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Is the Fear Index Still Frightening for the New Members of BRICS? A Study on the Stock Markets and VIX Relationship

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Abstract

The phenomenon of globalization continues to increase the integration of stock markets over time. While this integration complicates effective portfolio diversification, it also amplifies volatility spillovers during periods of financial depression. Such spillovers predominantly flow from US markets to global markets. The BRICS bloc, with its economic objectives, holds the potential to mitigate or eliminate the influence of Western markets. This potential is likely to strengthen with the inclusion of new member countries and the other countries expected to join in the near future. This study aims to examine whether the stock market relationships of the countries that joined BRICS in 2024 with US markets have undergone any changes. In this context, the impact of the VIX on these countries' stock markets before and after their membership was analyzed using the Toda-Yamamoto test. The findings reveal that, in the pre-membership period, there was causality from the VIX to two out of the three countries under study. However, these effects disappeared in the post-membership period. The empirical findings obtained were also supported by multivariate (BEKK) GARCH models. It was determined that the risk transmission observed during the pre-membership period disappeared in the post-membership period. The study demonstrates that BRICS membership serves as a threshold that eliminates the influence of US markets on the stock markets of new member countries. This finding provides predictive insights for the stock markets of countries that are potential candidates for future BRICS membership. Moreover, this result provides significant evidence that the stock markets of newly joined countries may present an opportunity for portfolio diversification for investors.

Keywords: VIX, BRICS, Toda-Yamamoto, BEKK-GARCH.

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1. INTRODUCTION

The acceleration effect of technological advancements on globalization, particularly over the past half-century (Vos, 1988), is an undeniable fact. In the economic sphere, the emergence of powerful e-commerce platforms and the establishment of various regional trade associations have propelled international trade to unprecedented levels compared to the past. Meanwhile, the continuously evolving and diversifying FinTech products have significantly contributed to the integration of financial markets.

The growing integration of both real and financial markets has long been viewed predominantly through its positive aspects, turning it into a widespread phenomenon. Globalized markets have offered companies opportunities to expand far beyond their local markets. Countries and corporations in need of funding have gained access to a broader spectrum of financing opportunities through global markets. Similarly, investors have benefited from a vast universe of financial instruments, enabling them to undertake speculative investment moves and diversify their portfolios for effective risk management.

However, alongside these and many other positive gains of financial globalization, there are also existing and potential negative aspects it brings. Moreover, these negative aspects have become increasingly pronounced over the years as globalization intensifies. Since the early stages of globalization, companies that adapted more quickly to globalization have come from countries with higher incomes and better macroeconomic conditions (Claessens & Schmukler, 2007). This has led to much faster development of financial globalization in Western countries (Arshanapalli & Doukas, 1993; Eichengreen & Park, 2005) and has created a mutually reinforcing cycle for these countries economically. This situation has further deepened the power asymmetry between national economies.

Some of the negative effects of the strengthening of financial globalization have not been limited to the macroeconomic level but have also impacted financial investments. Nowadays, there are minimal differences between Western economies and their financial markets (Bentes, 2015, p. 205). This situation has significantly reduced the benefits of portfolio diversification for investors (Patel et al., 2022, p. 1). The increasing integration of financial markets has amplified the volatility spillover between markets (Alfreedi, 2019; Jebran & Iqbal, 2016; Ji et al., 2020). Events such as the 1997 Asian Crisis (Chancharoenchai & Dibooglu, 2006), the 2000 dotcom bubble (Zhou & Sornette, 2003), the 2001 Enron Scandal (Ivaschenko, 2004), the 9/11 attacks (Mun, 2005), the 2008 Mortgage Crisis (Mensi et al., 2016) and COVID-19 Crisis (Akhtaruzzaman et al., 2021) are significant examples of how financial crises quickly transformed from a regional scale to a global one.

There are various uncertainty indices (e.g., TEU, EPU, FSI, MCI, FCI) and volatility indices (e.g., VIX, OVX, GVZ, EMP, IDEMV) that are calculated based on different macroeconomic indicators, financial instruments, or commodities to measure uncertainties and/or risks in financial markets and economies (see Akdeniz & Catık, 2017; Huang et al., 2023; Ilhan et al., 2022; Li et al., 2023; Siriopoulos & Fassas, 2013, for more details on indices). Among these indices, the VIX is one of the most frequently used in the international literature and is widely recognized by economic agents. The VIX (CBOE's Volatility Index) reflects the expected 30-day volatility of S&P 500 index options, serving as an indicator of uncertainty and risk levels (Whaley, 2009) in the stock markets. A high VIX level suggests expectations of volatile market conditions in the future. Although the VIX is based on the S&P 500 index, it is regarded as a measure of uncertainty not only specific to the US markets but also across global markets (Altinkeski et al., 2024; Cheuathonghua et al., 2019; Smales, 2022). This situation can be addressed within the scope of financial market integration and volatility spillover, particularly originating from US stock markets to other stock markets.

The transmission channels between VIX and stock markets have been examined from various perspectives in the literature. One of these perspectives relates to investors' risk perceptions (Gozgor et al., 2016, p. 36). VIX is also referred to as the "fear index" because it reflects market confidence among investors (Lu & Zeng, 2023, p. 335). In this context, considering the transmission within the scope of investor sentiment constitutes one of these perspectives (Smales, 2017). During periods when investors are optimistic, stock markets are positively affected, while during periods of pessimism, they are negatively affected (Fernandes et al., 2014). It has also been found that investors' pessimistic expectations regarding a country/region's economy are not limited to stock markets but also spillover into other financial market instruments (Cipriani & Guarino, 2008). In addition, it has been determined that investor sentiment is contagious and that this contagion can even include irrationality (Huang & Wang, 2017). In this context, many researchers have examined the relationship between the VIX and stock markets from a behavioral finance perspective (Akin & Akin, 2024; Griffith et al., 2020). Since the introduction of the Asian Disease Problem, it has been well-known how framing influences the perception of risk and uncertainty (see Kahneman & Tversky, 1979; Tversky & Kahneman, 1981, for more details). This effect has also been observed in the way changes in the VIX are perceived by investors (Sarwar, 2012). On the other hand, another psychological effect found in the relationship between VIX and stock markets is related to loss aversion (Akin & Akin, 2024; Demirer et al., 2018; Fassas et al., 2020).

BRICS (Brazil, Russia, India, China, and South Africa) stands out as a bloc symbolizing the strengthening of emerging economies in the globalization process. These countries possess the potential to exert significant influence on the balances within the global financial system due to their economic scale and geopolitical positions. Formed as a response to the increasing dominance of Western-centered financial systems over the world economy, this union aims to weaken US hegemony and create a more balanced distribution of economic power. In 2024, with the inclusion of Egypt, Iran, Ethiopia, Saudi Arabia, and the United Arab Emirates, the number of BRICS member countries has reached 10. As a result, BRICS now accounts for approximately 40% of the global population and 30% of the world's gross domestic product.

The existence of BRICS and its initiatives hold significant importance not only for the political and macroeconomic impacts it creates but also for financial investments. For investors, BRICS has the potential to offer a diversification opportunity, especially against increasingly integrated Western financial markets. Additionally, during periods of financial crises or depressions in Western markets, BRICS may serve as a safe haven. Moreover, volatility transmission between markets may affect investors' risk perception (Gong et al., 2022). When one market becomes more volatile, investors may perceive increased risks in other markets as well and adjust their positions accordingly. As a result, investor sentiment can increase the volatility (Rupande et al., 2019) in these financial markets as well. The sharp diversification of financial markets in investors' perceptions, in a political and geopolitical context, has the potential to prevent risk transmission and herd behavior (see Shiller, 1995, for more details) within the scope of behavioral finance.

In recent years, with the acceleration of globalization and financial integration, studies on the relationships between stock markets, risk transmissions, and volatility spillovers have generally been limited to developed economies. Particularly, there is a limited number of studies on the relationships between emerging markets or frontier markets and the US markets and/or how these relationships have evolved during periods of global economic uncertainty. This situation forms the main motivation of the study.

The study has a multi-dimensional objective perspective. The first is to make an inference about whether the stock markets of BRICS member countries offer investors an opportunity to diversify their portfolios. Another objective is to determine whether BRICS membership contributes to the stock markets of newly joined countries in avoiding global risks and uncertainties. In this way, it will be possible to predict whether BRICS could provide potential protection against financial risk transmission caused by globalization for the financial markets of countries that may join the union in the near future.

2. LITERATURE

Research on spillovers and contagion among stock markets has gained significant momentum in recent years. The connectedness between markets is of critical importance in terms of investment forecasting and portfolio diversification. Particularly during periods of financial depression in globally influential stock markets, offering alternatives to investors is vital for enhancing resilience during such times.

In the literature, various variables are used to measure the risk transmission mechanism between global markets. Some of these include volatility indices (Balcilar et al., 2023; Elsayed et al., 2022; Tian et al., 2021), credit spreads (Bostanci & Yilmaz, 2020; Caporale et al., 2021; Kumar & Singh, 2024), currency market volatilities (Albrecht & Kočenda, 2025; Huynh et al., 2023) and monetary policies (O'Donnell et al., 2023). One of the frequently utilized variables in studies on risk transmission originating from US stock markets is the VIX. Table 1 reports some studies examining the effects of VIX on global stock markets.

Table 1. Studies on the Impact of the VIX

Author(s)	Dependent Variable(s)	Findings
Sarwar (2014)	European Stock Markets	It has been found that the VIX significantly impacts European stock markets, particularly during financial crisis periods. Moreover, uncertainty-driven fears are observed to be more persistent in Europe compared to the US markets.
Ding et al. (2014)	VSTOXX, VDAXNEW, VXJ, VSMI	It has been found that there is an asymmetric bidirectional relationship between VIX and other market volatility indices. It has also been determined that the effect of VIX is greater during both tranquil and crisis periods.
Kang et al. (2014)	Japan and Korea Stock Markets	It has been determined that the VIX has a negative relationship with stock markets.
Buncic and Gisler (2016)	17 Stock Markets	The use of VIX has been found to improve volatility forecasting across all 17 stock markets.
Kim et al. (2016)	6 OECD Stock Markets	The study has identified that the VIX explains the correlations and volatilities of OECD countries during and after the US financial crisis.
Sarwar and Khan (2017)	Emerging Stock Markets	It has been determined that the effects of the VIX on emerging stock markets are present in all periods, with a heightened impact during crisis periods. Furthermore, the uncertainty in US stock markets exerts a suppressive influence on emerging stock markets that is stronger than the impact of their own lagged values.
Chang et al. (2018)	US and European Stock Index ETFs	It has been found that VIX has a strong negative effect on European ETFs in the short term.
Cheuathonghua et al. (2019)	42 Stock Markets	It has been determined that VIX has an asymmetric effect on markets, with its impact being more intense in markets with high volatility and low trading volume. Additionally, it has been reported that VIX spillovers make a stronger impact on returns in developed country markets and on volatility in emerging country markets.
Marfatia (2020)	Dynamic Correlations Between the US Stock Market and 20 International Stock Markets	VIX has been identified as the Granger cause of the dynamic correlation between the US and 17 stock markets.
Wang et al. (2020)	19 Equity Indices	The study examines the forecasting performance of VIX and the EPU index on 19 equity indices. It has been determined that VIX has a stronger predictive capability (on 12 equity indices) compared to the EPU index.
Ceylan (2021)	Dynamic Correlations Between US, UK, Germany and France Stock Markets	It has been found that shocks in VIX lead to an increase in correlations between the stock markets of four countries.
Grima et al. (2021)	Dow Jones, DAX, CAC40, FTSE100, MIB, SSEC, Nikkei225	It has been found that there is cointegration between VIX and all indices except CAC40 and MIB.
Li et al. (2023)	23 Stock Markets	In a study conducted using various uncertainty and volatility indices, VIX was found to demonstrate the best performance in economic forecasting, with a significant increase in its forecasting power reported after the COVID-19 pandemic.
Altinkeski (2024)	20 Developed and 20 Emerging Countries	A high level of connectedness between VIX and both developed and emerging market stock markets has been reported.

On the other hand, as a result of its mission and expansion efforts, BRICS' relationship with US stock markets has increasingly gained attention in the literature. Kishor and Singh (2014) reported that news originating from the US affects the stock markets of BRICS countries, except for China and Brazil. Syriopoulos et al. (2015) found significant return and volatility spillover between the US and BRICS stock markets and business sectors. Mensi et al. (2016) found a strong asymmetric relationship in volatility spillovers between the US and BRICS countries, as well as significant dynamic correlations among the stock markets. Additionally, they determined that the 2008 Financial Crisis heavily impacted the Brazil, India, China, and South Africa markets. McIver and Kang (2020) examined volatility spillover between the US and BRICS countries. They found that spillover increased following the onset of the 2008 Financial Crisis and in the post-European debt crisis period. Additionally, the study revealed that the US, Brazilian, and Chinese stock markets are net volatility transmitters, whereas the Russian, Indian, and South African stock markets are net recipients.

In addition, VIX is one of the commonly used variables to determine the relationships between the US and BRICS stock markets (Bouri et al., 2018; Mensi et al., 2014; Sarwar, 2012; Smales, 2022; Wang & You, 2023). These studies generally conclude that VIX has an asymmetric effect on BRICS, with the asymmetry being reduced during crisis periods when VIX rises or becomes more volatile. However, some limited studies (Shahzad et al., 2022; Zhang & Giouvris, 2022) have found that the relationship between VIX and BRICS markets disappears periodically.

3. DATA AND METHODOLOGY

3.1. Data

The study aims to examine the relationship between the VIX and the stock markets of the new member countries of BRICS before and after their membership. As part of the BRICS+ concept, Egypt, Iran, Ethiopia, Saudi Arabia, and the United Arab Emirates joined the group in 2024. However, Ethiopia and Iran were excluded from the study due to Ethiopia's lack of an organized stock exchange and incomplete access to Iran's stock market data.

The research developed six different VAR models, with VIX as the independent variable and the stock markets of Egypt, the United Arab Emirates, and Saudi Arabia as the dependent variables. The first three models represent the period before these countries joined BRICS, while the latter three models represent the period after their BRICS membership.

The study utilized benchmark indices of the countries, incorporating daily closing prices (USD) into the research. Only trading days when all markets were open were included. The data was sourced from Refinitiv Eikon and analyzed using their natural logarithmic values. The countries, their benchmark indices, index codes, and research periods are detailed in Table 2.

Table 2. Variables and Periods

Countries	Benchmark Indices	Index Codes	Periods	Dates
Egypt	Egyptian Exchange 30	EGX 30	Before BRICS Membership	01 Jan 2023 – 31 Dec 2023
UAE	FTSE Abu Dhabi Securities Exchange	FTSE ADX		
Saudi Arabia	Tadawul All Share Index	TASI	After BRICS Membership	01 Jan 2024 – 01 Dec 2024

In the remainder of the study, the variables will be referred to by their index codes. Symbol (B) will be added next to the index codes for the pre-membership period, while symbol (A) will be used for the post-membership period.

3.2. Methodology

The Toda-Yamamoto test was employed in the study to determine whether causality exists among the variables. The Toda-Yamamoto test is based on the Granger Causality (Granger, 1969). However, it differs in that it can be applied even if the time series is non-stationary or cointegrated (Wolde-Rufael, 2005, p. 896). Additionally, it operates using the asymptotic properties. This enables it to provide more valid and reliable results, particularly in large samples and makes it applicable even when the time series do not exhibit a normal distribution.

A linear method has been chosen for the causality test because, despite the high frequency of the time series, the limited period covered allows for the neglect of regime changes and structural breaks. Hence this approach aims to prevent the incorporation of noise into the model due to the additional degrees of freedom in nonlinear models, which can sometimes lead to incorrect results.

Toda and Yamamoto (1995) proposed a model that allows valid inferences to be drawn from the classical Granger Causality test statistic using a VAR model that includes a procedure ensuring the asymptotic χ^2 distribution of the Wald statistic. The Toda-Yamamoto method is based on the VAR (k+dmax) model and artificially increases the lag of the appropriate VAR model through the maximum order of integration. In the model, k is the appropriate lag order chosen based on information criteria and dmax is the maximum order of integration, determined by the unit root tests. In the Toda-Yamamoto method, the augmented VAR model is as follows:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2i} Y_{t-j} + \sum_{i=1}^{k} \Phi_{1i} X_{t-i} + \sum_{j=k+1}^{d_{max}} \Phi_{2j} X_{t-j} + \sum_{i=1}^{k} \Omega_{1i} X_{2t-i} + \sum_{j=k+1}^{d_{max}} \Omega_{2j} X_{2t-j} + \ldots + \varepsilon_{it} \quad (1)$$

Hence "X_1 does not Granger cause Y" if $\Phi_{1i} = 0 \forall_i$ or "X_2 does not Granger cause Y" if $\Omega_{1i} = 0 \forall_i$.

In this context the Toda-Yamamoto method consists of a three-step application process (Abolghasemi & Dimitrov, 2021, p. 4543):

- Determination of the maximum order of integration (dmax) and selecting the optimal lag length (k)
- Estimation of the augmented VAR model (k+dmax)
- Conducting the Modified Wald Test (MWALD)

The VAR models to be tested in the study are as follows:

Model 1:

$$EGX30(B)_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} EGX30(B)_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2i} EGX30(B)_{t-j} + \sum_{i=1}^{k} \Phi_{1i} VIX(B)_{t-i} + \sum_{j=k+1}^{d_{max}} \Phi_{2j} VIX(B)_{t-j} \quad (2)$$

Model 2:

$$FTSEADX(B)_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} FTSEADX(B)_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2i} FTSEADX(B)_{t-j} + \sum_{i=1}^{k} \Omega_{1i} VIX(B)_{t-i} + \sum_{j=k+1}^{d_{max}} \Omega_{2j} VIX(B)_{t-j} \quad (3)$$

Model 3:

$$TASI(B)_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} TASI(B)_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2i} TASI(B)_{t-j} + \sum_{i=1}^{k} \psi_{1i} VIX(B)_{t-i} + \sum_{j=k+1}^{d_{max}} \psi_{2j} VIX(B)_{t-j} \quad (4)$$

Model 4:

$$EGX30(A)_t = \vartheta_0 + \sum_{i=1}^{k} \vartheta_{1i} EGX30(A)_{t-i} + \sum_{j=k+1}^{d_{max}} \vartheta_{2i} EGX30(A)_{t-j} + \sum_{i=1}^{k} \varsigma_{1i} VIX(A)_{t-i} + \sum_{j=k+1}^{d_{max}} \varsigma_{2j} VIX(A)_{t-j} \quad (5)$$

Model 5:

$$FTSEADX(A)_t = ¥_0 + \sum_{i=1}^{k} ¥_{1i} FTSEADX(A)_{t-i} + \sum_{j=k+1}^{d_{max}} ¥_{2i} FTSEADX(A)_{t-j} + \sum_{i=1}^{k} Ø_{1i} VIX(A)_{t-i} + \sum_{j=k+1}^{d_{max}} Ø_{2j} VIX(A)_{t-j} \quad (6)$$

Model 6:

$$TASI(A)_t = \Pi_0 + \Pi_{1i} TASI(A)_{t-i} + \sum_{j=k+1}^{d_{max}} \Pi_{2i} TASI(A)_{t-j} + \sum_{i=1}^{k} Ч_{1i} VIX(A)_{t-i} + \sum_{j=k+1}^{d_{max}} Ч_{2j} VIX(A)_{t-j} \quad (7)$$

The null hypothesis in the relevant models is rejected, and the independent variable is determined to be the Granger cause of the dependent variable if $\Phi_{1i} \neq 0\forall_i$ or $\Omega_{1i} \neq 0\forall_i$ or $\psi_{1i} \neq 0\forall_i$ or $\varsigma_{1i} \neq 0\forall_i$ or $Ø_{1i} \neq 0\forall_i$ or $Ч_{1i} \neq 0\forall_i$.

4. RESULTS

4.1. Descriptive Statistics

Table 3 presents descriptive statistics for variables in the study.

Table 3. Descriptive Statistics of Variables

Variables	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	J-B
VIX(B)	2.8240	3.3239	2.4815	0.1854	0.1453	2.0959	8.7921 [0.01]
EGX 30(B)	6.4137	6.7330	6.1619	0.1445	0.8551	2.5041	30.9165[0.00]
FTSE ADX(B)	7.8763	7.9378	7.8300	0.0241	0.6149	2.8561	14.9512 [0.01]
TASI (B)	7.9855	8.0682	7.8846	0.0422	-0.2318	2.1837	8.5937 [0.01]
VIX(A)	2.7363	3.5177	2.4449	0.1834	1.0599	4.0810	51.9094 [0.00]
EGX 30(A)	6.4827	6.9018	6.2373	0.1716	1.2414	3.1712	56.7749 [0.00]
FTSE ADX(A)	7.8338	7.8938	7.7713	0.0219	0.0647	3.5857	3.2992 [0.19]
TASI (A)	8.0801	8.1381	8.0278	0.0262	0.2355	2.3181	6.2951 [0.04]

Note: J-B is Jarque-Bera normality test

When Table 3 is examined, it is observed that the VIX had a lower average in 2024 compared to 2023. Among the stock indices, EGX 30 and TASI exhibited an increasing average in the subsequent period, while FTSE ADX experienced a decline in its average. It is also evident that EGX 30 had significantly higher market volatility compared to the other stock indices in both periods. The Jarque-Bera normality test results indicate that the distribution of the time series is not normal (except for FTSE ADX (A)).

4.2. Unit Root Tests

To determine the maximum order of integration in the models, stationarity tests were conducted for the variables included in the study. In this context, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied. For the ADF unit root test, the Akaike Information Criterion (AIC) was used to determine the appropriate lag length. For the PP unit root test, the spectral estimation method was selected as Bartlett kernel, and the suitable bandwidth was determined using the Newey-West method. Results are presented in Table 4.

Table 4. Unit Root Tests

Variables	ADF(Intercept)		ADF (Intercept and Trend)		PP (Intercept)		PP(Intercept and Trend)	
	Lvl	1st Dif.	Lvl	1st Dif.	Lvl	1st Dif.	Lvl	1st Dif.
VIX(B)	-1.946(3)	-9.756***(2)	-3.139(2)	-9.734***(2)	-2.236(1)	-17.840***(3)	-3.198 (3)	-17.802***(3)
EGX 30(B)	0.120(4)	-7.703***(3)	-2.551(4)	-7.895***(3)	0.220(1)	-14.384***(2)	-2.732(2)	-14.628***(3)
FTSE ADX(B)	-2.630(0)	-14.730***(0)	-2.510(0)	-14.763***(0)	-2.655(3)	-14.730***(1)	-2.566(3)	-14.763***(1)
TASI (B)	-1.251(1)	-11.677***(0)	-1.714(1)	-11.675***(0)	-1.176(3)	-11.702***(2)	-1.588(3)	-11.701***(2)
VIX(A)	-3.118**(2)	-16.852***(0)	-3.607**(2)	-16.822***(0)	-3.245**(3)	-16.782***(2)	-3.696**(3)	-16.752***(2)
EGX 30(A)	-1.628(2)	-12.899***(0)	-1.499(2)	-12.900***(1)	-1.723(6)	-16.782***(7)	-1.684(5)	-16.754***(8)
FTSE ADX(A)	-2.241(2)	-10.927***(1)	-2.151(2)	-10.946***(1)	-2.154(4)	-13.328***(9)	-2.045(5)	-13.400***(9)
TASI (A)	-1.736(8)	-5.755***(7)	-2.375(8)	-5.768***(7)	-2.055(4)	-13.691***(1)	-2.635(4)	-13.692***(1)

Note: Values in parentheses indicate lag lengths (for ADF test) and bandwidths (for PP test). The symbols *** denote 1%, ** denote 5% significance levels.

When Table 4 is examined, it is observed that all variables in the study are I(1) according to both ADF and PP unit root test results. Accordingly, the maximum order of integration in the models is determined as 1.

4.3. Causality Tests

In the first step of the Toda-Yamamoto test, VAR models were estimated to determine the optimal lag orders. The AIC was used to identify the optimal lag orders. The optimal lag orders for the models are presented in Table A1 (Appendix A).

When Table A1 is examined, it is determined that k=1 for Model 1, k=2 for Models 2 and 3, and k=3 for Models 4, 5 and 6 (Appendix A). The maximum order of integration (dmax) for all models in the study is 1. The condition $k \geq dmax$ is satisfied for all models. Accordingly, analyses will be conducted based on the VAR (k+dmax) model to determine Granger causality.

Before determining causality, diagnostic tests for the established VAR models were conducted. For this purpose, Autocorrelation LM tests were applied to check for autocorrelation problems in the models. Additionally, the inverse roots of autoregressive polynomial in the models were examined to determine whether the models were stationary at the specified lag orders.

When Table A2 is examined, it is observed that the probability values at all lag orders in all models are greater than 0.05. Therefore, it has been determined that there is no autocorrelation problem in the models (Appendix A). Similarly, when Figure A1 is examined, it is seen that the inverse roots of autoregressive polynomial in all models are less than 1 and inside of the unit circle (Appendix A). Accordingly, it can be stated that all models are stationary at the specified lag orders.

The MWALD (Modified Wald) test was applied to the models to test causality. The test results are reported in Table 5.

Table 5. MWALD Tests

Period	Models	H_0	$\chi 2$	Prob.	Decision
Before BRICS Membership	1	VIX(B) ≠> EGX 30(B)	1.8350	0.1755	Accept
	2	VIX(B) ≠> FTSE ADX(B)	11.7553	0.0028	Reject
	3	VIX(B) ≠> TASI(B)	23.2475	0.0000	Reject
After BRICS Membership	4	VIX(A) ≠> EGX 30(A)	1.5065	0.6807	Accept
	5	VIX(A) ≠> FTSE ADX(A)	6.2765	0.0989	Accept
	6	VIX(A) ≠>TASI(A)	3.6171	0.3058	Accept

Note: In determining the probability values, "k degrees of freedom" were used as the basis.

Upon examining Table 5, it can be observed that the null hypotheses in Model 1, Model 4, Model 5, and Model 6 could not be rejected. However, the null hypotheses in Model 2 and Model 3 were rejected, leading to the conclusion that the independent variable VIX(B) is the Granger cause of the dependent variables FTSE ADX(B) and TASI(B).

A significant portion of studies in the literature has found that US stock market movements have an impact on the BRICS countries (Kishor & Singh, 2014; Syriopoulos et al., 2015) They have also determined that risk transmission, especially during crisis periods, shows a noticeable increase (McIver & Kang, 2020; Mensi et al., 2016). Studies examining this relationship through the VIX variable have generally found similar results (Bouri et al., 2018; Mensi et al., 2014; Sarwar, 2012; Smales, 2022; Wang & You, 2023). This suggests that the attention reallocation mechanism (Ceylan, 2021; Mondria & Quintana-Domeque, 2013) operates strongly. According to the research findings, new members of the bloc were under a similar effect before their membership, but this effect ceased after their membership. Whether this is a temporary psychological impact for international investors will be clarified in future studies.

Unexpected progress in this regard (which may actually be expected by many) can be China and India completing their rise as new volatility transmitters, having prepared the ground with their exchange rate competitiveness and strengthened it with the know-how they have acquired.

5. ROBUSTNESS CHECK

GARCH-based methods were applied in order to examine the robustness of the empirical findings. Before applying the GARCH models on the time series made stationary by first-order differencing, an ARCH-LM pre-test was conducted to ensure the presence of ARCH effects. The ARCH-LM test reveals the regressive characteristics of the analyzed series (Bailey, 1909). The results presented in Table A3 support the presence of ARCH effects in the series (Appendix A).

For the robustness check, the volatility structures (variance-covariance) of the series were first cross-examined using the Bivariate BEKK-GARCH test (Engle & Kroner, 1995). In BEKK-GARCH models, using a (1,1) lag order to determine volatility spillovers between series generally yields successful results (Horpestad et al., 2019; Xie et al., 2021). Hence, the BEKK-GARCH (1,1) model has been used to detect the risk transmission dynamics between the series. The results related to the models are presented in Table B1 (Appendix B). It is observed that both ARCH and GARCH effects exist between the series in the period before the countries' BRICS membership (see, $A_{(1,2)}$ and $B_{(1,2)}$ parameters in Table B1). When examining the off-diagonal parameters of the A matrix, it is found that shocks in VIX(B) have a statistically significant effect at the 1% level on FTSE ADX(B) (coeff: -3.500) and TASI(B) (coeff.: 4.382). Looking at the off-diagonal parameters of the B matrix, it is identified that volatility transmission exists from VIX(B) to EGX30(B) and FTSE ADX(B) at the 1% level of statistical significance. In the post-membership period, both ARCH and GARCH effects disappear. These results are consistent with the findings of the Toda-Yamamoto test.

The volatility causality of the series has also been examined for the robustness check. In this context, the VAR-BEKK-GARCH method has been used. In the first stage, a Diagonal BEKK-GARCH (1,1) model was constructed. The model results are presented in Table A4 (Appendix A). In the second stage, Granger causality tests were applied to the residuals of the series in the model. According to the results presented in Table 2B, volatility causality exists between VIX(B) and both FTSE ADX(B) and TASI(B) in the pre-membership period (Appendix B). However, in the post-membership period, no statistically significant volatility causality was found from VIX(A) to the other variables. The findings obtained from the volatility causality are fully consistent with the results of the Toda-Yamamoto test.

6. CONCLUSION AND RECOMMENDATIONS

Numerous recent studies have shown that price and volatility movements in the US stock markets tend to spill over into global markets. Strong integration among international stock markets makes it challenging to construct effectively diversified portfolios. Another common finding in the literature is that risk transmission significantly increases during crisis periods. This can be observed in recent financial crises, where many initially began as regional events but quickly evolved into global phenomena. Examining and defining the dynamics between global stock markets is crucial both for financial investments and macroeconomic stability.

For investors, particularly those with low-risk appetite or hedging objectives, accurately identifying alternatives that offer diversification, hedging, or safe-haven properties under different conditions is vital. This is not only important for protecting investors' benefits but also for ensuring the continued healthy transfer of these funds to the real economy.

Although the BRICS bloc may pose potential risks due to political polarization, it is of critical importance to global economic balances. Its presence also has the potential to limit risk transmission between financial markets. However, most studies to date have generally reported various forms of connectedness between Western markets and BRICS. The nature of these linkages varies depending on the periods and conditions examined in these studies, highlighting the need for ongoing research to define these dynamics better.

This study investigates whether there are differences in the linkage characteristics between US markets and the countries that joined the BRICS bloc as of 2024. Specifically, it examines the causality of VIX as an independent variable on the stock markets of these new member countries before and after their membership. The findings reveal that Egypt's stock market shows no relationship with VIX in both pre- and post-membership periods. Meanwhile, causality from VIX to UAE and Saudi Arabia's stock markets, which existed in the pre-membership period, ceased after their membership. Similar findings were obtained in the multivariate GARCH models conducted to ensure the robustness of the empirical findings. At the same time, there was risk transmission from the VIX to the UAE and Saudi Arabia's stock markets during the pre-membership period, this transmission disappeared in the post-membership period.

The findings offer various insights for investors and for the stock markets of countries potentially joining BRICS in the future. They suggest that the stock markets of new member countries can be utilized for portfolio diversification in the short term. Additionally, the BRICS threshold appears to have the potential to reduce or eliminate the impacts of Western markets on these countries.

Despite the novelty and relevance of the study, it has certain limitations. Long-term relationships between markets should be revisited as the time horizon expands. Furthermore, the safe-haven characteristics of these markets during a potential Western-origin financial crisis should also be tested. A promising research motivation lies in exploring how the BRICS threshold impacts the financial markets of future member countries. Additionally, inter-market linkages within the BRICS bloc should be examined. Although previous studies have analyzed relationships among the founding member countries, the inclusion of new members may reshape these linkages.

Ethics Committee approval was not required for this study.

The author declares that the study was conducted in accordance with research and publication ethics.

The author confirms that no part of the study was generated, either wholly or in part, using Artificial Intelligence (AI) tools.

The author declares that there are no financial conflicts of interest involving any institution, organization, or individual associated with this article.

The author affirms that the entire research process was performed by the sole declared author of the study.

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APPENDIX A. SUPPLEMENTARY DATA

The following are the supplementary data to this article.

Table A1. Optimal Order of the VAR Models

Lag	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0	-1.963314	-5.409576	-5.034068	-1.278566	-5.550348	-4.961949
1	-8.444503*	-10.40260	-9.963810	-5.901.502	-10.01950	-9.227913
2	-8.423813	-10.44883*	-10.09246*	-5.891.058	-10.05105	-9.229611
3	-8.423244	-10.41934	-10.06476	-5.909648*	-10.05780*	-9.240584*
4	-8.411211	-10.41143	-10.05587	-5.883.598	-10.03295	-9.209603
5	-8.430225	-10.38521	-10.03419	-5.862.678	-10.00948	-9.183322
6	-8.399933	-10.36976	-10.01120	-5.838.501	-9.972844	-9.165190
7	-8.380793	-10.34789	-9.980311	-5.805.293	-9.946365	-9.143939
8	-8.352704	-10.31665	-9.956540	-5.778.287	-9.932487	-9.128258

Table A2. Autocorrelation LM Tests

Lag	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Stat	Prob.	Stat	Prob.	Stat	Prob.	Stat	Prob.	Stat	Prob.	Stat	Prob.
1	8.6211	0.0712	6.5539	0.1614	5.1158	0.2756	1.8688	0.7598	1.9482	0.7452	2.2790	0.6844
2	7.6270	0.1062	2.7344	0.6032	4.3909	0.3556	3.2198	0.5217	2.5751	0.6312	1.0682	0.8992
3	6.3272	0.1760	6.6210	0.1573	3.8438	0.4275	3.3041	0.5082	1.1221	0.8907	3.1308	0.5361
4	6.9212	0.1401	3.3003	0.5088	4.9261	0.2949	3.2545	0.5161	1.9919	0.7372	1.1138	0.8920
5	0.2255	0.9940	2.2355	0.6925	1.3461	0.8534	2.5141	0.6421	1.2951	0.8622	3.4297	0.4886
6	2.5180	0.6414	3.7265	0.4442	1.9274	0.7491	0.5638	0.9669	2.1901	0.7008	5.2948	0.2583
7	4.0125	0.4043	1.5109	0.8246	3.9931	0.4069	1.4846	0.8293	7.8497	0.0972	6.2663	0.1801
8	3.8210	0.4307	3.1070	0.5400	1.6959	0.7914	1.6687	0.7963	6.7168	0.1516	4.7843	0.3101

Figure A1. AR Roots Graphs

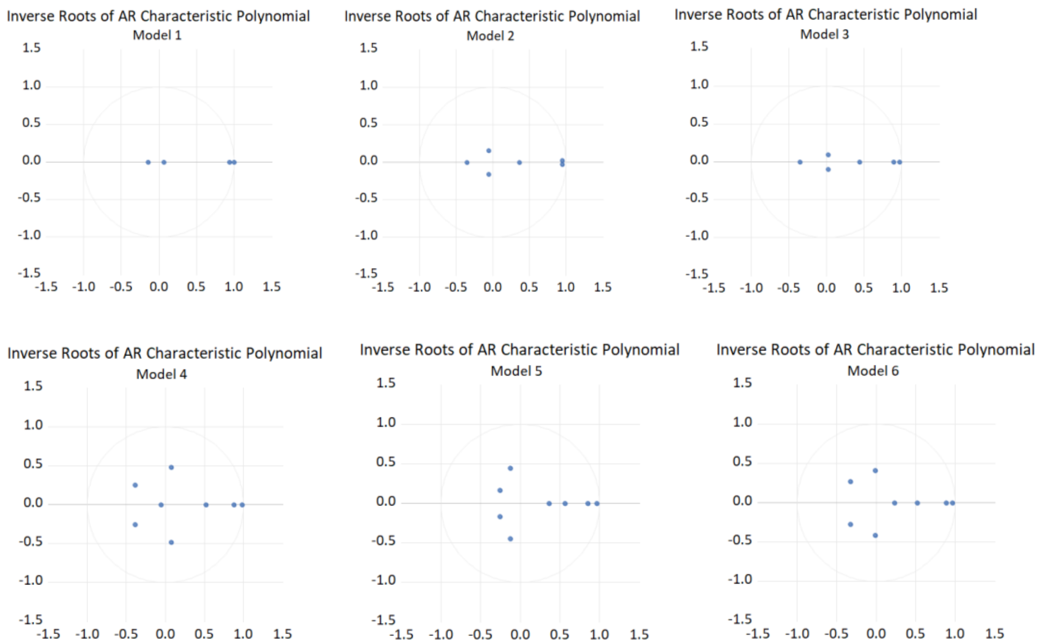

Table A3. ARCH-LM Tests

Variables	ARCHLM(1)
DVIX(B)	7.835***
DEGX 30(B)	7.521***
DFTSE ADX(B)	4.829**
DTASI (B)	5.125**
DVIX(A)	7.971***
DEGX 30(A)	7.758***
DFTSE ADX(A)	12.221***
DTASI (A)	5.201**

Note: The symbols *** denote 1%, ** denote 5% significance levels

Table A4. Diagonal BEKK-GARCH Matrix

Models	$A_{(1,1)}$	$A_{(2,2)}$	$B_{(1,1)}$	$B_{(2,2)}$
DEGX 30(B) - DVIX(B)	0.342***	0.279***	0.920***	0.893***
DFTSE ADX(B) - DVIX(B)	1.048***	0.291***	0.104	0.892***
DTASI (B) - DVIX(B)	-0.024	0.369***	-0.889***	0.935***
DEGX 30(A) - DVIX(A)	1.109***	0.334***	0.769***	0.806***
DFTSE ADX(A) - DVIX(A)	0.525***	0.330***	0.740***	0.801***
DTASI (A) - DVIX(A)	0.304**	0.314***	0.790***	0.819***

Note: The matrix values represent the model coefficients. The symbols *** denote 1%, ** denote 5% significance levels

APPENDIX B. ROBUSTNESS CHECK

Table B1. Bivariate BEKK-GARCH Matrix

Models	$A_{(1,2)}$	$A_{(2,1)}$	$B_{(1,2)}$	$B_{(2,1)}$
DEGX 30(B) - DVIX(B)	-0.256	-0.083***	-3.233***	0.034
DFTSE ADX(B) - DVIX(B)	-3.500***	0.017*	4.839***	0.085***
DTASI (B) - DVIX(B)	4.382***	-0.031***	0.393	-0.005
DEGX 30(A) - DVIX(A)	-0.018	-3.517***	0.196	-0.300***
DFTSE ADX(A) - DVIX(A)	2.536	-0.023*	-3.780	0.010
DTASI (A) - DVIX(A)	-0.042	-0.040***	-0.426	0.044***

Note: The matrix values represent the model coefficients. The symbols *** denote 1%, ** denote 5% significance levels

Table B2. VAR-BEKK-GARCH Causality Tests

Period	Models	H_0	F stat.	Prob.
Before BRICS Membership	7	resVIX(B) ⇏ resEGX 30(B)	1.5765	0.2089
	8	resVIX(B) ⇏ resFTSE ADX(B)	3.2089	0.0422**
	9	resVIX(B) ⇏ resTASI(B)	2.9272	0.0555*
After BRICS Membership	10	resVIX(A) ⇏ resEGX 30(A)	0.0302	0.9702
	11	resVIX(A) ⇏ resFTSE ADX(A)	0.2523	0.7771
	12	resVIX(A) ⇏resTASI(A)	0.0798	0.9233

Note: The symbols ** denote 5%, * denote 10% significance levels