



## Investigation of The Relationship Between VIX Index and BRICS Countries Stock Markets: An Econometric Application

Samet GÜRSOY<sup>1\*</sup>

<sup>1</sup> Asst. Prof. Dr., Burdur Mehmet Akif Ersoy University, Bucak Zeliha Tolunay School of Applied Technology and Management, Department of Customs Business, Burdur, Turkey

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### ABSTRACT

The VIX index, the largest volatility indicator index of the USA, has been derived from the S&P 500 index and has been carefully monitored by international investors since 1993. While the VIX index was previously followed by investors from developed countries, it is now followed by investors who evaluate their investments in developing countries. In this study, it was examined the effect of price movements in the VIX index on the stock markets of the developing (BRICS) countries between the dates of 02.24.2011 and 06.01.2020. Toda Yamamoto causality test was used by using daily closing data. In addition, bilateral results were examined for each variable in the study. Considering the findings obtained from the study, it was observed that the VIX index is in bilateral causality with Russia (RTSI) and South Africa (INVSFA40) stock markets as of the baseline period. On the other hand, it is determined that the price movements in the VIX index have a unilateral causality relationship on India (BSESN) and China (SSEC) indices. However, it has been seen that the VIX index does not have a unilateral or bilateral causal relationship with the Brazilian (BOVESPA) stock market.

**Keywords:** VIX index, Stock Markets, BRICS Countries.

### VIX Endeksi ve BRICS Ülkeleri Borsaları Arasındaki İlişkinin İncelenmesi: Ekonometrik Bir Uygulama

#### ÖZET

ABD'nin en büyük volatilité gösterge endeksi olan VIX endeksi, S&P 500 endeksinden türetilerek elde edilmiş ve 1993'ten beri uluslararası yatırımcılar tarafından dikkatle takip edilmektedir. VIX endeksi önceleri gelişmiş ülke yatırımcıları tarafından takip edilirken artık

yatırımlarını geliştirmekte olan ülkelerde değerlendiren yatırımcıların da takibine alınmıştır. Bu çalışmada ise 02.24.2011 ile 06.01.2020 dönemleri arasında VIX endeksinde gerçekleşen fiyat hareketlerinin geliştirmekte olan BRICS ülkeleri borsaları üzerindeki etkisi incelenmiştir. Günlük kapanış verileri kullanılarak yapılan çalışmada Toda Yamamoto nedensellik testi kullanılmıştır. Ayrıca çalışmada her bir değişken için iki taraflı sonuçlar da incelenmiştir. Çalışmadan elde edilen bulgulara bakıldığında, baz alınan dönem itibari ile, VIX endeksinin Rusya (RTSI) ve Güney Afrika (INVSFA40) borsaları ile iki taraflı nedensellik ilişkisi içinde olduğu görülmüştür. Diğer bir taraftan VIX endeksindeki fiyat hareketliliğinin Hindistan (BSESN) ve Çin (SSEC) endeksleri üzerinde tek taraflı nedensellik ilişkisi gerçekleştirdiği saptanmıştır. Bununla birlikte VIX endeksinin Brezilya (BOVESPA) borsası ile ne tek taraflı ne de çift taraflı bir nedensellik ilişkisi içinde olmadığı görülmüştür.

**Anahtar kelimeler:** (VIX) endeksi, Pay Piyasaları, BRICS Ülkeleri.

## **1. INTRODUCTION**

The volatility movements of financial assets are one of the market indicators that affect investors' decision making. The concept of volatility is defined by definition as " The expression of variability in the price of an asset "(BTS, 2020). If volatility is high in financial markets, it makes these investors uneasy and discourages on the investment decisions. Beside of these, the investors not only follow the volatility in the national markets but also closely follows the volatility in the international markets. Especially with the acceleration of globalization, the volatility that occurs in one of the interconnected financial markets affects other financial markets due to the contagiousness brought by financial globalization. For this reason, investors also take into account the volatility in the international financial markets when making an investment decision. Accordingly, many volatility indexes were created that affect investors' decision-making processes. While these indices rating volatility on financial assets, they also serve as an indicator that measures the risk of investment. One of these indicators is that (VIX) index which was the first and most considered into global markets.

The VIX index was developed in 1993 by the Chicago Options Exchange (Chicago Board Options Exchange - CBOE) and was calculated to measure the volatility in the market (Fernandes etc., 2014: 2). The VIX index, which started to be calculated since 1993, was calculated on the basis of the S&P 500 index since September 2003, although it was initially calculated on the basis of the S&P 100 index. However, 28 indices are calculated in six different categories for the measurement of volatility expected by CBOE. The VIX index is used as an

indicator to predict future expected movements of the securities markets. It's also named as implied volatility index (Sakarya and Akkus, 2018: 352). In the index, optionally calculated on the difference between the purchase and sale prices. With the convergence of purchase and sale prices, the value of VIX index also decreases. It gives an idea about the volatility determined by investors in the index and expected in the stock market in the next 30 days (Akdağ, 2019: 236). The VIX index measures the 30-days volatility expectation of the S&P 500 which one of the largest stock markets in the USA (Bardgett, 2019: 1).

Related studies show that there has been an overall inverse relationship between the VIX Index and the S&P 500 index. The fall in stock prices traded in the S&P 500 index, in other words, the formation of a sales wave in the stock market, expresses the depreciation for investors and thus the stock market becomes a more risky investment area. This situation causes the VIX Index to increase. Based on the tension created by the risky environment in question, the VIX Index is also called the "fear index" (Öner et al., 2018: 111-112).

In this study, a causal relationship between the VIX index and the stock markets of developing countries (BRICS) will be questioned. In this context, the relevant studies in the literature section of the study will be presented in the form of a literature summary, and the contribution of this study to the literature will be specified. In the third part of the study, the purpose of the study and the methodological method used will be explained. Then, the findings will be shared and interpreted. And in the last part, the findings obtained from the study will be associated with the previous studies, and the results obtained from this study will be presented comparatively. Finally, suggestions will be made to stock market investors in terms of contributing to policy makers and other studies in this area.

## **2. LITERATURE REVIEW**

For this study, many studies were examined in the literature related to VIX index and stock markets. It was recognized that majority of the studies conducted in developed countries, the literature review was mostly followed by this projection. And also, it was run time series models such as GARC DCC, ADCC. It is hoped that the model and currentness used in the study will contribute to the literature.

McGuire and Schrijvers, in their 2003 study, examined the relationship among the bond spreads of the selected emerging countries, oil prices, VIX Index, American stock market indices and American interest rates. The study covers the period of January 1998 - June 2003.

Turkey has also taken place in developing countries. At the end of the study, according to the findings, a single financial indicator was found to explain approximately 80% of the developing country's bond spreads. In addition, it was commented that the main indicator in question could reflect the changes in investors' attitudes towards risk.

Korkmaz and Çevik (2009) examined the impact of the VIX Index on the stock markets of 15 developing countries. According to the results of the analysis conducted using the data for the period January 2004 - March 2009, developing countries have a leverage effect on the conditional variance of the stock markets and the bad news coming to the financial markets increases volatility more. In addition, the VIX Index, Argentina, Brazil, Mexico, Chile, Peru, Hungary, Poland, Turkey, Malaysia, Thailand and Indonesia by affecting the stock market has been found to increase the volatility.

Arbatlı (2011) investigated the factors affecting foreign direct investment in developing countries' economies. As a result of the analysis carried out using data from the period of 1990-2009 for 46 developing countries, the unconditional correlation between the VIX Index used to represent these factors and foreign direct investment is low; however, in some periods such as after 2006, it has been observed that there is a significant negative relationship between the VIX Index and foreign direct investment. Finally, it concluded that global risk aversion and uncertainty factors play an important role in explaining foreign direct investment.

Basher and Sadorsky (2016). In their study, they examined the relationship between VIX index, gold, oil and bond prices and stock market indexes of developing countries. DCC, ADCC and GOGARCH methods were applied in their studies where they used daily data between January 4, 2000 and July 31, 2014. According to the results of MSCI Emerging Markets Index, which shows 23 developing countries together, the positive correlation was found between stock market indices and oil prices of developing countries. In addition, it was determined that there is a negative relationship between VIX index, bond prices and emerging market stock indexes and oil prices.

In their study, Bouri et al. (2017) wanted to test whether Bitcoin could be a protection tool against global uncertainties. For this purpose, the Ordinary Least Squares (OLS) Model ran between period of March 17, 2011 and October 7, 2016 by using daily date of the (VIX) index and Bitcoin prices and 14 developed and developing countries stock prices. As a result of the study, it was observed that Bitcoin acts as a fence against uncertainty that Bitcoin returns respond positively to uncertainty in both higher amounts and shorter frequency movements.

Finally, when using quantile regressions on the quantum, it has been observed that hedging is observed at shorter investment horizons and at both the upper and lower ends. In summary, they found that Bitcoin is a sheltered harbor in uncertainty.

Sarwan and Khan (2017) investigated the effects of uncertainty on the US stock exchange (VIX) on the stock returns of 5 Latin American countries (Brazil, Mexico, Chile, Colombia and Peru) and the MSCI emerging markets index. Between the dates of 01.06.2003 and 30.09.2014, using the daily data, they used the Granger causality test and the GARCH method. The study is divided into three periods as pre-financial crisis period, financial crisis period and post-financial crisis period. According to the findings; it has been concluded that VIX has been the cause of causation to Latin American countries only for the period after the financial crisis.

İskenderoğlu and Akdağ (2018) tested the causality relationship between the VIX index and the stock markets of 11 developed and developing countries. Granger and Frequency Causality Analysis was run in the study, where daily data was used between January 2015 and December 2017. At the end of the study, it was determined that VIX index has causality relationship with all indices except US and Germany indices.

Öner et al. (2018) tested the causal relationship between the VIX index and the stock markets of developing countries also includes Turkey. In developing countries, it was determined the Turkey (BIST100) Index, Chile (IPSA) Index, South Africa (Jalsha) Index, South Korea (KS11) Index, Russia (MICEX) Indices, Argentina (Merval) Index, Mexico (MXS) Index, Thailand (SETI) Index, Taiwan (TWII) Index and Poland (WIG20) Indexes. Granger causality and cointegration tests were used in the study where daily data was used between 23 November 2006-10 May 2017. Considering the findings obtained from the study, the causality relationship between VIX index and BİST100 index towards the BIST100 index was determined. In addition, at least one short or long-term relationship was found with all other developing country stock market indices except the Argentina (MERVAL).

### **3. METHODOLOGY**

#### **3.1. The Aim of the Study and Method**

In this study, it is aimed to test the existence of a statistically significant relationship between the VIX index and the BRICS countries exchanges. Accordingly, Toda Yamamoto causality test was conducted between February 24, 2011 and January 6, 2020 using daily data

(2290 Observations). All data were obtained from investing.com. Firstly, Lee-Strazicich (LS) Unit Root Test was used to ensure the stability of the obtained daily data. The (LS) test has advantages in terms of determining structural breaks on the dates and also was shared with the break dates in this study. And finally, after obtaining the stationary data, Analysis was carried out in the form of a double test. While VIX index was taken as dependent variable in the equation, BOVESPA, RTSI, BSESN, INVSAF40, SSEC indices were taken independent variables. In the same way, two tests will be carried out in which each variable is both dependent and independent. Thus, not only the VIX variable, but also the effects of the price change on the Stock markets on VIX were taken into account.

### 3.2. Date Set

In the application part of this study, price series of variables are used. All data covering between 11.02.2011 and 06.01.2020 was obtained from investing.com also given in the table below.

**Table 1.** Data set

Variable	Variable Description	Time Period	Period of Dates	Source of Dates
<b>VIX</b>	VIX (Voatility index)	February 11	Daily	www.investing.com
<b>BOVESPA</b>	Bovespa Index (Brazil)	2011		
<b>RTSI</b>	RTSI Index (Russia)	–		
<b>BSESN</b>	BSE Sensex 30 (India)	January 6		
<b>INVSAF40</b>	South Africa 40 Index	2020		
<b>SSEC</b>	SSEC Index (China)			

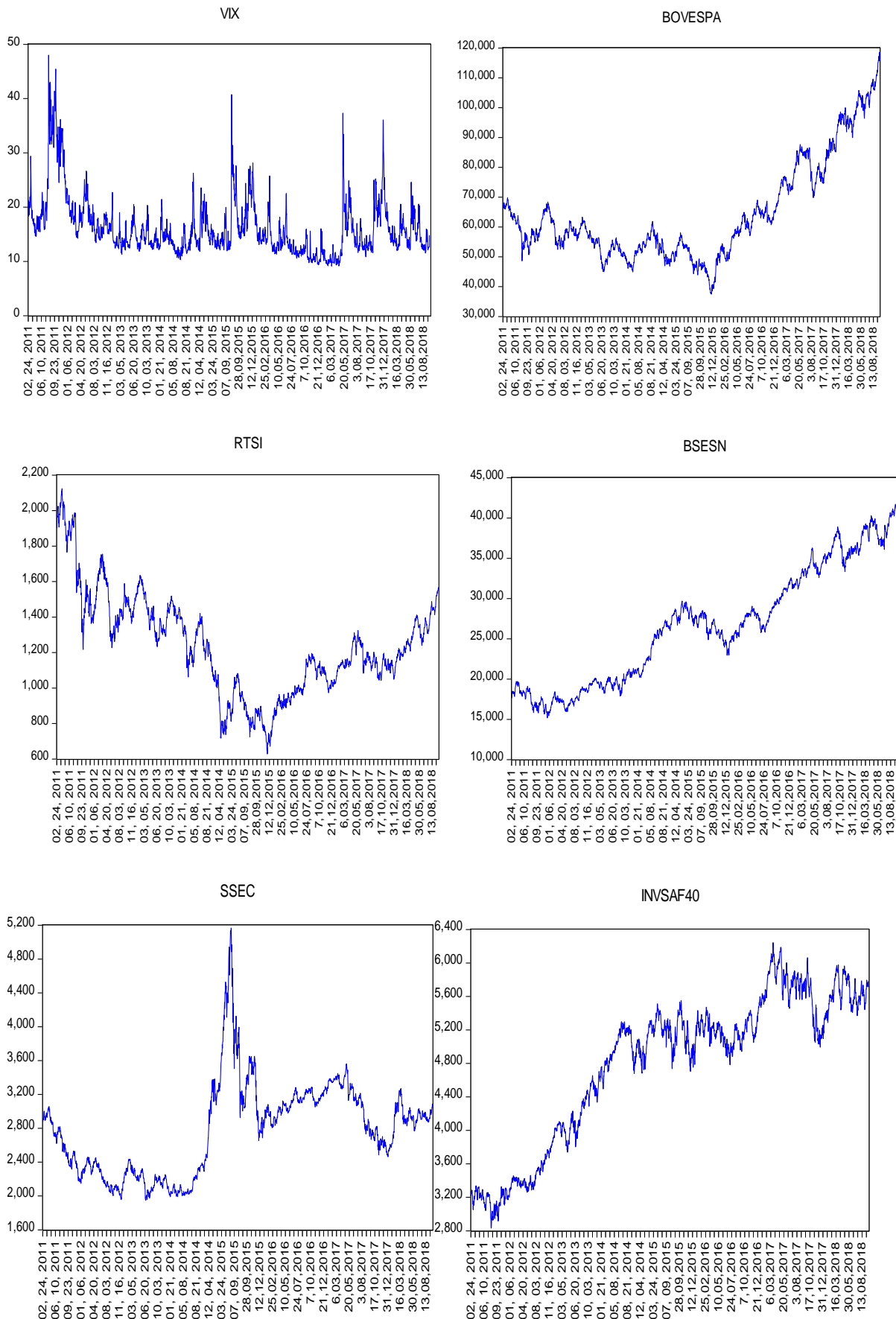


Figure 1. Charts of series

### 3.3. The Research Hypotheses

In the research, two hypotheses have been established on the series of variables that test the existence of unit root. In addition, two hypotheses have been established that question the existence of a causality relationship between the variables. The four hypotheses established for the whole study are as follows.

*H0: There is no causal relationship between VIX variable and BOVESPA, RTSI, BSESN, SSEEC, INVSAF40, indices variables.*

*H1: There is a causal relationship between VIX variable and BOVESPA, RTSI, BSESN, SSEEC, INVSAF40, indices variables.*

*H2: There is a unit root for the data of the series and it is not stationary.*

*H3: There is no unit root for the data of the series and it is stationary.*

### 3.4. Lee-Strazicich Unit Root Test

To investigate the relationship between variables, the stationarity of variables (whether they have unit root or not) should be tested first. ADF, PP, etc. unit root tests are also some of the stationary tests. However, these tests do not take into account structural breaks. For this purpose, another test Lee Strazicich (2003) unit root test, which also takes into account the structural breaks and tests the stability, was applied to the data.

Unlike conventional ADF (Augmented Dickey-Fuller) based structural break unit root tests, the LM (Lagrange Multiplier) unit root test also allows breaks under the null hypothesis. Accordingly, the LM unit root test has several advantages. Since the breakpoints are initially determined as endogenous, the test is not subject to false refusals in case of breaks and the presence of the unit root. The most important thing is that if the alternative hypothesis is correct, there are no false rejections. In the LM test, the rejection of the null hypothesis necessarily refers to the rejection of the unit root without fractures, but without fractures (Özcan, 2012: 10).

As a correction to these criticisms by Lee Strazicich (2003, 2004), a new unit root test has been added to the literature. According to this new test, structural breakage can be allowed in each of the basic and alternative hypotheses.

The method used in the LM unit root test is as follows;



$$y_1 = \delta Z_t + e_t \quad e_t = \beta e_{t-1} + \varepsilon_t \quad (1)$$

In equation (1), the  $Z_t$  exogenous variables vector denotes error terms with the property  $\varepsilon_t \sim iid N(0, \sigma^2)$ . The model that includes two changes in the level is expressed as  $A Z_t = [1, t, D_{1t}, D_{2t}]$ . Here; for  $D_{jt} = 1, t \geq T_{bj} + 1, j = 1, 2$  and 0 for other cases.  $T_{bj}$  shows the break time. Model C contains 2 changes in trend and level, model  $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]$ . Here;  $DT_{jt} = t - T_{bj}$  for  $t \geq T_{bj} + 1, j = 1, 2$  and 0 for other cases. While the process of data creation (DGP) includes breaks under the basic hypothesis ( $\beta = 1$ ), it is in the form of an alternative hypothesis ( $\beta < 1$ ). Lee and Strazicich used the following equation to obtain the LM unit root test statistics.

Lee and Strazicich used the following equation to obtain LM unit root test statistics.

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + u \quad (2)$$

Here;  $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \delta, t=2, \dots, T$ ; and  $\tilde{\delta}$  value is the coefficient obtained from  $\Delta Z_t$  in the regression of  $\Delta y_t$ .  $\tilde{\psi}_x$  is found with  $y_1 - Z_1 \delta$  where  $y_1$  and  $Z_1$  are the first elements of  $y_t$  and  $Z_t$  in the order specified (Lee and Strazicich 2003: 1083).

Critical values accepted for single and double fracture unit root tests are obtained from the studies for a single fracture in Lee and Strazicich (2004), two fractures in Lee and Strazicich (2003). If a test statistic greater than the critical values is obtained, the unit root basic hypothesis containing the structural break is rejected (Yıllancı, 2009: 331).

### 3.5. Toda-Yamamoto Causality Test

This method, developed by Toda and Yamamoto (1995), was created to take the Granger causality test to a higher level. In addition, the model tries to enhance some of the problems that occur in the Granger causality test. To be able to test Granger causality for time series, the series must first become stationary and stabilize at the same level. However, once this condition has been met, co-integration must also occur to demonstrate a long-term relationship between stationary series at the same level. In other words, only the Granger causality test can be performed between the series that are stable at the same level and have a cointegration relationship between them. However, the Toda-Yamamoto test revealed that time series, which are at different levels of stability, may have causality between them, and even causality testing can be done without the need for a stationary test. This model can also be tested regardless of

whether there is a co-integration between the series, regardless of co-integration (Toda and Yamamoto, 1995).

In the case of the performing Toda and Yamamoto (1995) test, the appropriate lag length ( $k$ ) is determined by the VAR model. In the second stage of the analysis, the degree of integration ( $d_{max}$ ) of the variable, which has the highest degree of integration, is added to the lag length ( $k$ ) of the model. In the last stage, the VAR model is estimated according to the lags with series level values ( $k + d_{max}$ ). The VAR model is applied with the help of the following equations (Toda and Yamamoto, 1995 and Doğan, 2018: 24);

$$Y_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}Y_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}X_{t-i} + u_t \quad (3)$$

$$X_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}X_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}Y_{t-i} + v_t \quad (4)$$

In the Toda-Yamamoto test, the basic hypothesis and alternative hypothesis can be discussed as follows.

$H_0$ : The X variable is not the Granger cause of the Y variable.

$H_1$ : The X variable is the Granger cause of the Y variable.

The success of the Toda-Yamamoto causality test is directly related to the correct determination of the value of the series ( $d_{max}$ ) and ( $k$ ) in the model (Yavuz, 2006: 169).

A) These equations were established for VIX and BOVESPA variables in model;

$$BOVESPA_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}BOVESPA_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}VIX_{t-i} + u_t \quad (5)$$

$$VIX_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}BOVESPA_{t-i} + v_t \quad (6)$$

$$VIX_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}BOVESPA_{t-i} + u_t \quad (7)$$

$$BOVESPA_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}BOVESPA_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}VIX_{t-i} + v_t \quad (8)$$

B) These equations were established for VIX and RTSI variables in model;

$$RTSI_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}RTSI_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}VIX_{t-i} + u_t \quad (9)$$

$$VIX_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}RTSI_{t-i} + v_t \quad (10)$$

$$VIX_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}RTSI_{t-i} + u_t \quad (11)$$

$$RTSI_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}RTSI_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}VIX_{t-i} + v_t \quad (12)$$

B) These equations were established for VIX and BSESN variables in model;

$$BSESN_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}BSESN_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}VIX_{t-i} + u_t \quad (13)$$

$$VIX_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}BSESN_{t-i} + v_t \quad (14)$$

$$VIX_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}BSESN_{t-i} + u_t \quad (15)$$

$$BSESN_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}BSESN_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}VIX_{t-i} + v_t \quad (16)$$

C) These equations were established for VIX and SSEC variables in model;

$$SSEC_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}SSEC_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}VIX_{t-i} + u_t \quad (17)$$

$$VIX_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}SSEC_{t-i} + v_t \quad (18)$$

$$VIX_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}SSEC_{t-i} + u_t \quad (19)$$

$$SSEC_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}SSEC_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}VIX_{t-i} + v_t \quad (20)$$

D) These equations were established for VIX and INVSAF40 variables in model;

$$INVSAF40_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}INVSAF40_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}VIX_{t-i} + u_t \quad (21)$$

$$VIX_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}INVSAF40_{t-i} + v_t \quad (22)$$

$$VIX_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}VIX_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}INVSAF40_{t-i} + u_t \quad (23)$$

$$INVSAF40_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}INVSAF40_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}VIX_{t-i} + v_t \quad (24)$$

**Table 2.** Lee- Strazicich unit root test results

Lee Strazicich (Model C)						
Variable	Level	Level Breaking Date	Critical Value	1.	1. Difference Breaking Date	Critical Value
	Test Statistics			Difference Test Statistics		
VIX	-5.689540*	10 August 2012	-3.922130			
BOVESPA	-4.411910*	9 October 2015	-4.059449			
RTSI	-4.566403*	19 May 2015	-4.056076			
BSEN	-3.341494	28 July 2017	-3.982218	-21.04708*	14 Nov. 2014	-4.038286
SSEC	-3.339993	20 January 2015	-4.044412	-12.51619*	1 April 2015	-4.051643
INVSAF40	-4.516936*	19 February 2014	-4.009447			

\*: It is significant at 5% level.

According to the LS unit root test results, it was determined that the majority of the series were stationary at the level without breaking.

*H2*: There is a unit root for the data of the series and it is not stationary.

*H3*: There is no unit root for the data of the series and it is stationary.

Among variables, only BSESN and SSEC variables are not stationary at level. *H2* hypothesis is not able to rejected for and *H3* is rejected. For this reason, it was observed that the first difference was obtained for the series, and the stationarity was ensured. On the other hand, *H3* hypothesis not able to rejected for VIX, BOVESPA, RTSI, INVSAF40 variables. *H2* is rejected. In addition, when the breaking dates obtained for all variables are analyzed, it is seen that there is no extraordinary situation in the markets and there are breaks due to political and political movements in the countries.

### 3.6. Toda-Yamamoto Causality Test

Toda-Yamamoto Model was used to examine the causality between the series. The tests were carried out one by one between the variables in the form of a double test. While performing the Toda-Yamamoto test, the lag length (*k*) of the series was found according to the Schwarz Information Criterion (SC) and the maximum degree of integration  $d_{max}$  was found according to the Lee-Strazicich (LS) unit root test. Then, by applying Wald statistics to the *k*-lagged values in this model, it was tried to determine whether there was a causal relationship.

**Table 3.** Toda-Yamamoto causality test results

Dependent Variable	Independent Variable	$d_{max}$	<i>k</i>	Chi-Square Test Statistics	Chi-Square Test Value	Significant Relation
BOVESPA	VIX	0	1	0.968666	0.3250	No relation
RTSI		0	2	39.90069	0.0000*	VIX → RTSI
BSESN		1	2	88.19602	0.0000*	VIX → BSESN
SSEC		1	2	67.34655	0.0000*	VIX → SSEC
INVSAF40		0	2	91.43283	0.0000*	VIX → INVSAF40

\*: It is significant at 5% level.

The optimal lag length was determined according to the criterion SC,  $d_{max}$  = the maximum stationarity level according to the unit root test of Lee Strazicich, *k* = VAR denotes the lag length. According to the findings obtained from the analyzes in which the VIX index was taken as the independent variable in Table 3, a causality relationship with a 5% significance level was realized from the VIX variable to the variables RTSI, BSESN, INVSAF40 and SSEC. It is seen that *H1* hypothesis is rejected, *H0* hypothesis is not able to rejected. However, there

was no causality relationship between VIX variable and BOVESPA variables at a 5% significance level. It is seen that the established  $H_0$  hypothesis is not able to rejected. The  $H_1$  hypothesis is rejected.

$H_0$ : The independent variable is not the Granger cause of the dependent variable.

$H_1$ : The independent variable is the Granger cause of the dependent variable.

More specifically, a strong causality relationship has been identified from the VIX index to the stock markets. It was found that a price change in the VIX index is the reason for the change in the RTSI, BSESN, INVSAF40, and SSEC indices.

**Table 4.** Toda-Yamamoto causality test results

Dependent Variable	Independent Variable	dmax	k	Chi-Square Test Statistics	Chi-Square P-value	Significant Relation
VIX	BOVESPA	0	1	0.990072	0.3197	No relation
	RTSI	0	2	7.044503	0.0295	RTSI → VIX
	BSESN	1	2	2.785884	0.2483	No relation
	SSEC	1	2	0.298418	0.8614	No relation
	INVSAF40	0	2	8.785647	0.0124	INVSAF40 → VIX

\*: It is significant at 5% level.

The optimal lag length was determined according to the criterion SC, dmax = the maximum stationarity level according to the unit root test of Lee Strazicich, k = VAR denotes the lag length

In Table 4, according to the findings obtained from the analysis that BOVESPA, RTSI, BSESN, INVSAF40, SSEC indices were taken as a independent variables, a causality relationship from RTSI, INVSAF40 variables to VIX was determined. It was seen that the  $H_1$  hypothesis was rejected  $H_0$  hypothesis was not able to rejected. However, there was no causality relationship between from BOVESPA, BSESN, SSEC variables to VIX variables at a 5% significance level. It is seen that the established  $H_1$  hypothesis is not able to rejected. The  $H_0$  hypothesis is rejected.

$H_0$ : The independent variable is not the Granger cause of the dependent variable.

$H_1$ : The independent variable is the Granger cause of the dependent variable.

More specifically, a partial causality relationship has been determined from stock markets to the VIX index. It was found that a price change in RTSI, INVSAF40 indices is the reason for the change in the VIX index. On the other hand, it was found that a price change in BOVESPA, BSESN, SSEC indices is not the reason for a change in the VIX index.

#### **4. CONCLUSION**

Today, Investors who are trying to get the best profit of their investments, follow VIX and a number of similar indicators. The VIX index is a volatility index, and it is the most considered index among these indicators. A volatility index is created in relation to a financial asset or market. However, this relationship may have emerged due to the indirect effect of another volatility index on that index. In this context, investors need to take into account periodic causal relationships when interpreting the changes in the indices they follow in the portfolio management process.

In this study, the effects of price changes in the VIX index between the dates of 02.24.2011 and 06.01.2020 on the developing countries were examined. And also, daily closing prices of VIX index and BRICS countries stock markets, causal relationship was tested with Toda Yamamoto analysis. Before the analysis was run, Lee Strazicich unit root test was used. All variables were found to be stable at I (0) level except for India (BSESN) and China (SSEC) stock markets. Both of these variables became stationary after taken to first difference. In addition, the breaking dates of the series were also shared. it is seen that there is no extraordinary situation in the markets and there are breaks due to political and political movements in the countries.

Considering the findings obtained from the study, it has been observed that the VIX index is in a bilateral causality relationship with Russia (RTSI) and South Africa (INVSAF40) stock markets. On the other hand, it is determined that the price changes in the VIX index have a unilateral causality relationship on India (BSESN) and China (SSEC) indices. However, it was concluded that there is no unilateral or bilateral causal relationship between VIX index and the Brazilian (BOVESPA) stock market. Findings for Brazil (BOVESPA) contradict with Korkmaz and Çevik (2009) study, while findings with India (BSESN) and China (SSEC) are similar to study of the Öner vd.. (2018) study. On the other hand, when we look at the causality relationship between Brazil and the VIX index, similar results were found with Sarwan and

Khan (2017). Therefore, it is among other findings that this result is in the opposite direction with the study of İskenderoğlu and Akdağ (2018).

From this point of view, it is concluded that price movements are effective in stock markets in the VIX index. The findings obtained were compatible with a previous study. Therefore, it has been confirmed by the findings of this study that the VIX index is an important indicator especially for international investors. The change in the VIX index is important for investors who want to invest in stock markets in developing countries. Based on this, it is important to follow this index for maximum profit on stock portfolios. It is hoped that this study will save time and effort in terms of both international investors, policy makers, and academics in this field. And also it is also thought to be an up-to-date investment guide for investors who want to invest in developing countries.

## **REFERENCES / KAYNAKLAR**

- Akdağ, S. (2019) VIX korku endeksinin finansal göstergeler üzerindeki etkisi: Türkiye örneği. *Hitit Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 12(1), 235-256.
- Akdağ, S., Deran, A. & İskenderoğlu, Ö. (2018). Pmi ile çeşitli finansal göstergeler arasındaki ilişkinin dinamik nedensellik analizi ile incelenmesi: Türkiye örneği. 22. *Finans Sempozyumunda*, Mersin Üniversitesi. Retrieved: 02.04.2020, <http://185.109.28.8/finans22/22-Finans-Sempozyumu-Bildiriler-Kitabi.pdf>
- Arbatlı, E. (2011). Economic policies and fdi inflows to emerging market economies. *International Monetary Fund*, WP/11/192.
- Bardgett, C., Gourier, E. & Leippold, M. (2019). Inferring volatility dynamics and risk premia from the S&P 500 and VIX markets. *Journal of Financial Economics*, 131(3), 593-618.
- Basher, S. A. & Sadorsky, P. (2016). Hedging emerging market stock prices with oil, gold, vix, and bonds: A comparison between DCC, ADCC and GO-GARCH. *Energy Economics*, (54), 235-247.
- Borsa Terimler Sözlüğü (BTS). (2020). Retrieved: 02.04.2020, <http://www.terimleri.com/borsa/Volatilite.html>
- Bouri, E., Gupta, R., Tiwari, A. K. & Roubaud, D. (2017). Does bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters*, (23), 87-95.
- Doğan, Z., Buyrukoğlu, S. & Kutbay, H. (2018). Türkiye’de bitcoin işlemlerinin vergilendirilmesi ve muhasebeleştirilmesine ilişkin öneriler. *Vergi Sorunları Dergisi*, (361), 23-33.
- Fernandes, M., Medeiros, M. C. & Scharth, M. (2014). Modeling and predicting the CBOE market volatility index. *Journal of Banking & Finance*, (40), 1-10.
- Investing.com (2020). [www.investing.com](http://www.investing.com) CBOE, Retrieved: 6 April 2020, <https://www.investing.com/search/?q=CBOE>



İskenderoğlu, Ö. & Akdağ, S. (2018). VIX korku endeksi ile çeşitli ülkelerin hisse senedi endeks getirileri arasında bir nedensellik analizi. *Uluslararası Ekonomi Araştırmaları ve Finansal Piyasalar Kongresi*, Nevşehir Hacı Bektaş Veli Üniversitesi. Retrieved: 01.04.2020, [http://ierfm.com/Documents/ierfm\\_2018\\_bildiri\\_kitabi.pdf](http://ierfm.com/Documents/ierfm_2018_bildiri_kitabi.pdf).

Korkmaz, T. & Çevik, E., İ. (2009). Zimni volatilité endeksinden geliřmekte olan piyasalara yönelik volatilité yayılma etkisi. *BDDK Bankacılık ve Finansal Piyasalar Dergisi*, 3(2), 87-105.

Lee, Junsoo & Strazicich, M. C. (2004) Minimum LM unit root test with one structural break. *Working Paper, Appalachian State University*, 04-17.

Lee, Junsoo & Strazicich, M. C. (2003) Minimum lagrange multiplier unit root test with two structural breaks, *Review of Economics and Statistics*, 85(4), 1082-1089.

Mcguire, P. & Schiijvers, M. A. (2003). Common factors in emerging market spreads. *Bis Quarterly Review*, December, 65-78.

Öner, H., İçelliođlu, C. ř. & Öner, S. (2018). Volatilité endeksi (VIX) ile geliřmekte olan ÷lke hisse senedi piyasası endeksleri arasındaki engel-granger eřbütünleşme ve granger nedensellik analizi. *Finansal Araştırmalar ve Çalışmalar Dergisi*, 10(18), 110-124

Özcan, B. (2012). İşsizlik histerisi hipotezi oecd ÷lkeleri için geçerli mi? Yapısal kırılmalı birim kök analizi. *Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, (40), 95-117.

Sakarya, ř. & Akkuş, H. T. (2018). Bist-100 ve bist sektör endeksleri ile vix endeksi arasındaki ilişkisinin analizi. *Balıkesir Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 21(40), 351-374.

Sarwar, G. & Khan, W. (2017). The effect of US stock market uncertainty on emerging market returns. *Emerging Markets Finance and Trade*, 53(8), 1796-1811.

Tıraşođlu, B. Y. (2014). Yapısal kırılmalı birim kök testleri ile oecd ÷lkelerinde satın alma gücü paritesi geçerliliđinin testi. *Ekonometri ve İstatistik e-Dergisi*, (20), 68-87.

Toda, H. Y. & Yamamoto, T. (1995). Statistical inference in vector auto regressions with possibly integrated processes. *Journal of Econometrics*, (66), 225-250.

Yavuz, N. Ç. (2006) Türkiye’de turizm gelirlerinin ekonomik büyümeye etkisinin testi: Yapısal kırılma ve nedensellik analizi. *Dođuş Üniversitesi Dergisi*, 7(2), 162-171.

Yılancı, V. (2009). Yapısal kırılmalar altında Türkiye için işsizlik histerisinin sınanması. *Dođuş Üniversitesi Dergisi*, 10(2), 324-335.