market characteristics.

2016	BRZ	SAF	RUS	CHN	IND
EMBI Global – number of issues	25	14	22	59	7
Total value of issues (in local currency)	39,800	19,300	53,500	53,200	4265
Total value of issues (in million USD)	11,711	1380	823	7715	62
Average issue years to maturity (in years)	11.04	9.78	7.00	7.43	5.33
EMBI Global – EIR duration	6.53	6.66	5.10	5.49	4.66
EMBI Global – stripped YTM	5.71	6.50	5.00	5.60	4.61
EMBI Global – spread duration	6.40	5.13	4.23	3.81	3.49

Note: Table shows the bank characteristics with the relevant set of variables representing the status of development of bond market. Local currency denominated issues are converted in USD terms using USD exchange rate of each BRICS country. The effective interest rate (EIR) duration shows the change in the value of bond prices due to change in yield. Stripped Yield to Maturity (YTM) measures the non-collateralized return on bond adjusted for any monetary incentives. BRZ (Brazil), SAF (South Africa), RUS (Russia), IND (India), CHN (China), EMU (European Monetary Union), USA (United States), and JAP (Japan).

The total spillover index explains the spillovers from all the assets/markets to the total FEVD (see Diebold and Yilmaz, 2012).

Similarly, directional spillovers which measure the volatility spillover received by asset/market i from the universe of markets j is calculated as

$$DS_{i \leftarrow j}(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H)} \times 100 \tag{3}$$

and

$$DS_{j \leftarrow i}(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H)} \times 100 \tag{4}$$

Finally, the net spillovers from one variable to another for a set of variables are calculated by taking the difference of Eqs. (3) and (4) as.

$$NS_i(H) = S_{i \leftarrow j}(H) - S_{j \leftarrow i}(H) \tag{5}$$

Table 2
Descriptive statistics.

	BRZ	SAF	RUS	IND	CHN	EMU	USA	JAP
Mean	0.191	0.156	0.186	0.102	0.125	0.091	0.022	0.053
Std. dev.	2.320	1.384	3.712	1.032	0.753	1.536	0.668	1.613
Max.	12.611	14.184	31.058	9.124	8.712	5.575	2.793	9.583
Min.	−20.924	−13.824	−40.565	−4.695	−4.685	−5.472	−3.092	−7.154
Skew.	−1.370	−0.786	−2.563	0.057	0.868	−0.169	−0.358	0.360
Kurt.	16.370	33.624	38.643	11.443	23.414	3.585	4.238	5.344
JB	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
Q(10)	32.346	48.668	122.894	13.764	27.365	7.213	14.809	13.383
	[0.000]**	[0.000]**	[0.000]**	[0.184]	[0.002]**	[0.705]	[0.139]	[0.086]*
$Q^2(10)$	359.055	481.954	983.185	243.84	221.477	76.68	97.517	88.149
	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
ARCH (10)	18.514	78.316	49.727	13.481	17.914	4.776	7.380	7.577
	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
ADF	−20.70**	−37.46**	−10.060**	−30.871**	−31.914**	−33.054**	−33.723**	−18.098**
Obs.	1016	1016	1016	1016	1016	1016	1016	1016

Note: The table reports the summary statistics for the weekly returns (in %) of the BRIC, USA, Japan and Europe indices. The following statistics are reported: mean, standard deviation (SD), skewness (Skew), kurtosis (Kurt), Jarque-Bera (JB) test. Q-statistics is denoted by Ljung and Box (1978) test statistic. Augmented Dickey-Fuller (ADF) test is used to check stationarity of sample series. Values in [] are p-values. BRZ (Brazil), SAF (South Africa), RUS (Russia), IND (India), CHN (China), EMU (European Monetary Union), USA (United States), and JAP (Japan).

** Indicates the level of significant 5% and better.

* Indicates the level of significant below 10%.

4.2. DECO-MGARCH model

To further confirm the connectedness results, this study applies dynamic equicorrelation model of multivariate generalized autoregressive conditional heteroscedasticity (henceforth, DECO-MGARCH) Engle and Kelly (2012). To overcome the problem of curse-of-dimensionality, Engle and Kelly (2012) developed the DECO model which is capable of handling the large number of variables and simplifies the computational and presentation difficulties associated with a high-dimensional system. Like MGARCH-DCC model, the DECO model also follows two-step estimation procedure. In the first step, we estimate univariate GARCH model for each series to obtain the conditional variance. In the second step, we calculate dynamic conditional correlations from standardized residuals.

$$H_t = D_t R_t D_t \tag{6}$$

In Eq. (6), H_t is the $n \times n$ conditional covariance matrix, R_t is the dynamic correlation matrix and D_t is a diagonal matrix with time-varying standard deviations.

$$D_t = \ diag\left({h_{11t}}^{1/2} \ldots {h_{kkt}}^{1/2}\right) \tag{7}$$

$$R_t = \ diag\left({q_{11t}}^{-1/2} \ldots {q_{kkt}}^{-1/2}\right) Q_t \ diag\left({q_{11t}}^{-1/2} \ldots {q_{kkt}}^{-1/2}\right) \tag{8}$$

where Q_t is a symmetric positive definite matrix:

$$Q_t = (1-\theta_1-\theta_2)\overline{Q} + \theta_1 \varepsilon_{t-1}\varepsilon_{t-1}' + \theta_2 Q_{t-1} \tag{9}$$

$\overline{Q}$ is the $n \times n$ unconditional correlation matrix of the standardized residuals ε_{it}. The parameters θ_1 and θ_2 are non-negative with a sum of less than unity. The basic formulation of DECO model starts with the application of consistent DCC (cDCC) model by modifying the Eq. (9) in the following manner:

$$Q_t = (1-\theta_1-\theta_2)\overline{Q}^* + \theta_1\left(Q_{t-1}^{*1/2}\varepsilon_{t-1}\varepsilon_{t-1}' Q_{t-1}^{*1/2}\right) + \theta_2 Q_{t-1} \tag{10}$$

Using cDCC framework, Engle and Kelly (2012) propose the calculation of ρ_t by taking the off-diagonal elements of conditional correlation correlation matrix Q_t. The equicorrelation is then defined as:

$$\rho_t^{DECO} = \frac{1}{n(n-1)}\left(P_n' R_t^{cDCC} P_n - n\right) = \frac{2}{n(n-1)} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{q_{ij,t}}{\sqrt{q_{ii,t}, q_{ij,t}}} \tag{11}$$

where $q_{ij,\ t} = \rho_t^{DECO} + \alpha_{DECO}(u_{i,\ t-1}u_{j,\ t-1} - \rho_t^{DECO}) + \beta_{DECO}(q_{ij,\ t} - \rho_t^{DECO})$, which is the (i,j)th element of matrix Q_t derived from the cDCC model. The scalar equicorrelation to obtain the conditional correlation matrix: $R_t = (1 - \rho_t)I_n + \rho_t P_n$, where P_n represents the $n \times n$ matrix of ones and I_n is the n-dimensional identity matrix. The process allows us to come-up with the single time-varying correlation coefficient shown in Fig. 2.

5. Empirical results and discussion

5.1. Unconditional correlation analysis

Before we analyze the cross-index spillover among sample indices, we begin with the analysis of unconditional correlation matrix reported in Table 3. It appears that among BRICS, BRZ shows high correlation with RUS. Similarly, SAF exhibits high correlation with RUS and BRZ. RUS and IND exhibit a negative correlation with the USA. CHN appears to be highly correlated with the USA, indicating the very limited possibility of forming a portfolio. We also find that except CHN, all countries exhibit very low or even negative correlation with EMU, USA, and JAP, implying that the bond indices of BRICS can be combined with the EMU, USA, and JAP in the construction of a bond portfolio.

5.2. Return and volatility connectedness analysis

In this section, we analyze the connectedness results obtained using DY model (see Table 4). The DY model is estimated using the 10-step-ahead procedure.[7] Following Forsberg and Ghysels (2007) and Zhang and Wang (2014), we use the absolute returns to calculate the volatility spillover.[8] We examine return and volatility spillovers results in two ways: Firstly, we seek to explain the

[7] For VAR estimation, we choose appropriate lag length by using the criteria of AIC (Akaike Information Criterion).
[8] For further details, please refer Zhang and Wang (2014).

Table 3
Heat-map of unconditional correlations.

	BRZ	SAF	RUS	IND	CHN	EMU	USA	JAP
BRZ	1.000							
SAF	0.378	1.000						
RUS	0.552	0.440	1.000					
IND	0.217	0.318	0.165	1.000				
CHN	0.167	0.342	0.168	0.075	1.000			
EMU	0.063	0.222	0.038	0.248	0.311	1.000		
USA	0.044	0.210	-0.005	-0.090	0.685	0.327	1.000	
JAP	-0.041	-0.007	-0.088	-0.017	0.195	0.209	0.299	1.000

Note: The table reports unconditional correlations. BRZ (Brazil), SAF (South Africa), RUS (Russia), IND (India), CHN (China), EMU (European Monetary Union), USA (United States), and JAP (Japan).

return and volatility spillovers spillover among BRICS indices followed by return spillover between BRICS and global indices. The results reveal that among BRICS, BRZ explains about 19.59% of forecast-error-variance-decomposition (FEVD) of RUS followed by the SAF (9.07%), implying that the risk arising from BRZ may have risk implications on RUS and SAF. The magnitudes of directional returns spillovers from BRZ to RUS and SAF are in agreement with return spillover results. For SAF, it contributes 11.51% FEVD of RUS followed by BRZ (9.71%), IND (7.87) and CHN (7.82), respectively. RUS shows highest spillover with BRZ and SAF with the contribution to FEVDs by 19.79% and 11.82%, respectively. However, the cross-index spillover of IND is very limited as the magnitude of spillover is very low except SAF (5.94%) which reaches upto 6.08% as reported in volatility spillover results. CHN exhibits relatively higher level of spillover with SAF with the extent of FEVD of 8 and 7.64% for returns and volatility spillovers, respectively (see Table 4, panels A and B). Analyzing the net spillovers results, we find that among BRICS; BRZ and IND are net receivers of return and volatility spillovers, implying that the risk arising from other sample indices will have spillover implications on BRZ and IND. Continuing on the same line, we find that for RUS and BRZ, both are almost close to each other, though RUS appears to be the net transmitter of return and volatility spillover by a small margin. Same is the case between SAF and BRZ, SAF is the net transmitter of a shock to BRZ by a small amount. Overall, it appears that the magnitude of net spillover among BRICS is not very high, suggesting a moderate level of cross-index spillover. Except IND and CHN, we find homogenous dependence structure across BRZ, SAF and RUS. Secondly, we now analyze the return spillover between BRICS and global indices represented by EMU, USA, and JAP. The results reveal that except CHN, none of the BRICS bond indices exhibit high magnitudes of returns and volatility spillovers with EMU, USA, and JAP, indicating a limited spillover between these indices (see Table 4, panels A and B). While considering JAP as regional factor for IND and CHN, we do not find significant level of returns and volatility spillovers moving from JAP to BRICS and otherwise. Considering the case of EMU, we find that it shows the maximum amount of return and volatility spillovers with USA with the magnitude of 5.62 (return) and 5.66 (volatility) spillover followed by CHN (5.25%). USA shows strongest return spillover with CHN followed by EMU and JAP. The extent of returns and volatility spillovers of USA with these indices ranges from 6.86 to 25.16% in case of return spillover and 6.94–25.21% for volatility spillover. The JAP as a regional factor for BRICS explains the FEVD of return spillover USA (4.5%) followed by CHN (2.46%). The volatility spillover results of JAP confirm the return spillover values. On net terms, the results suggest that EMU and JAP are equally a net receiver as well as a net transmitter of returns and volatility spillovers shocks to BRICS bond indices. However, the overall net spillover results suggest that EMU and JAP are net receivers of return and volatility spillovers from all other variables. The possible explanation could be because of the composition of these indices.

Finally, we analyze the extent of total return and volatility spillovers reaches up to 33.40% and 33.20%, respectively. These values indicate that on average, the round 33% of the FEV in all sample bond indices results from returns and volatility spillovers. From the market integration perspective, the magnitudes of return and volatility spillover could be It also implies that the connectedness between BRICS and global bond indices are in evolving stage and may strengthen in future with the consistent performance of BRICS financial markets.

To summarize, it is apparent from above analysis that except IND and to some extent CHN, the magnitudes of returns spillovers are high among BRICS. As a pair, BRZ and RUS show the strongest spillover followed by SAF and RUS. However, at the individual level, we find that the bond index of SAF appears to exhibit the largest amount of return spillover followed by RUS and BRZ. IND's bond market seems to be the least integrated market among BRICS. To global and region indices, the results suggest that except China, none of BRICS indices explain a significant amount of cross-index spillover. CHN's bond market seems to be highly integrated with USA's bond market, and same is the case between USA and CHN. However, EMU appears to be moderately interconnected with SAF, IND, and CHN. JAP shows highest return spillover with USA only and report no significant amount of connectedness with BRICS. Based on the magnitude of net spillover moving from one to all variables, we find that RUS followed by SAF and CHN are the net transmitters of a shock to all variables. To have a better grip on static spillover analysis, we plot the time-varying spillover indices along with net return spillovers from one bond index to all others. The plots of total bond return and volatility spillovers indices are shown in Fig. 1. We have considered 100-week rolling window for the estimation of return and volatility spillover index. The plot ranges between 25% and 65%. Both indices clearly reveal the phases of major downturns marked by Argentinean banking crisis (2001), Brazilian Real Depreciation (2002), 10-Year US-Treasury Bill rise in 2004, Iceland currency crisis (2006), US mortgage crisis (2007–2008), Russian financial crisis (2008–2009), EMU slowdown (2009–2010) and

Table 4
Directional spillover results.

Panel A: Returns spillover

	BRZ	SAF	RUS	IND	CHN	EMU	USA	JAP	From others	Net spillover
BRZ	63.98	9.71	19.79	3.03	2.49	0.32	0.53	0.16	36	−0.8
SAF	9.07	58.79	11.82	5.94	8	3.18	3.09	0.12	41.2	5.3
RUS	19.59	11.51	63.51	1.57	3.07	0.16	0.18	0.4	36.5	3
IND	3.6	7.87	1.99	78.69	1.25	4.89	1.46	0.26	21.3	−5
CHN	2.05	7.82	3.28	0.39	53.59	5.25	25.16	2.46	46.4	5.2
EMU	0.36	4.26	0.37	4.6	7.07	73.16	7.35	2.83	26.8	−4.1
USA	0.32	4.65	1.06	0.47	26.75	5.62	56.63	4.5	43.4	1.2
JAP	0.2	0.68	1.18	0.33	3.01	3.27	6.86	84.48	15.5	−4.8
Contri. to other	35.2	46.5	39.5	16.3	51.6	22.7	44.6	10.7	267.2	
Contri. incl. own	99.2	105.3	103	95	105.2	95.8	101.3	95.2	33.40%	

Panel B: Volatility spillover

	BRZ	SAF	RUS	IND	CHN	EMU	USA	JAP	From others	Net spillover
BRZ	64.16	9.6	19.55	3.17	2.49	0.32	0.55	0.16	35.8	−0.5
SAF	9.06	59.64	11.14	6.08	7.64	3.22	3.1	0.12	40.4	5
RUS	19.58	10.9	63.91	1.71	3.08	0.17	0.21	0.42	36.1	2.2
IND	3.73	7.9	2.13	78.41	1.25	4.86	1.46	0.25	21.6	−4.9
CHN	2.03	7.47	3.07	0.39	54.02	5.26	25.21	2.56	46	5.1
EMU	0.36	4.26	0.34	4.59	7.04	73.14	7.38	2.89	26.9	−4.1
USA	0.32	4.64	1	0.47	26.6	5.66	56.73	4.58	43.3	1.6
JAP	0.22	0.64	1.11	0.32	3.04	3.34	6.94	84.39	15.6	−4.6
Contri. to other	35.3	45.4	38.3	16.7	51.1	22.8	44.9	11	265.6	
Contri. incl. own	99.5	105.1	102.2	95.1	105.2	96	101.6	95.4	33.20%	

Note: Table illustrates the estimated results of Diebold and Yilmaz (2012) model. Panel A of Table illustrates return spillover results. Panel A of Table shows volatility spillover index results. The DY model is estimated using 10-step-ahead-forecast-error variance decomposition. Contri. (contribution).

the recent phases of crude oil price decline (2004), Chinese stock market crash (2015) and Brazilian economic crisis (2016). All these events have significant impact on the movements of bond indices. Analyzing the trend of both indices, we find there is an increase in return spillover during 2007–08 and reaches its highest in 2009 and immediately dips afterward, indicating the significant bond market upheavals during the global financial crisis (2008), Russian economic upheaval and subsequent Eurozone debt crisis (2009). Post-2009 period also shows variations in the magnitude of total spillover ranges between 57% and 70%. The period could be linked to the possible impact of the unconventional monetary policy pursued by the USA and European Central Bank. During 2014–2016, the spillover index shows upward trend till 2015, and it declines afterward. The possible explanation of these variations could be attributed to oil market upheavals and recovery of the USA and other European countries. We have plotted the time-varying net spillover of sample bond indices.

To confirm the results reported by DY method (see Table 4), we also estimate the DECO-MGARCH model.

5.3. Net-pairwise spillover analysis

In this section, we discuss the rolling net pair-wise return and volatility spillovers moving from one variable to another (see Figs. 3–6). There are two important observations we make it by looking at the plotted charts. First, the magnitudes of returns and volatility spillovers are small and exhibit in some cases the possible cases of asymmetry. This is because the patterns of negative and positive values are not consistent and fluctuating asymmetrically overtime. For example, for RUS-BRZ and RUS-SAF, the figures reveal that RUS seems to be the net transmitter of return spillover shocks to BRZ and SAF. Similarly, for IND-BRZ, IND-SAF, and IND-RUS, we find that on average, IND appears to be the net transmitter of a shock to RUS and SAF whereas, for BRZ, IND is equally a net transmitter as well as the net receiver of spillover shock, indicating a possible case of asymmetry. For CHN-BRZ, CHN-SAF, CHN-RUS, and CHN-IND, the plots exhibit that CHN appears to be the net transmitter of returns and volatility spillover shocks BRZ, SAF, RUS and IND. For EMU-BRZ, EMU-SAF, EMU-RUS, EMU-IND and EMU-CHN, we find that EMU is the net transmitter return and volatility spillovers shocks to BRICS indices though RUS, IND and CHN exhibit some amount of asymmetry. Between USA and BRICS including EMU, the plots suggest that USA is the net emitter of return and volatility spillover shocks to these indices, implying that USA bond index is one of the primary drivers of the bond market returns of BRICS (see Fig. 4). The case of USA is consistent with the findings of Piljak (2013) who also reports higher comovement between USA and emerging markets. Between JAP and BRICS (see Figs. 4 and 6), the net spillover plots reveal that JAP is the net emitter of a shock to all indices of BRICS though in some cases there exists some amount of asymmetry. However, JAP is a net receiver of shock from EMU and USA. Finally, we can say that among BRICS, IND and CHN are dominant triggers of shocks and BRICS bond yields are net receivers of return and volatility spillovers shocks from USA, EMU, and JAP. However, we derive similar inference from the net pairwise return and volatility spillovers results shown in Figs. 3–6.

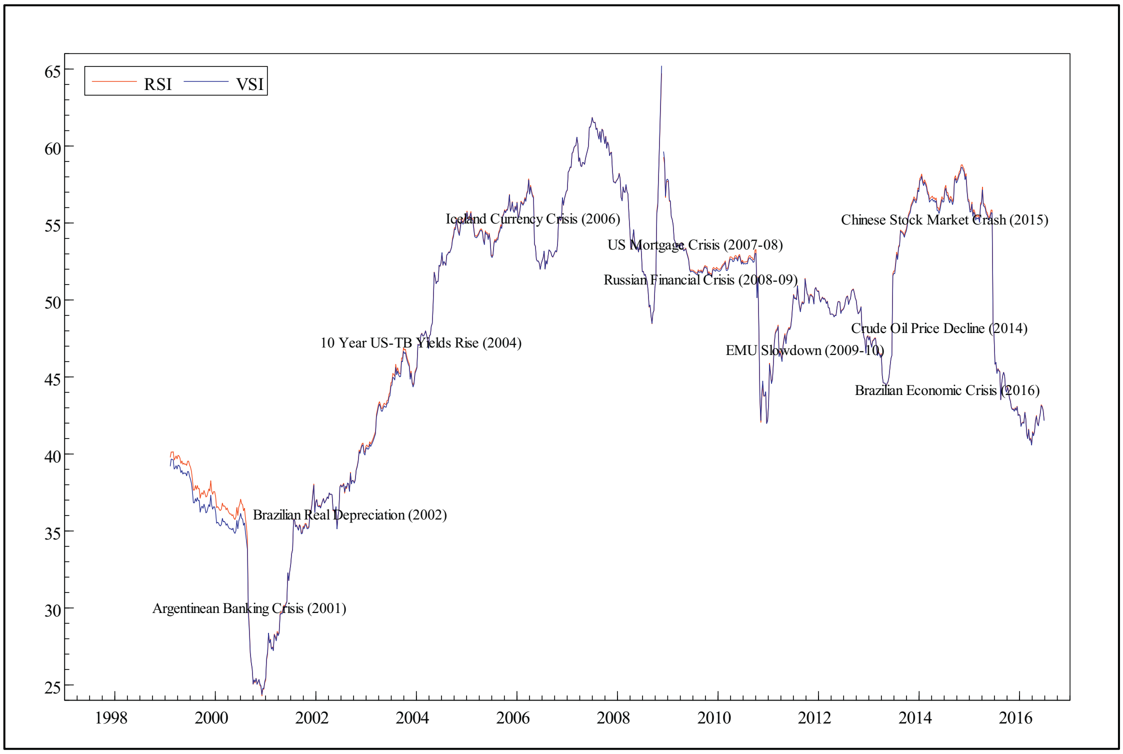

Fig. 1. Total returns and volatility spillover indices of sample bond markets. We estimate the Diebold and Yilmaz (2012) model using 100-week rolling window. RSI and VSI denote the return and volatility spillovers indices.

Fig. 7 illustrate the networks of high return spillovers among sample bond yields, particularly the ones where the magnitudes of directional spillovers are large.[9] The thick and pronounced green lines exhibit greater extent of spillover compared to thicker ones. The thinness of orange colour of each node shows the size of the sovereign bond market. For example, in our study, the JAP is the largest followed by USA and USA. Fig. 7 exhibits the return spillover for eight sample bond indices' yields. Among BRICS; IND and CHN are major transmitters of returns spillovers. The case of IND is in contrast with returns and volatility spillover results. It could be possibly due to its small market size. Overall, the triggers in return spillovers are JAP, USA, and EMU to BRICS.

5.4. DECO-MGARCH model

To substantiate the findings obtained from DY method particularly the magnitude of return and volatility spillovers, we apply the DECO-MGARCH given by Engle and Kelly (2012). Using yield data of sample bond indices, we estimate the DECO-MGARCH (1,1) model. The results are reported in Table 5 panels A and B. The panel A shows the estimated of univariate GARCH model for each series in the model. The results exhibit that both ARCH (α) and GARCH (β) terms are significant and persistent (sum of close to unity). Panel B reports the estimates of DECO model, the parameters (a) is positive and significant, indicating the persistence of shocks across sample bond indices. The coefficient (b) is also positive and significant suggesting the high persistence of volatility across sample bond yields. The sum of these coefficients validates the use of DECO-MGARCH model. The diagnostic results reported in the right side of panel A suggest the absence of serial correlations captured shown by Ljung-Box statistics for residuals and squared standardized squared residuals, validating the use of DECO-MGARCH model.

Fig. 2 displays the dynamic equicorrelation for sample bond yields. We find that the dynamic conditional correlations are able to capture the major turning points during the sample period. The major ups and downs in time-varying correlations also suggest the frequent adjustments in the bond portfolio combing the sample indices. We find that the extent of equicorrelation rises sharply during the recent financial crisis US mortgage crisis (2007–2008) and EMU slowdown (2009–2010). The extent of dynamic rise and fall in equicorrelation is in line with the total return and volatility plots shown in Fig. 1.

[9] Since there is high similarity with respect to the magnitudes of net returns and volatility spillovers, we have reported the plot of only the rolling pairwise net return spillover.

Table 5
DECO DCC results.

	Cst(μ)	AR(1)	Cst(V)	α	β	Q(10)	p-Values	Q^2(10)	p-Values
BRZ	0.178	0.028	0.103	0.270	0.749	15.135	0.127	1.196	0.999
	[0.000][a]	[0.405]	[0.019][a]	[0.000][a]	[0.000][a]				
SAF	0.225	−0.041	0.170	0.439	0.516	11.667	0.307	1.437	0.999
	[0.000][a]	[0.348]	[0.013][a]	[0.000][a]	[0.000][a]				
RUS	0.229	0.052	0.048	0.353	0.724	20.126	0.028	5.336	0.867
	[0.000][a]	[0.803]	[0.039][a]	[0.000][a]	[0.000][a]				
IND	0.163	−0.003	0.010	0.215	0.812	12.351	0.262	6.572	0.765
	[0.000][a]	[0.929]	[0.095]	[0.000][a]	[0.000][a]				
CHN	0.134	−0.099	0.058	0.175	0.700	8.036	0.625	9.040	0.528
	[0.000][a]	[0.010][a]	[0.000][a]	[0.000][a]	[0.000][a]				
EMU	0.091	−0.057	0.035	0.067	0.918	11.756	0.301	5.779	0.833
	[0.046][a]	[0.069][b]	[0.059][b]	[0.000][a]	[0.000][a]				
USA	0.009	−0.075	0.011	0.055	0.919	10.627	0.387	9.719	0.465
	[0.666]	[0.027][a]	[0.180]	[0.020][a]	[0.000][a]				
JAP	0.018	0.022	0.138	0.078	0.870	5.580	0.849	15.226	0.124
	[0.377]	[0.695]	[0.056][b]	[0.000][a]	[0.000][a]				
Panel B: DECO model results									
ρ	0.495								
	[0.037][a]								
α	0.091								
	[0.013][a]								
β	0.901								
	[0.000][a]								
Log-likelihood	−11,692.8								

Note: Table illustrates DECO DCC results. Constants μ and V are corresponding intercept terms of mean and variance equations. AR (1) is first order autoregressive term. α and β are ARCH and GARCH terms, respectively. Q-statistics is Ljung-Box test. ρ denotes the average correlation between market i and j. Values in parentheses [] are p-values.

[a] Denotes the level of significance at 5% and below.
[b] Denotes the level of significance at more than 5%.

5.5. Determinants of net pairwise directional returns and volatility spillovers

In this subsection, we analyze the determinants of directional returns and volatility spillovers. To do this, we undertake extensive search procedure of finding out the potential determinants of risk spillover. A close appraisal of existing literature suggests that return and volatility spillovers in bond markets are explained by two types of determinants viz., macroeconomic and investment sentiment. Following Csonto and Ivaschenko (2013), Piljak (2013), Poghosyan (2014), Chakrabarti and Zeaiter (2014), Dornbusch et al. (2000), Gómez-Puig et al. (2014), and Fernández-Rodríguez et al. (2015, 2016), we consider following macroeconomic determinants viz., government debt as percentage of GDP, current account balance-to-GDP, inflation and interest rates as measures of economic and policy competitiveness. For investment sentiments, we consider two proxies viz., macroeconomic environment rankings of BRICS from Global Competitiveness Report published by World Economic Forum (WEF) and stock market volatility calculated using GARCH model.[10] All variables are downloaded from Thomson Datastream. Due to the paucity of data, we consider the data estimation period as 2006Q4–2016Q2. To generate a sufficient number of observations, yearly values of sample variables are interpolated into quarterly data. Similarly, we generate quarterly observations of weekly net pairwise return and volatility spillovers by taking the three-month average of each BRICS country's data. For macroeconomic ranking variables, we keep the rank same in every quarter in a year. We construct a balanced panel data of selected variables for BRICS countries and apply fixed effect (FE) model. In addition to these variables, we have also introduced a dummy variable to capture the possible impact of global financial crisis (2008–2009) as upheavals during this period is apparently obtained by directional return and volatility spillover plots. The dummy variable takes the value of 1 during the crisis period and 0 otherwise. Table 6 shows the results.[11] We find that among macroeconomic determinants, except inflation rate; government debt, current account deficit and interest rate exhibit negative and statistically significant impact on the net pairwise directional return and volatility spillovers. About investment sentiment indicators, it appears that stock market volatility affects negatively, whereas, the macroeconomic environment variables exhibit a positive impact on net directional return and volatility spillovers of BRICS. Seemingly, the coefficient of dummy variable

[10] We have done this because of the unavailability of longer time-series data of VIX. We use Exponential GARCH model to calculate the time-varying stock market volatility.
[11] For the same of brevity, we report only the results of return spillover because volatility spillover results are same as return spillover. However, results are available upon request.

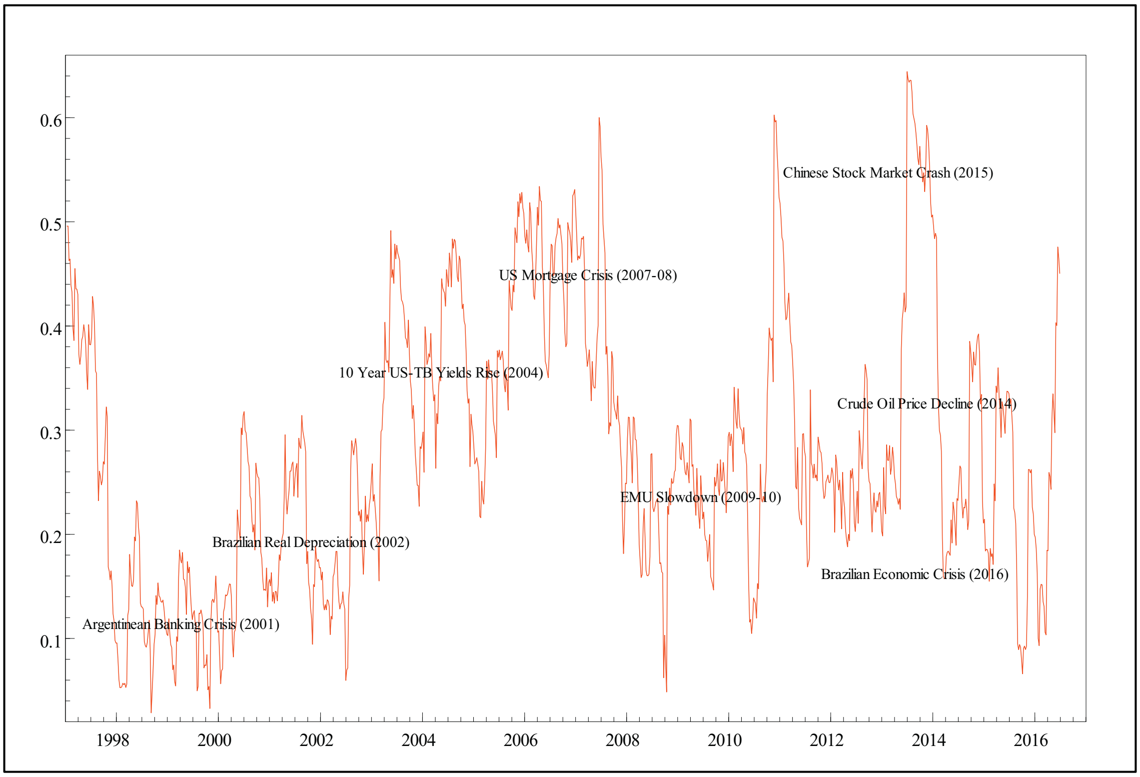

Fig. 2. Dynamic equicorrelation of sample bond markets.

also shows a negative sign, and it is statistically significant, implying that the global financial crisis (2008) had a substantial impact on the market news and the reactions of market participants. It is in line with Fernández-Rodríguez et al. (2015) who also report similar evidence in the case of EMU bond markets.

6. Conclusion and discussion

We note that in the literature, a majority of studies have examined the cross-bond-yield market spillovers in the case of developed markets mainly EMU because of their well-developed bond market. This study takes a different perspective and examines this phenomenon in the case of emerging markets viz., BRICS versus global indices. The study examines the time-varying nature of returns and volatility spillovers via directional interconnectedness method and dynamic conditional correlation modelling perspectives. The study reports that among BRICS bond market returns; South Africa followed by Russia and Brazil exhibit an active transmission of volatility shocks to others. The pairwise net spillover results suggest that Brazil-Russia and South Africa-Russia are more integrated through spillover than the rest in BRICS. However, based on the magnitudes of net returns and volatility spillovers moving from one variable to all others, we find that Russia and South Africa are strongest transmitters of shocks to all other variables in BRICS. It implies that Russia and South Africa may act as a catalyst of risk trigger during the crisis period. It appears to be intuitionally correct because of their larger bond market size. It is one of the significant findings of this study. For BRICS and global indices, we find that China and USA are highly integrated. Japan appears to be net transmitter of returns and volatility spillovers shocks to BRICS but the extent of directional returns and volatility spillover is not as strong as we find in case of USA. However, the plots of spillover results exhibit surprising results. We find that India and China appear as the net transmitter of a shock to all other in BRICS, though the magnitude is lower, indicating their presence in the global bond market. The case of India is surprising as it has smallest sovereign debt market in BRICS. It could be one of the important topics of further extension of this research. The study also finds out the possible determinants of cross-market spillover. We find that government debt, current account deficit, and interest rate exhibit negative sign for the net pairwise directional return and volatility spillovers. About investment sentiment indicators, it appears that stock market volatility affects negatively, whereas, the macroeconomic environment variables exhibit positive sign for net directional return and volatility spillovers of BRICS.

One of the striking findings of this study is that the plots of total return and volatility spillovers are able to capture the major turning points during the sample period. This is further confirmed by the plot of DECO-MGARCH model.

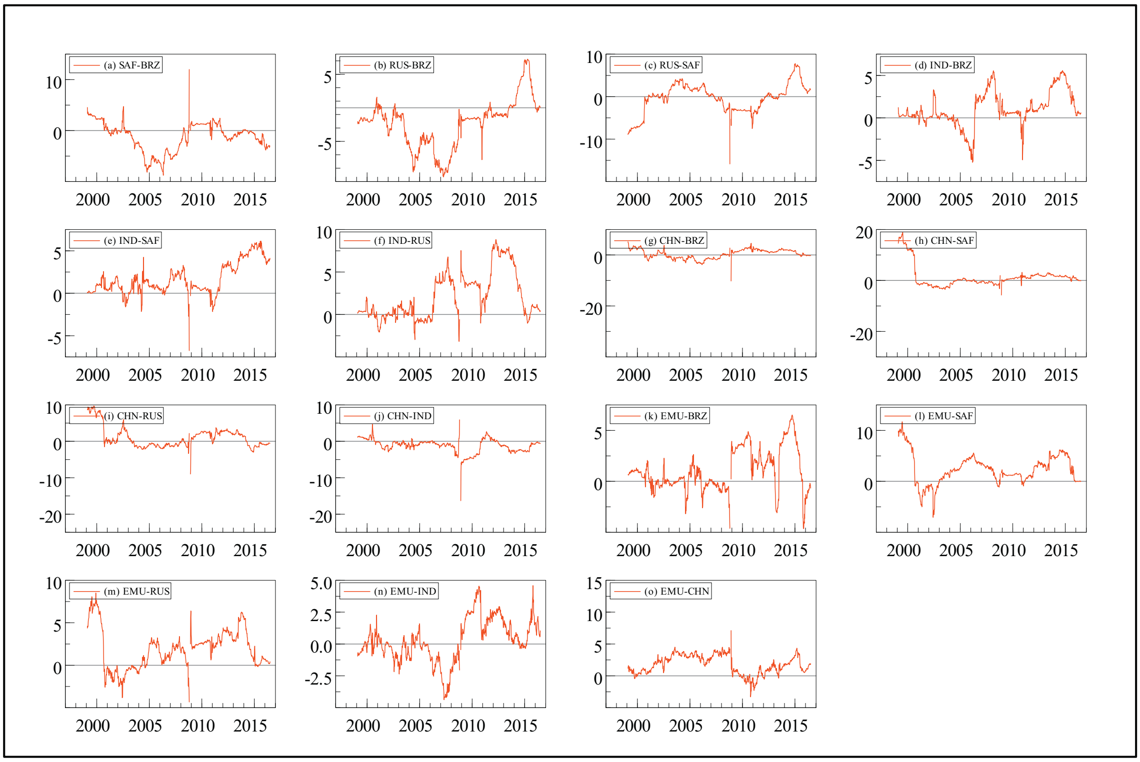

Fig. 3. Net pair-wise returns spillover is moving from one variable to another variable, 100-week rolling window.

Fig. 4. Net pair-wise returns spillover is moving from one variable to another variable, 100-week rolling window.

Fig. 5. Net pair-wise volatility spillover is moving from one variable to another variable, 100-week rolling window.

Fig. 6. Net pair-wise volatility spillover is moving from one variable to another variable, 100-week rolling window.

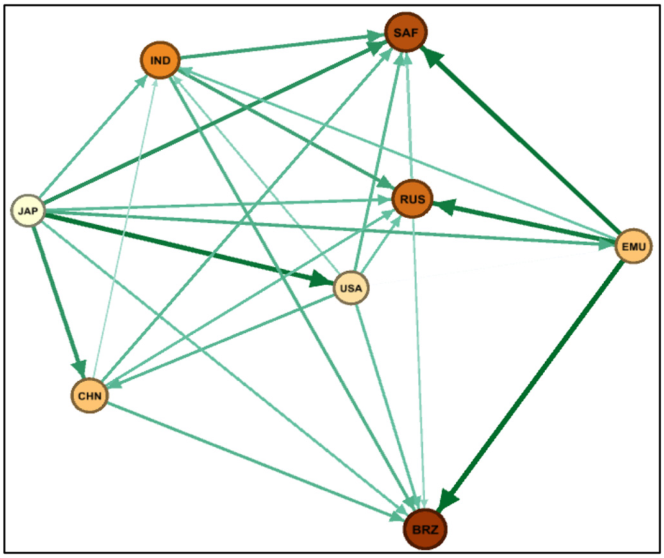

Fig. 7. Time-varying net pairwise directional return spillovers for the sample bond indices covering full sample period. Notes: The above network plot exhibits high and visible directional return spillovers between the 28 pairs of the sample bond indices' yield. The intensity of colour decides the corresponding node size of each sample market. The fade yellow to dark orange exhibit the large to small bond market size. BRZ, RUS, IND, CHN, SAF, USA, EMU and JAP stand for Brazil, Russia, India, China, South Africa, United States of America and the European Monetary Union and Japan, respectively. The thickness of green edges (thick to thin, in descending order), correspond, respectively to cases where we find a high net pairwise directional connection. An edge represents the average value of pairwise spillover over the sample period.

Table 6
Panel regression results.

	Without dummy	With dummy
Constant	3.0518 (2.72)*	2.7883 (2.54)*
		−0.6573 (−3.14)*
Macroeconomic variables		
Government debt/GDP	−0.0643 (−5.29)*	−0.0641 (−5.40)*
Current account/GDP	−0.2971 (−6.84)*	−0.2676 (−6.16)*
Inflation	0.0382 (0.93)	0.0344 (0.85)
Interest rate	−0.111 (−4.56)*	−0.0896 (−3.62)*
Proxies for investor sentiment		
Stock market volatility	−0.0104 (−3.38)*	−0.0075 (−2.40)*
Macroeconomic environment	0.5901 (1.99)*	0.5826 (2.02)*
R^2		
Within	0.3776	0.4094
Between	0.216	0.2911
Overall	0.1139	0.1557
Observations	195	195

Note: Table illustrates panel regression results of determinants of net pairwise directional return spillovers. The dependent variable is net return spillover index. The values in brackets exhibit *t*-statistics.
* Denotes the level of significance at 5% and better.

These results have important implications for policy makers and investors dealing with the U.S. and BRICS bond market investments and tracing the possible causes of risk transmission. From the asset allocation perspective, among BRICS, India, and China appear to be the most attractive market for hedging and risk minimization owing to lower magnitudes with other bond market indices. From the policymakers' perspective, the findings help to build decoupling strategies to protect to safeguard the markets against adverse risk. Another useful implication of this study can be further extended in analyzing the bilateral investment flowing mainly from USA, EMU and Japan to BRICS countries. In recent years, USA and Japan have taken extraordinary interest in facilitating various infrastructure development activities in BRICS. As a result, the sovereign debt exposure of these two countries is increasing at a high pace. For instance, Japan accounts for about one fourth of India's sovereign debt portfolio. Similarly, India's debt investment exposure to the US bond market has substantially gone up in recent years due to the strategic concerns. Therefore, this study can be further extended to examine the micro-level bond exposure of global and regional players to emerging markets.

Acknowledgements

We are thankful to the Editor and Anonymous referees for their helpful comments and suggestions. All errors and omissions are solely ours.

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