Quantile Connectedness Across Socially Responsible Equity Markets of The BRICT Nations [1]

Ogan Erkin ERKAN [2] , Habil GÖKMEN [3]

Abstract

This paper investigates the shock linkages between the socially responsible equity indices of Brazil, Russia, India, China, and Türkiye, by using the quantile connectedness approach that is used by Chatziantoniou et al. (2021), to assess the median-based and tail connectivity, we will analyse daily time series data from April 4, 2018, to March 31, 2023. The outcomes of the static and dynamic analyses can be summarized as follows: for static quantile connectedness, Russia and India are net transmitters of shock at the tails, while China is a net receiver. China and Türkiye are net receivers, whereas Brazil, India, and Russia are net transmitters at the median quantile. Considering the dynamic quantile connectedness assessment, the findings indicate that the magnitude of connectedness significantly increases positive and negative shock connectedness. This suggests that during periods of extreme market volatility, socially responsible equity indices in BRICT nations experience more pronounced shock propagation. This suggests that socially responsible investments are susceptible to contagion and, as a result, provide restricted portfolio diversification advantages during periods of extreme market volatility. The analysis also indicates that there was a substantial rise in the overall dynamic connection during the COVID-19 pandemic and the Russia-Ukraine war.
Keywords: Quantile Connectedness Approach, Socially Responsible Investments, BRICT Countries
Jel Codes: C58, D53, F65, G15

BRICT Ülkelerinin Sosyal Sorumlu Sermaye Piyasalarındaki Kantil Bağıntısı

Özet

Bu makalede, Brezilya, Rusya, Hindistan, Çin ve Türkiye'nin sosyal sorumlu sermaye endeksleri arasındaki şok bağlantılıkları incelenerek, Chatziantoniou vd. (2021) tarafından kullanılan kantil bağıntılılık yaklaşımını kullanarak ortalamada ve kuyruk bağlantılıklarını değerlendiriliyor. Veriler 4 Nisan 2018'den 31 Mart 2023'e kadar günlük zaman serilerini analiz eder. Statik ve dinamik analizin bulguları aşağıdaki şekilde sunulabilir. Statik kantil bağıntılılığı açısından kuyruk şoklarında, Rusya ve Hindistan net iletkenlerdir, Çin ise net alıcıdır. Ortalama kantilde ise Çin ve Türkiye net alıcılar, Brezilya, Hindistan ve Rusya net göndericilerdir. Dinamik kantil bağıntılılık değerlendirmesi göz önüne alındığında, bulgular, bağıntılılığın büyüklüğünün olumlu ve olumsuz şok bağıntılılığını önemli ölçüde artırdığını gösteriyor. Bu, BRICT ülkelerindeki sosyal sorumlu hisselerindeki piyasa dalgalanması dönemlerinde daha belirgin bir şok yayılmasını gösteriyor. Sosyal sorumlu yatırımların bulaşıcılığa duyarlı olabileceği ve bunun sonucunda aşırı piyasa dalgalanması dönemlerinde sınırlı portföy çeşitliliği avantajları sağlayacağına işaret ediyor. Analiz ayrıca, COVID-19 salgını ve Rusya-Ukrayna savaşı sırasında genel dinamik bağlantının önemli ölçüde arttığını gösteriyor.
Anahtar Kelimeler: Kantil Bağıntılılık Yaklaşımı, Sosyal Sorumlu Yatırımlar, BRICT Ülkeleri
Jel Kodu: C58, D53, F65, G15

1. INTRODUCTION

Over the past ten years, there has been a substantial rise in spending dedicated to socially responsible and sustainable activities, particularly in developed countries. The worldwide Sustainable Investment Alliance (GSIA) 2020 research reported that worldwide sustainable investments reached a total value of around $35.3 trillion in 2020. Although these figures provide a useful overview of market trends, they also prompt questions about the definitions and criteria used by these researchers to classify assets as "sustainable". The categories in question are vital since they directly influence what is seen as socially responsible investments. These categories also impact the strategic decisions made by shareholders in the investment community.

In the sophisticated world of finance, socially responsible investments (SRI) have become a significant influence, transforming both investment strategies and market dynamics internationally. In addition to this, the investment landscape of the developing economies of the BRICT nations—Brazil, Russia, India, China, and Türkiye has also been adopting socially responsible investments quite rapidly, based on environmental, social, and governance (ESG) principles. This study explores the relationship between socially responsible equity markets in different countries, specifically focusing on the connectedness between socially responsible investment and financial interconnectedness during the period of 2018 to 2023, amidst global economic disruptions and socio-political changes.

The ethical considerations of investors who want to achieve not just financial profits but also positive impacts on society can be accredited as the foundations of SRI (Renneboog et al., 2008). As the SRI advanced through time, the achievement of sustainable growth while also making financial rewards gained momentum, and new methods developed. Scholtens (2017) depicts this advancement as the increased tendency of investors to choose firms that demonstrate robust environmental, social, and governance (ESG) performance. Incorporating environmental, social, and governance (ESG) elements into investment choices, as emphasized by Fatemi et al. (2018), not only supports overall sustainability objectives but also provides a detailed comprehension of risk and opportunity in the unpredictable environments of developing economies. It also impacts the strategic decisions made by shareholders in the investment community.

According to Eurosif in 2021, the transition towards generating tangible impact is crucial to "fully unleashing the potential and transformative capacity of capital markets, thereby bridging the investment shortfall required to realize net-zero emissions and the Sustainable Development Goals (SDGs)". The statement highlights the vital need for capital markets to allocate financial resources for sustainable investments but also needs to ensure that these investments yield substantive, positive environmental and social outcomes. Subsequently, higher consciousness about climate change and sustainability has considerably attracted the interests of policymakers and investors. This has steered policymakers and investors towards green and environmentally sustainable investments. Thus, this has also implied that the strategic decisions made by shareholders are impacted by the considerations of sustainability and environment in the ever-changing investment space.

The SRI is likely to prosper in emerging economies because these economies are famous for their fast development and extreme approaches towards market development. Although the BRICT countries differ in their economic and regulatory landscapes, they offer a specific view to exploring cross-quantile spillovers of socially responsible equities in such a global context. The focus of this research is to reveal some aspects of these interrelated markets through the application of advanced statistical methods aimed at measuring quantile connectedness. This measure goes beyond usual correlation coefficients

and can be useful for understanding market dynamics during periods of high volatility (Baruník and Křehlík, 2018).

Brazil has established itself as a frontrunner in sustainable finance among the BRICS countries, distinguished by robust regulatory frameworks and a swiftly expanding market for green bonds (Oliveira et al., 2016). Russia is now in the first phases of development in its Scientific Research and Innovation (SRI) sector, indicating promising growth propelled by rising awareness and legislative backing (Zhou et al., 2020). India's Sustainable Development Index (SRI) indicates a robust dedication to sustainability via governmental efforts and business governance changes (Ren et al., 2020). China is the leading country in Asia when it comes to adopting sustainable and responsible investment (SRI) practices. They do this by using government interventions and market-based instruments, with a focus on innovative green finance projects (Helmers et al., 2017). Türkiye has lately joined the SRI (Socially Responsible Investment) movement and is making advancements in incorporating ESG (Environmental, Social, and Governance) factors into investment choices, indicating a significant change in the trajectory of the financial industry (Dikau and Volz, 2021).

These insights emphasize the varied terrain of sustainable finance and socially responsible investment in various nations, each with unique advantages and opportunities for improvement. Brazil distinguishes itself via its sophisticated legislative frameworks and strong green bond market, establishing a commendable benchmark. Currently, Russia and Türkiye are in the first phases of development, indicating potential for future expansion. India's thriving SRI sector highlights a firm commitment to sustainability, while China's pioneering approaches establish it as a leader in advancing sustainable practices via green finance projects.

This study asserts that the understanding of the quantile linkages of SRI markets within Brazil, Russia, India, China, and Türkiye (BRICT) could help contribute to the academic literature on sustainable finance and also serve as a decision-support tool for investors dealing with emerging market complexities. The purpose of the investigation is to scrutinize in detail the interdependencies in these markets in order to explain how strong or fragile an SRI investment could be considering fluctuations in the world economy and political relations.

2. LITERATURE REVIEW

The growing prominence of socially responsible investing has led to a surge of research interest in the dynamics of socially responsible equity markets, particularly in the emerging economies of the BRICT nations: Brazil, Russia, India, China, and Türkiye. These countries have witnessed a rapid expansion of socially conscious investment instruments, reflecting the increase in demand for sustainable and ethical investment opportunities (Benlemlih and Bitar, 2018; Smolo et al., 2022).

According to Scholtens (2017), an ever-increasing focus on ethics among investors is a major sign of the evolving significance of socially responsible investment (SRI). Similarly, the work performed by Fatemi et al. (2018) studies the extent to which SRI affects performance in developing countries. In fact, their findings reveal that ethical investment decisions are not free from financial results. According to Renneboog et al. (2008) research, they examine the most important determinants of investing behaviour in developing countries, especially in the BRICS nations. They distinguish several factors, such as ethical, social, and financial principles, that play a role in influencing SRI.

The availability of credit and investment flows in Brazil has been impacted by global economic circumstances, which have had an effect on the country's investment environment (Mazzucato and Penna, 2016). The significance of green finance and innovation in tackling environmental concerns and

attaining sustainable development objectives is paramount, particularly in developing countries like Brazil (Behera et al., 2023). In Brazil, there is a growing movement towards adopting ESG norms, which aligns with the worldwide trend of responsible investing. This trend involves incorporating ESG factors into the decision-making processes of investments.

Russia's involvement in SRI is slowly changing, indicating a move towards incorporating ESG factors into investment choices. ESG practices are becoming more popular in Russia, as enterprises are adopting ESG norms to improve their reputation and appeal to investors (Nezhnikova, 2023). Izmailova (2023) emphasizes the growing significance of ESG concepts in Russia, driven by legal changes and social shifts towards sustainability. Both Nezhnikova (2023) and Izmailova (2023) delves into the difficulties and advantages of ESG investments in Russia, highlighting the crucial need for institutional support in developing a strong SRI framework. Although the country is currently in the early stages of adopting ESG practices, the government is actively encouraging and promoting ESG investing by providing subsidies and benefits to companies with high ESG ratings, which has led to an increasing awareness of the importance of considering ESG factors in investment strategies (Finogenova et al., 2022). Hence, this government support emphasizes a dedication to creating a favourable environment for the integration of ESG factors inside the Russian market.

The market dynamics of India's socially responsible investment sector are closely connected to the government's sustainability policies and the private sector's involvement in Environmental, Social, and Governance (ESG) principles. Gupta (2022) examines India's regulatory landscape, providing insight into the structure that governs sustainable investments. Raut et al. (2020) analyse the performance of ESG funds in India, emphasizing the increasing interest of investors in this area. In their study, Dutta and Paul (2023) investigate the incorporation of ESG elements into corporate performance in India. They highlight the significance of matching sustainability practices with economic results. Therefore, these studies jointly emphasize the important impact that ESG principles have in influencing investing practices, while also offering a complete perspective on the changing environment of sustainable investments in India.

Studies demonstrate that companies incorporate green finance and ESG criteria into their strategy and financial performance, supporting China's rising prominence in SRI and ESG investing. According to Wang et al. (2022), ESG disclosure serves as an incentive for enterprises to actively engage in the practice of disclosing their ESG information. This practice is driven by the desire for the long-term success of corporations and aims to enhance sustainable development through ESG disclosure. This shows that ESG considerations are becoming a major investment opportunity that affects financial decision-making in China. It should be noted that although ESG disclosure and sustainable business development are still maturing, knowledge of ESG's benefits for corporate performance is growing. Deng and Xiang (2019) study how ESG indices affect stock market performance and emphasize the importance of ESG principles for Chinese enterprises' long-term success. These results demonstrate that China's purposeful promotion of green financing and sustainable enterprises improves financial success through ESG aspects. This helps China adopt prudent investment methods.

Türkiye's growing interest in SRI can be depicted by Ateş et al. (2022), which shows an indication of a growing interest in sustainable investing in the country. Global SRI trends show a progressive adoption of norms since the creation of strong links between sustainable equity investments and financial markets. Kalash (2021) emphasizes the importance of environmental considerations in financial decision-making and investigates the impact of environmental performance on the capital structure and financial performance of Turkish listed firms. Another study by Kamaşak (2017) delves into the

contribution of tangible and intangible resources to firm profitability and market performance, where the study indicates that the importance of intangible resources and competencies to a company's performance outweighed that of tangible resources for Turkish firms. These offer practical implications for decision-makers navigating the competitive investment landscape of Türkiye.

The establishment of these socially responsible equity indexes in the BRICT countries demonstrates the increasing acknowledgment of the significance of incorporating sustainability factors into investment decision-making. It is crucial to comprehend the interconnection between socially responsible equity sectors in these maturing markets as they become increasingly linked with the global financial system.

Examining the connectedness of these markets is crucial, as shocks and volatility can transmit across borders, posing risks and opportunities for investors and policymakers alike (Baruník and Kley, 2019; Diebold and Yılmaz, 2012). To determine the strength of connections between financial markets, correlation-based metrics have long been used. However, these conventional approaches may fail to capture the asymmetric nature of such spillovers, particularly during periods of market stress (Magkonis and Tsopanakis, 2019).

The distinctive study by Diebold and Yılmaz (2014) lays the groundwork for understanding how financial markets are interconnected and offers an important tool to analyse the complex dynamics of quantile connectivity between them. Ando et al. (2018) and Chatziantoniou et al. (2021) further extend this methodology on the quantile connectedness approach to analyse the processes by which quantiles are propagated, enabling a more detailed description of extreme market behaviours. By examining the quantile connectedness, researchers can uncover asymmetric linkages between socially responsible equity markets, potentially revealing important insights for portfolio diversification and risk management strategies (Baruník and Kley, 2019; Diebold and Yılmaz, 2014). Thus, Diebold and Yılmaz's novel approach sheds light on the dependencies in market tail risk that are neglected by average-based measures, making it a necessary analytical assessment for this research on quantile connectedness across socially responsible equity markets of the BRICT nations.

The application of the quantile connectedness framework to the socially responsible equity markets of the BRICT nations is particularly intriguing, as these countries have exhibited varying degrees of economic development, institutional frameworks, and sustainability-related policies (Benlemlih and Bitar, 2018). Understanding the nature and extent of connectedness across these markets can provide valuable insights for investors and policymakers seeking to navigate the complex landscape of sustainable finance.

3. METHODOLOGICAL STEPS

In order to examine the level of interdependence between the socially responsible equity markets of the BRICT nations, we used the Quantile Vector Autoregression (QVAR) model on the return data of these markets. Our estimate strategy involves using the QVAR approach to measure the static and dynamic connectivity of returns in the BRICT Socially Responsible equities markets. The specific methods used to calculate the estimates are provided and analysed in the next sections.

3.1. A Quantile VAR Model

This research utilizes the quantile connectedness approach introduced by Chatziantoniou et al. (2021) to examine the transfer mechanism based on quantiles in the socially responsible stock markets of BRICT nations. The quantile connection approach used in this study is mostly derived from the research conducted by Diebold and Yılmaz (2012, 2014). The authors used a generalized Vector Autoregression

(VAR) framework and a rolling-window dynamic analysis as the foundation for their approach. The connection principle relies on the second moment of the VAR model, namely the breakdown of the variance of prediction errors. The manner in which structural disruptions within a network impact the volatility of individual constituent variables becomes apparent in this decomposition. In essence, significant co-movements among the variables of the network are represented by high values of total connectedness. Moreover, substantial interconnections may indicate the occurrence of contagion between variables, a phenomenon that can be identified using directional connectedness metrics.

Recent empirical research has enhanced and refined these connection measures by including more intricate ones, such as time-varying parameter vector autoregressive (TVP-VAR) connectedness metrics. The approaches proposed by Antonakakis et al. (2020) may address some issues encountered in traditional rolling-window dynamic research. The quantile connectedness approach, an enhanced version of the original concept proposed by Chatziantoniou et al. (2021), examines structural events at both high quantiles (indicating extremely positive outcomes) and low quantiles (indicating very negative outcomes). This study seeks to ascertain if the degree of correlation between variables depends on the size of the impact and whether the impact is positive or negative.

In order to calculate all connectivity metrics, the first step is to estimate a quantile vector autoregression, QVAR(p), which is organized in the following manner:

$$\boldsymbol{x}_t = \boldsymbol{\mu}(\tau) + \boldsymbol{\Phi}_1(\tau)\boldsymbol{x}_{t-1} + \boldsymbol{\Phi}_2(\tau)\boldsymbol{x}_{t-2} + \cdots + \boldsymbol{\Phi}_p(\tau)\boldsymbol{x}_{t-p} + \boldsymbol{u}_t(\tau) \tag{1}$$

In the model we are discussing, $\boldsymbol{x}_t$ and $\boldsymbol{x}_{t-i}$, where i=1, ..., p, represent vectors of endogenous variables with a dimension of N×1. Here, τ falls within the interval [0,1] and denotes the quantile under consideration. The term p indicates the lag length pertinent to the QVAR model. Moreover, $\boldsymbol{\mu}(\tau)$ is an N×1 dimensional vector signifying the conditional mean. The $\boldsymbol{\Phi}_j(\tau)$ is an N×N dimensional matrix associated with the QVAR coefficients, while $\boldsymbol{u}_t(\tau)$ represents the $N×1$ dimensional error vector, accompanied by an N×N dimensional error variance-covariance matrix, $\boldsymbol{\Sigma}(\tau)$. To convert the QVAR(p) model into its quantile vector moving average (QVMA (∞)) format, we employ Wold's theorem:

In the model under consideration, $\boldsymbol{x}_t$ and $\boldsymbol{x}_{t-i}$, where i=1, ..., p, are vectors of endogenous variables having a size of N×1. Here, τ is a value between 0 and 1 that represents the specific quantile being considered. The variable p represents the lag duration that is relevant to the QVAR model. Furthermore, $\boldsymbol{\mu}(\tau)$ is a vector of dimensions N×1 that represents the conditional mean. The $\boldsymbol{\Phi}_j(\tau)$ is a matrix with dimensions N×N that is linked to the QVAR coefficients. $\boldsymbol{u}_t(\tau)$ is a vector with dimensions $N×1$ that represents the error, together with an error variance-covariance matrix $\boldsymbol{\Sigma}(\tau)$ with dimensions N×N. In order to transform the QVAR(p) model into its quantile vector moving average (QVMA (∞)) format, the Wold's theorem can be used as follows:

$$\boldsymbol{x}_t = \boldsymbol{\mu}(\tau) + \sum_{j=1}^{p} \boldsymbol{\Phi}_j(\tau)\boldsymbol{x}_{t-j} + \boldsymbol{u}_t(\tau) = \boldsymbol{\mu}(\tau) + \sum_{i=0}^{\infty} \boldsymbol{\Psi}_i(\tau)\boldsymbol{u}_{t-i} \tag{2}$$

Subsequently, generalized forecast error variance decomposition (GFEVD) is calculated, which is a key element of the connectivity technique described in the studies of Koop et al. (1996), Pesaran and Shin (1998), and Chatziantoniou et al. (2021). The Generalised Forecast Error Variance Decomposition (GFEVD) is a metric used to quantify the impact of a shock in one series (j) on another series (i), purposefully in relation to its contribution to the variance of prediction errors. The notion is expressed as follows:

$$\theta_{ij}(H) = \frac{(\boldsymbol{\Sigma}(\tau))_{jj}^{-1} \sum_{h=0}^{H} ((\boldsymbol{\Psi}_h(\tau)\boldsymbol{\Sigma}(\tau))_{ij})^2}{\sum_{h=0}^{H}(\boldsymbol{\Psi}_h(\tau)\Sigma(\tau)\boldsymbol{\Psi}'_h(\tau))_{ii}} \tag{3}$$

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{k=1}^{N} \theta_{ij}(H)} \tag{4}$$

Next, a process of normalizing each member of the variance decomposition matrix is performed in the above expression. Moving forward, according to Diebold and Yılmaz (2014), the following are some connectedness expressions to measure connectedness based on GFEVD:

$$TO_i(H) = \sum_{i=1,i\neq j}^{N} \tilde{\theta}_{ij}(H) \tag{5}$$

The above variable *TOᵢ(H)* indicates the overall level of connectedness between variable *i* and other influencing components. It measures how much a shock in variable *i* spreads to all other variables in the system.

$$FROM_i(H) = \sum_{i=1,i\neq j}^{N} \tilde{\theta}_{ij}(H) \tag{6}$$

The above variable *FROMᵢ(H)* measures the overall impact of external factors on variable *i*, indicating how much variable *i* is affected by shocks from all other variables in the network.

$$NET(H) = TO_i(H) - FROM_i(H) \tag{7}$$

The above variable *NETᵢ(H)* indicates the difference between the two measures, with a positive value indicating that variable *i* is seen as a net transmitter of shocks to the system, and a negative value indicating that variable *i* is a net receiver of shocks from other markets.

$$TCI(H) = N^{-1} \sum_{i=1}^{N} TO_i(H) = N^{-1} \sum_{i=1}^{N} FROM_i(H) \tag{8}$$

The above variable *TCI(H)* represents the total connectedness index, which designates the level of interconnectedness in the network, a higher the value, greater the market risk, and conversely, a lower value suggests lesser risk.

The net pairwise directional connectedness is represented as *NPDCᵢⱼ(H)*. If the value is less than zero, it means that series *i* has a less influence on series *j*, whereas a positive value indicates the opposite.

$$NPDC_i(H) = \tilde{\theta}_{ij}(H) - \tilde{\theta}_{ji}(H) \tag{9}$$

4. DATA

The socially responsible equity indexes of each BRICT nation were used in this study. All the indexes were developed to monitor organizations with the greatest level of social responsibility, which includes performance elements including environmental, social and governance, and sustainability. The daily returns of equity indexes, including five emerging markets used, that are plotted in Figure 1: Brazil, Russia, India, China, and Türkiye. The Socially Responsible Indexes include the BOVESPA Corporate Sustainability Index (ISE), MOEX - RSPP Responsibility and Transparency Index, S&P BSE 100 ESG (SPBSEESG), SSE Social Responsibility Index (SSESRI), and BIST Sustainability Index (XUSRD). Utilizing daily returns provides a comprehensive dataset that is crucial for obtaining precise estimations of the models used in this investigation. The duration of our research spans from April 4th, 2018 to March 31st, 2023, resulting in a total of 1307 daily observations. Studying this period is crucial due to the remarkable increase of socially responsible investments in recent decades, accompanied by exceptional changes in volatility induced by major global events like the COVID-19 epidemic and the Russia-Ukraine conflict. The data used in this article is obtained from the investing.com and moex.com websites, which are open source. The daily closing prices of the indexes were converted into returns (r_t) by calculating the first difference of the natural logarithm of each index. The formula used to calculate this is $r_t = \ln (P_t / P_{t-1}) \times 100$, where P represents the stock price index at time t and t-1.

Figure 1 illustrates the return plots of the socially responsible indices for each country. Major world events like the COVID-19 pandemic and the Russia-Ukraine crisis are showing some shocks in returns, as can be seen from the plots. Given that all the skewness coefficients are negative, the return series exhibits a high left-tail distribution. Since all the excess kurtosis coefficients are greater than 3, it is implied that each return series is leptokurtic, or heavy tailed. There is no normal distribution for all equity return series, according to the Jarque Bera (JB) test. The ERS unit root test reveals the stationarity of every equity return series. No autocorrelations were detected in the log-returns and squared log-returns. Table 2 demonstrates that the correlation coefficients among the equity return series of the BRICT countries exhibit a positive relationship. The findings were statistically positive; however, the correlations were modest across all socially responsible equity indices. The modest correlations provided further justification for our interest in examining potential measures of the interconnectedness among the socially responsible equity indices of BRICT countries.
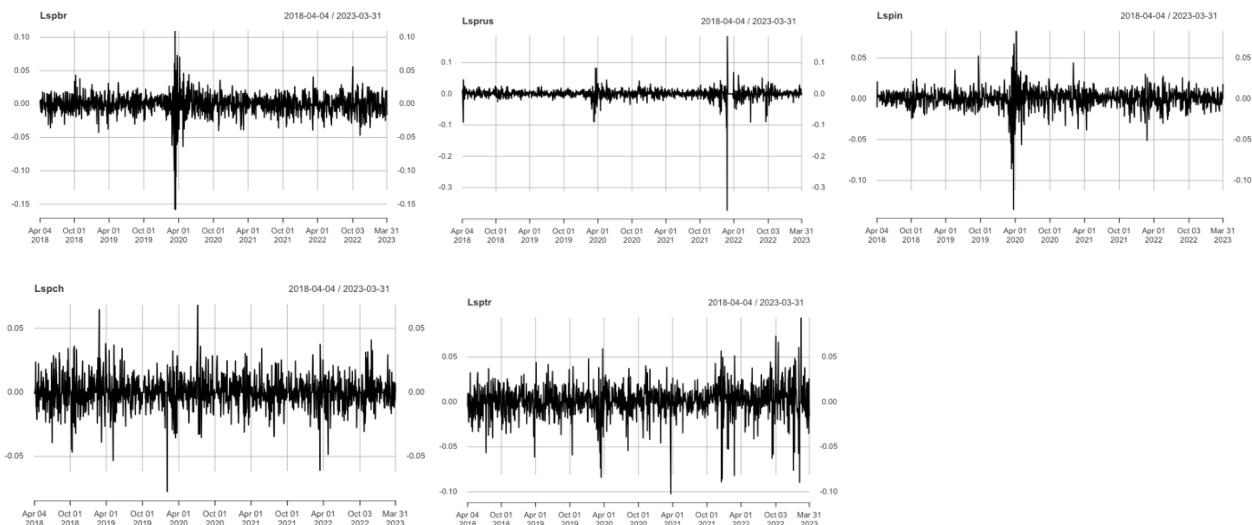
Figure 1. Return Plots

Table 1. Descriptive Statistics

	Mean	Variance	Skewness	Ex.Kurtosis	JB	ERS	Q(20)	Q2(20)
Brazil	0	0.000***	-1.495***	17.281***	16749.531***	-14.772***	67.616***	1438.396***
Russia	0	0.000***	-6.251***	141.701***	1101984.684***	-14.696***	38.476***	73.323***
India	0	0.000***	-1.471***	19.685***	21574.717***	-6.019***	53.496***	644.071***
China	0	0.000***	-0.098	3.686***	741.802***	-16.485***	14.785	42.858***
Türkiye	0.001**	0.000***	-0.753***	5.227***	1611.469***	-12.051***	13.447	108.317***

Table 2. Correlation coefficients between the return series

	Brazil	Russia	India	China	Türkiye
Brazil	1***				
Russia	0.121***	1***			
India	0.086***	0.178***	1***		
China	0.016	0.122***	0.138***	1***	
Türkiye	0.075***	0.154***	0.183***	0.076***	1***

(** $p < .05$, *** $p < .01$)

5. EMPIRICAL RESULTS

This section provides and examines the estimates derived from the return series using the given quantile VAR model (Equation 2). The section presents the findings of the static and dynamic connectedness of the BRICT socially responsible equity markets. An analysis of the extreme tail connectivity and spillover using a 25-step prediction horizon has been conducted. The lag is used as 1 based on the Akaike Information Criterion (AIC). A rolling window of 200 days was used. The empirical findings are categorized into two sections. The first section examines the fixed interconnection and transmission of effects, while the subsequent section concentrates on the dynamic interconnection and overall directional transmission of effects among the markets.

The model mentioned earlier offers connectivity measurements, such as the TCI (Equation 8), which ranges from 0 to 100, the "TO" and "FROM" directional spillovers (Equation 5 and Equation 6), and the net directional spillovers "NET" (Equation 7). Hence, the level of connectivity between the median ($\tau = 0.50$), lower ($\tau = 0.25$), and higher ($\tau = 0.75$) quantiles for a structure spanning socially responsible equity indices from Brazil, Russia, India, China, and Türkiye is explicitly defined in this study. The discussion will focus on the substantial spillover connection between the extremes and the median tile.

## 5.1. Connectedness at the Median (τ =0.5)

The mean interconnection between the socially responsible equity indices of the BRICT countries can be computed, irrespective of a time-varying perspective. The average connectedness among the equity indices, together with the TO, FROM, and NET spillovers between the variables, is displayed in Table 3 below at the median quantile (τ = 0.5). The occurrence of overflow across parameter pairs can be observed in the off-diagonal values.

Table 3. Connectedness of Socially Responsible Equity Index Returns Assessed at Median Quantile

τ = 0.5	Brazil	Russia	India	China	Türkiye	FROM
Brazil	82.47	5.28	6.39	1.65	4.21	17.53
Russia	6.01	75.3	8.42	1.94	8.33	24.7
India	6.55	8.69	73.28	4.08	7.41	26.72
China	2.65	2.77	4.92	87.37	2.29	12.63
Türkiye	4.19	8.69	7.69	1.86	77.57	22.43
TO	19.39	25.43	27.42	9.53	22.24	104.01
Inc.Own	101.86	100.73	100.7	96.9	99.81	TCI
NET	1.86	0.73	0.7	-3.1	-0.19	20.80

Evidently, a considerable yet negligible fraction of the spillovers originate FROM or TO indexes of other nations. In contrast, substantial portions of the volatility spillover stem from the variance of the nation's own socially responsible index itself, which exceeds 73% to 87%. This implies, the socially responsible indexes have a consistent value and are less likely to be affected by unexpected events in the market, under average market conditions. In Brazil's instance, it transmits 6.01% of market shocks to Russia, 6.55% to India, 2.65% to China, and 4.19% to Türkiye. This means that the Brazilian Equity index transmitted a total of 19.39% of spillovers to the other four indexes in the network. Brazil conveys 82.47% of its own variance share of volatility spillovers. The Brazilian equity index was subjected to 5.28 percent volatility shocks from the Russian index, 6.39 percent from the Indian index, 1.65 percent from the Chinese index, and 4.21 percent from the Turkish index. In total, the Brazilian equity index received 17.53 percent of its shock variations from the other four indexes. While BOVESPA Corporate Sustainability Index (ISE), MOEX - RSPP Responsibility and Transparency Index, and S&P BSE 100 ESG (SPBSEESG) indices demonstrate as net shock transmitters, the SSE Social Responsibility Index (SSESRI), and BIST Sustainability Index (XUSRD) appear as net shock receivers. In contrast, the Brazilian index surpassed transmitting net shocks with 1.86%, while the Chinese index was the most potent at receiving net shocks with 3.1%.

Figure 2. Network plot of net pairwise directional connectedness at the median quantile
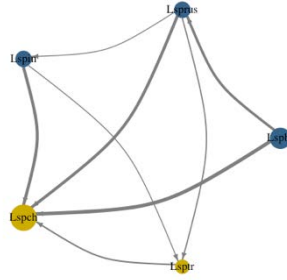
At average market conditions, the net pairwise directional connectedness shows how the chosen indices' pairwise spillover shock transitions are oriented and how strong they are. The network plot for averaged spillovers in terms of returns is shown in Figure 2. The blue nodes represent the stock market as a net transmitter, while the yellow nodes represent the stock market as a net shock receiver. The size of each node in these circumstances corresponds to the market's strength within the network, whether it is transmitting or receiving information. From which, it can be clearly seen that the Chinese index is a moderate net receiver of shocks, together with the Turkish index, which is a low net receiver of shocks, while the rest of the nodes are moderate net transmitters of shocks.

The Total Connectedness Index (TCI) is 20.80% at the median quantile ($\tau = 0.50$), indicating that only 20% of the fluctuations in the system variables can be attributed to their interconnectedness. The TCI is a metric that measures the degree of interconnectivity within the entire network. To assess the degree of activity in this measure of connectedness, one may analyse the varying level of connectedness over time using figure 3. The observable interdependence of the factors clearly indicates the influence of the COVID-19 outbreak and the Russia-Ukraine hostilities, which are evident and significant. Time-varying total connectedness is a useful tool for successful portfolio management, as shown by many studies (Agyei et al., 2022; Aharon et al., 2021; Malik and Umar, 2024; Umar and Bossman, 2023) in the literature. The findings indicate that the TCI has significant fluctuations, ranging from 15% to 60%, in terms of returns. These fluctuations reach their highest levels throughout various noteworthy event periods.

Figure 3. Total connectedness over time at the median quantile
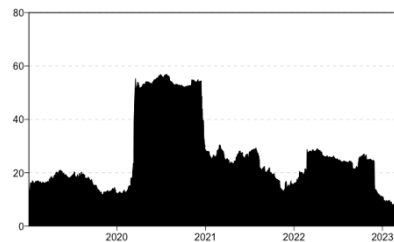
5.2. Connectedness at the Lower ($\tau = 0.25$) and Upper Quantiles ($\tau = 0.75$)

This section delves further into the detailed interconnectedness of the socially responsible equity indices of BRICT countries through a comparative analysis of the connectedness dynamics at the median quantile and across the extreme tails (at $\tau = 0.25$ and $\tau = 0.75$). In the same manner as the median quantile, the averaged and dynamic connectedness for the lower and upper quantiles is presented to accomplish the above.

Table 4 displays the average level of interconnectedness between a bear market or market downturn situation and severe negative shocks. Similarly, Table 5 displays a bull market, which refers to a period of significant growth in the market characterized by positive shocks and favourable conditions. In order to effectively manage high risks, it is essential to differentiate between different types of shocks. Further elucidating the intensity of the connectedness, the own variance portion of spillovers for each index ranges between 54 and 68% in the lower and upper quantiles. At the lower quantiles, the net transmitters of shocks, which are Brazilian (2%), Russian (3%), and Indian (1.54%), and the net receivers of shocks, which are Chinese (6.36%), and Turkish (0.17%), are showing similarities with the median quantile. Whereas at the upper quantile, the Brazilian index becomes a net receiver of shocks with 0.02%, while the Turkish index becomes a net transmitter of shocks with 0.69%.

Table 4. Connectedness of Socially Responsible Equity Index Returns Assessed at Lower Quantiles

τ = 0.25	Brazil	Russia	India	China	Türkiye	FROM
Brazil	65.31	10.15	11.22	5.05	8.26	34.69
Russia	9.7	60.48	11.61	6.2	12.01	39.52
India	11.94	12.24	56.04	8.74	11.03	43.96
China	6.68	8.11	10.63	67.85	6.73	32.15
Türkiye	8.37	12.01	12.03	5.8	61.79	38.21
TO	36.69	42.52	45.5	25.79	38.04	188.54
Inc.Own	102	103	101.54	93.64	99.83	TCI
NET	2	3	1.54	-6.36	-0.17	37.71

Table 5. Connectedness of Socially Responsible Equity Index Returns Assessed at Upper Quantiles

τ = 0.75	Brazil	Russia	India	China	Türkiye	FROM
Brazil	61.71	10.48	12.22	5.94	9.65	38.29
Russia	10.41	57.68	12.89	6.36	12.66	42.32
India	11.24	12.73	54.28	9.38	12.38	45.72
China	7.36	7.97	11.59	65.38	7.7	34.62
Türkiye	9.26	12.97	13.23	6.23	58.31	41.69
TO	38.27	44.15	49.93	27.91	42.38	202.64

| Inc.Own | 99.98 | 101.83 | 104.21 | 93.29 | 100.69 | TCI |
| NET | -0.02 | 1.83 | 4.21 | -6.71 | 0.69 | 40.53 |

The Total Connectedness Index (TCI) is 37.71% at the lower quantile (τ = 0.25), while the TCI is 40.53% at the upper quantile (τ = 0.75). It is evident that the Tail Conditional Independence (TCI) increases by about double on the extreme quantiles. The findings suggest that irrespective of the tail's sign (positive, upper quantile or negative, lower quantile), the mean connectedness values exceed the connectedness value in the median quantile, as supported by the increasing evidence of extreme tail connectedness in the literature (Anyikwa and Phiri, 2023; Malik and Umar, 2024; Umar and Bossman, 2023; Bouri et al., 2021; Ghosh et al., 2023). The research reveals that the level of interconnectedness differs within quantiles, suggesting the presence of asymmetric behaviour for the indices.

On Figure 4 and Figure 5, a network plot of net pairwise directional connectedness is given for each extreme quantile. At the lower quantile (τ = 0.25), it can be seen that the Chinese index is a moderate net receiver of shocks, together with the Turkish index, which is low net receiver of shocks, while the rest of the nodes are moderate net transmitters of shocks. At the upper quantile (τ = 0.75), Chinese index is still a moderate net receiver of shocks, but the Brazilian index has become a low net receiver of shocks while the Turkish index becomes a net transmitter of shocks with a small node.

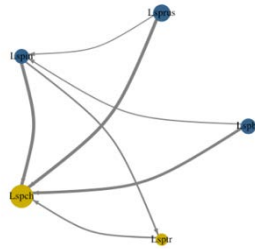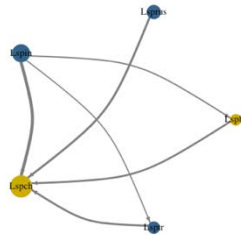**Figure 4.** Total connectedness over time at the lower quantile (τ = 0.25)

Figure 5. Total connectedness over time at the upper quantile (τ = 0.75)

Time-varying Connectedness through different quantiles is displayed in Figures 6 and 7. There are several peaks in extraordinary incident periods. Those periods exhibit similarities on different quantiles. During those extreme periods of time, namely the COVID-19 outbreak and the Russia-Ukraine hostilities, connectedness peaks at over 65%. The dynamics of connectedness across the lower and upper quantiles fluctuate by 30% and 70% magnitude brackets, respectively, and within a relatively narrow constraint, in contrast to the dynamics of connectedness at the median quantile (τ = 0.50), which varied from 15% to 60%. Aside from the moments of significant event shocks, the connection between the indexes

remains consistent and may even show a little decline under typical market circumstances. Cross-market connection escalation is visible during extreme event shocks, as Malik and Umar (2019; 2024) and Umar et al. (2021) suggest. However, there is a slight decrease in total connectedness, as Malik and Umar's (2024) paper displays similarity across time. This is also apparent at the lower and upper quantiles. Furthermore, Figure 6 and Figure 7 provide evidence supporting the presence of asymmetric quantile connectedness, which indicates a higher level of interconnectedness across markets at the higher quantiles compared to the lower quantiles.

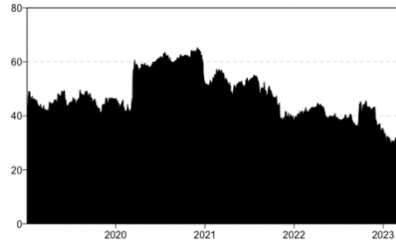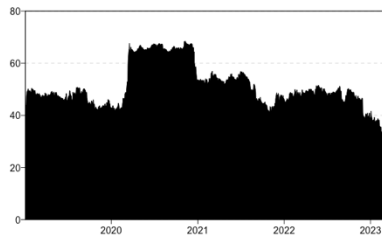**Figure 6.** Total connectedness over time at the lower quantile ($\tau = 0.25$)

Figure 7. Total connectedness over time at the upper quantile ($\tau = 0.75$)

6. CONCLUSION

Based on empirical evidence and intuitive reasoning, it can be inferred that periods of extreme events generate greater cross-market interdependence than average periods. This research employs a quantile-based connectedness approach to examine the complex interconnectedness of socially responsible equity indices in emerging nations. The dataset includes daily returns data for the BRICT nations (Brazil, Russia, India, China, and Türkiye) from April 4, 2018, to March 31, 2023. The objective of this article is to investigate the interdependence structure of the socially responsible equity indexes in the BRICT countries. This is accomplished by the evaluation of connectedness measures at the upper, median, and lower quantiles of the conditional distribution. An asymmetric response to extreme market conditions is indicated by the fact that connectedness is greater at the lower and upper ends in comparison to the median. The presence of asymmetric behaviour implies evidence of tail risk propagation. This suggests that under different market scenarios, investors should contemplate alternative investing approaches. Additionally, it has been determined that BRICT equity markets function as both transmitters and receivers of systemic risk at various quantiles.

These findings demonstrate congruence with contemporary literature. According to Yaya et al. (2024), between the five African countries stock markets' connectedness, stocks became less interconnected on the median quantile, whereas on the upper and lower quantiles, stocks exhibited asymmetrical spillovers. On extreme market fluctuations, Malik and Umar (2024) implied similar results for the oil price shocks connectedness with socially responsible equities of various countries, where strong spillovers are persistent in both tails. Similarly, Anyikwa and Phiri (2023) on the extreme market

conditions found asymmetric behaviour in both tails of BRICS countries, which indicates that in the developing countries, asymmetric behaviour could be persistent as the results are parallel to our findings. Even though Chinese socially responsible equities are net receivers of shocks, which shows alignment with the results of Anyikwa and Phiri (2023), on the contrary to their results, our findings suggest that Russian socially responsible equities became a net transmitter on all quantiles, whereas Brazilian socially responsible equities switched between transmitter and receiver at different quantiles. This indicates that there are some interconnectedness differences between conventional and socially responsible equities.

Policymakers and financial market participants interested in investing in BRICT nations should take note of the substantial ramifications of the findings. The findings suggest that socially responsible investments in BRICT nations are susceptible to contagion and hence provide limited advantages in diversifying investment portfolios during periods of significant market fluctuations. Thus, considering socially responsible investments in BRIC countries, investors, traders, and portfolio managers can utilize the findings to diversify their holdings in anticipation of significant market fluctuations. Although the quantile connectedness model enables the identification of spillover effects between markets across different market conditions, relying solely on daily data may not provide a comprehensive representation of the markets' behaviour over longer time periods. Potential future research can consider expanding the time span of the study, as five years could be seen as a limitation. Moreover, as the findings suggest, differences between conventional and socially responsible equities can be explored further in future research.

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