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The effect of stock market and banking sector developments on energy consumption in BRICS: Evidence from panel vector autoregressive analysis

Abstract

Energy is an important resource in the economic development of countries. While it is used as an input in production, it also has an important usage area in consumption. For these reasons, the factors affecting energy use have been the subject of many studies. This study examines the impact of financial development (FD) on energy consumption (EC) in BRICS countries (Brazil, Russia, India, China, and South Africa). In the study, EC, FD, economic growth, foreign direct investments and total trade (%GDP) variables for the period 1994–2017 were examined with the help of the PVAR (panel vector autoregressive) model. According to the findings, there is a unidirectional relationship from both EC and economic growth to the development of the banking sector.

Keywords: Financial development, energy consumption, banking sector, panel causality, panel vector autoregressive model

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1. INTRODUCTION

Energy is an important factor in countries' economic growth and development (Hussaini & Majid, 2015; Mukhtarov et al., 2020; Sadorsky, 2010). It is used as an input in the production of almost all goods and services. For this reason, the importance of energy in developing countries is gradually increasing (Islam et al., 2013; Mahalik et al., 2017; Mukhtarov et al., 2020; Stern, 2011). Many developing countries have growing economies, which causes a significant increase in energy demand (Sadorsky, 2010; Shahbaz & Lean, 2012). According to the International Energy Agency (IEA) report, it is estimated that the world energy demand will increase by 1.8% every year between 2005 and 2030. It is estimated that 74% of this increase will originate from developing countries. For this reason, the rapid growth of developing countries and the increase in their demand for energy is an important academic study. However, the direction of causality between FD, EC and economic growth has remained a matter of debate in studies conducted so far. It is known that there is no consensus on this issue (Islam et al., 2013).

The view that there is a relationship between EC, FD and economic growth has been accepted by many studies (McKinnon, 1973; Schumpeter, 1911; Shaw, 1973). This idea has been explained based on two different views (Fung, 2009; Robinson, 1952; Sadorsky, 2011). First, the efficiency of the financial system is mentioned (Bekaert & Harvey, 2000). Furuoka (2015) argues that household consumption will increase thanks to an efficient financial system. In other words, he states that with the increase in the demand for consumer goods, the energy demand will also increase. In Sadorsky's (2011) research, consumers buy loans at affordable prices thanks to increasing FD. Thus, it predicts that the demand for high energy-consuming products such as automobiles, residences and large household appliances will increase. Therefore, the production and consumption of such products lead to an increase in EC. Mankiw and Scarth (2008) state that the development in capital and money markets in countries positively affects both the real sector and the incomes of individuals and creates an economic richness effect.

According to another view, it is argued that an increase in production will increase EC along with it. The existence of a good financial sector will increase production activities in the country. This situation increases the activities of producers and causes an increase in EC (Furuoka, 2015; Gurley & Shaw, 1955; Xu, 2000). For example, Minier (2009) and Wang and Gong (2020) state that more funds can be provided to investment projects due to the developments in the stock market, causing foreign direct investment to countries to increase. Foreign direct investment encourages infrastructure investment and economic growth. It is emphasized that this situation can have a positive effect on EC. In addition, Gurley and Shaw (1955) and Xu (2000) state that financial costs will decrease thanks to a developed financial system, thus increasing investments and contributing to economic growth.

Both considerations mentioned earlier indicate an important relationship between FD and EC. In addition, FD and EC have a positive effect on economic growth by affecting both producers and consumers (Abu-Bader & Abu Qarn, 2008; Gomez & Rodriguez, 2019; Kakar, 2016; Ouyang & Li, 2018). When the literature is examined, it is seen that the results between EC and financial and economic development are controversial. For this reason, to contribute to the literature, we decided to examine the subject specifically for the BRICS countries (Brazil, Russia, India, China, and South Africa). There are two reasons for choosing the BRICS countries. First, we aim to contribute to the literature by carrying out a study specific to BRICS countries. Another reason is that energy demand is expected to increase by more than 1.4% annually in developing countries and emerging markets until 2030. In particular, it is estimated that about half of this increase will be met by China and India alone (World Energy Outlook, 2022). For these reasons, we preferred BRICS countries in our study. The next part of the study will present a summary of the literature on the subject. In the last section, the findings will be discussed.

2. LITERATURE REVIEW

Many studies are examining the relationship between EC and FD. When these studies are examined, it is apparent that there is no consensus on the subject. Because countries' FD and dependence on energy resources are different, especially in countries with increasing energy demand for sustainable economic growth, they must have a developed financial market to meet their energy costs. In addition, some countries meet their energy demands from their resources. Some countries even export excess demand production. This situation positively impacts the relevant country's financial market due to energy exports. Considering the relationship between the energy sector and FD causes different discussions in countries that meet their EC from their resources and those that meet them through imports. In addition, countries with a developed financial sector can not only meet their energy demand but also closely monitor technological developments in the energy sector by providing financing. For this reason, there may be different interactions between EC and financial markets in developed and developing countries.

Research the literature; it is seen that many studies conclude that FD increases energy demand (Al-Mulali & Lee, 2013; Baloch et al., 2019; Danish & Ulucak, 2021; Gaies et al., 2019; Godil et al., 2021; Islam et al., 2013; Ma & Fu, 2020; Mukhtarov et al., 2018; Mukhtarov et al., 2020; Ozdeser et al., 2021; Shahbaz et al., 2013; Tang & Tan, 2015; Yue et al., 2019; Nguyen et al. (2021); Thebuho (2022)). In his study on China, Xu (2012) determined that FD has a significant positive effect on EC. Islam et al. (2013) determined that economic growth and FD in Malaysia affect short- and long-term EC. Kakar (2016), the findings concluded that EC plays an essential role in the economic growth of both Pakistan and Malaysia. In addition, while there is a short-term balance between variables for Pakistan, they determined that such a situation is not valid for Malaysia. Mukhtarov et al. (2018) in their studies, they found that FD and economic growth have a positive effect on EC in the long run. Also, Mukhtarov et al. (2020) found that FD increase EC in Kazakhstan. Shahbaz and Yalın (2012) for Tunisia; Abosedra et al. (2015) for Lebanon; Mahalik et al. (2017) for Saudi Arabia; Eren et al. (2019) for India; Ji and Zhang (2019) for China; Raza et al. (2020) for 15 countries; Pradhan et al. (2019) for G-20 countries; Zeren and Hızarcı (2021) for 5 countries; Mukhtarv et. (2022) for Turkey; Kevser et al. (2022) for 15 countries and Yi et al. (2023) reached similar results for countries that consume the most renewable energy.

When the subject of FD and EC are examined within the scope of country groups, it is seen that panel data methods are used. Al-Mulali and Lee (2013) investigated the relationship between FD and EC for the GCC from 1980–2009. Their study, using panel dynamic ordinary least squares (DOLS), determined that FD increases EC in the long run. Abidin et al. (2015) investigated the issue for ASEAN. According to the ARDL boundary test results, a long-term relationship was discovered between FD, foreign direct investment, EC and trade. In addition, a one-way Granger causality relationship from foreign direct investment to EC and from EC to FD has been determined. Ouyang and Li (2018) investigated the relationship between FD, EC and economic growth for 30 provinces in China with the panel vector autoregressive (PVAR) approach. As a result of the study, they determined that FD in China negatively affects both economic growth and EC. In addition, it was concluded that the relationships between FD, EC and economic growth in China differ between regions. Gomez and Rodriguez (2019) used Kao, and Fisher-Johansen cointegration approaches for the North American Free Trade Agreement (NAFTA) for the 1975–2015 period. Their study concluded that there is a cointegration relationship between EC, FD, and economic growth. Gaies et al. (2019) examined the relationship between EC and FD in the context of MENA. The findings obtained from the two-stage system GMM analysis concluded that EC increases with FD. Baloch et al. (2019) investigated the relationship between EC, FD, foreign direct investment and economic growth variables for 25 selected OECD countries. According to the results of the cointegration analysis of the Westerlund panel used in their studies, they determined a cointegration relationship between the variables. In addition, they found that FD increased the energy demand for the OECD. Elike et al. (2019) examined the relationship between FD and EC in African countries. According to the Bootstrap panel causality test results they used in their studies, they found a causal relationship between variables for the Republic of Congo, Nigeria, Senegal and Zambia. However, they concluded no causal relationship between Benin, Cameroon, South Africa, Sudan and Togo variables.

Nkalu et al. (2020) examined the relationship between FD and EC for sub-Saharan African countries with a panel vector error correction model, cointegration test and Granger causality approaches. According to the Granger causality test results, there is a one-way causality relationship between FD and EC. They also determined a one-way causality relationship between per capita gross domestic product to population growth and urbanization. Finally, the study suggests that the governments of sub-Saharan African countries should ensure fiscal discipline to control the problems that will adversely affect the real gross domestic product growth, especially in the long run. Ma and Fu (2020) examined the impact of FD on EC in 120 countries. In this study, in which the GMM approach was used, they found that FD positively affected EC. In addition, it has been argued that the relationship between the development of EC and the financial sector in developing countries should be balanced. Nguyen et al. (2021) examined the impact of institutional quality and FD on EC in 112 countries. Accordingly, they stated that FD increases EC per capita. Yılmaz (2021) investigated the relationship between renewable energy and FD for the G7. He found no causal relationship between the variables but a positive asymmetric relationship. Thebuho (2022) investigated the symmetrical and asymmetrical relationship between FD and EC in Sub-Saharan African countries. It has been determined that positive and negative shocks in FD have a positive effect on EC in the long run. Ahmad et al. (2022) investigated the issue in 17 developing countries. They concluded that there is a positive relationship between FD and economic growth. Saygın and Iskenderoglu (2022), in their study on 20 developing countries, used stock market and banking data as FD indicators. When both variables are used, it has been determined that FD does not affect renewable EC.

In the literature, studies are examining the effects of FD and EC on economic growth (Kraft & Kraft, 1978; Yu & Choi, 1985; Apergis & Payne, 2010; Iyke, 2015; Esen & Bayrak, 2017; Aydin & Esen, 2018; Asteriu ve Spanos (2019); Pradhan et al. (2019); Ho & Iyke, 2020; Wang et al., 2022). In his study, Kakar (2016) stated that EC is important for economic growth in Pakistan and Malaysia. In addition, while there is a short-term balance between EC and economic growth for Pakistan, he stated that such a situation is not valid for Malaysia. On the other hand, Eren et al. (2019) investigated the issue for India. Accordingly, it has been determined that renewable EC and economic growth are affected by FD. In addition, it does not detect a bidirectional relationship between economic growth and EC. Gomez and Rodriguez (2019) used Kao and Fisher-Johansen cointegration approaches for the North American Free Trade Agreement (NAFTA) for the 1975–2015 period. According to the findings obtained from the study, they concluded that there is a cointegration relationship between EC, FD and economic growth. Raghutla and Chittedi (2020) determined that FD and EC affect economic growth in India. Chiu and Lee (2020) investigated the issue for 79 countries. Accordingly, they concluded that FD will reduce EC. According to Bin Amin et al. (2022) conducted studies on South African countries. According to their findings, it is concluded that an increase in FD reduces renewable EC by 0.07-0.15% in the long run.

In the literature, studies state that the effect of FD on EC is negative or non-existent (Çoban & Topcu, 2013; Ali et al. (2015); Riti et al., 2017; Gomez and Rodriguez (2019); Ouyang & Li, 2018; Yue et al., 2019). Wolde-Rufael (2006) has researched the subject in 17 African countries. He concluded that there is an inverse relationship between EC and economic growth in three countries. Çoban and Topcu (2013) concluded in their study of 27 European countries that there is no causal relationship between FD and EC. Ali et al. (2015) examined the issue for Nigeria and determined that FD negatively affects fossil fuel consumption in the short run. Farhani and Solarin (2017) determined in their study on the USA that FD reduces energy demand. In their study on India, Shahbaz et al. (2017) determined that FD is negatively related to EC. Support (2018) researched the issue in 17 de-

Table 1. Variables employed in the panel data analysis

Variables	Description	Source
ENERGY	EC (quad Btu)	U.S. Energy Information Administration
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank
FD1	Domestic credit to private sector (% of GDP)	World Bank
FD2	Stock market capitalization to GDP (%)	World Bank
TRADE	Trade (% of GDP)	World Bank
GDP	GDP per capita (constant 2010 US$)	World Bank

veloping countries. Accordingly, he determined that the developments in the financial markets harmed EC. Ouyang and Li (2018) found that EC harms economic growth in their study of China. In addition, they determined that financial instruments such as M2, credit, the revenue of the insurance industry, and stock market value negatively affect economic growth. Gomez and Rodriguez (2019) examined the relationship between EC and FD for NAFTA countries. They determined that there is a negative relationship between FD and EC. They also found a negative relationship between EC and economic growth.

3. DATA AND METHODOLOGY

3.1. Data

This study investigates the relationship between FD and BRICS countries. Annual data is used from 1994–2017. EC, FD, foreign direct investments, net inflow (%GDP), total trade (%GDP) and economic growth are used. Gross domestic product per capita is used as an indicator of economic growth. Two indicators are used for FD, namely the banking sector and stock market developments. These are domestic credit to the private sector (%GDP) for banking sector development and stock market capitalization to GDP (%) for stock market development. Table 1 gives information about the variables used in the analysis.

Firstly, the cross-sectional dependence test is performed in the study followed by the panel unit root test. Afterwards, The PVAR model is used to examine the relationship among the variables. The PVAR model is estimated with GMM. The impulse-response and variance decomposition are performed.

3.2. Cross Dependence Test And Panel Unit Root Test

Pesaran (2004) suggests the following test statistic based on the LM test statistics:

$$CD = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1) \qquad (1)$$

$\hat{\rho}_{ij}$ is the correlation coefficient between the residuals obtained from the least squares estimation. In this test, where the number of units is N and the time interval is T, the cases $T \rightarrow \infty$ and $N \rightarrow \infty$ are valid. For more detailed information, see Pesaran (2004).

It is important to note whether the series has a cross-sectional dependence to apply panel unit root tests. Panel unit root tests applied without considering the cross-sectional dependence cause dimensional distortions and low power in the series. Second-generation panel unit root tests, which consider cross-sectional correlations, have been proposed in the literature (Hurlin & Mignon, 2007). In the Pesaran (2007) approach, the cross-sectional Dickey-Fuller (CADF) equation is as follows. This equation (2) contains the cross-section averages of the lagged levels of the augmented Dickey-Fuller (ADF) equation and the first differences of the series.

$$\Delta y_{i,t} = \alpha_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + \varepsilon_{i,t} \quad (2)$$

In the Pesaran (2007) approach, the averages of the cross-sectional $(\bar{y}_{t-1} = N^{-1} \sum_{j=1}^{N} y_{j,t-1})$ and the cross-sectional dependence of errors $(\Delta \bar{y}_t)$ are included. Variables with $\Delta y_{i,t-s}$ and $\Delta \bar{y}_{t-s}$ (s=1,2, …) variables are added to the DF equation arranged as a horizontal section. The purpose of this is to prevent the serial correlation problem that may occur in errors. The panel unit root test is calculated as the average of the CADF statistics (Pesaran et al., 2013). Pesaran's (2007) panel unit root test is calculated as a cross-sectional generalized version of the IPS test based on the CIPS test.

$$\text{CIPS} = \frac{1}{N} \sum_{i=1}^{N} t_i\,(N, T) \quad (3)$$

CIPS statistic is used because CADF statistics are not cross-sectional dependence (Gengenbach et al., 2009).

3.3. Panel Vector Autoregressive Model

Researchers in different fields and applications use PVAR models. The models combine the traditional VAR model, which handles all variables in the system internally, and the panel data, which includes unobserved unit heterogeneity (Magazzino, 2017). PVAR model is one of the methods used in researching macroeconomic dynamics. It presents a model for internal and external shocks, which are the sources of these macroeconomic dynamics (Charfeddine & Kahia, 2019).

PVAR contains the lag lengths of each variable and the lag lengths of other variables included in the model. The PVAR model can reveal the time variation in the variance and coefficients of the shocks (Ouyang & Li, 2018). In the PVAR model, the shocks eventually approach zero, and it means that the shocks are temporary and return to the deterministic trends of the series in the long run (Góes, 2016).

Love and Zicchino (2006) apply the PVAR approach to examine the relationship between the financial conditions and investments of more than 8000 firms in 36 countries. The fixed effect PVAR model with k variables and p order can be defined in equation (1). The generalized moment method (GMM) can be used to estimate the PVAR model. The GMM is used in internality problems and biased due to omitted variables (Ma & Fu, 2020).

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \dots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + X_{it}B + u_i + \varepsilon_{it} \quad (4)$$

Y_{it} refers to the vector of the dependent variables and is the vector of independent variables in equation (4). shows the panel constant effects specific to the dependent variable and is the error terms of the model. $A_1, A_2, \dots, A_{p-1}, A_p$ and B are the matrices of the parameters to the estimate.

Impulse-response functions reveal the response of one variable to the innovations of another variable in the system, under the assumption that all other shocks are equal to zero. Since the variance-covariance matrix of the errors is unlikely to be diagonal, it is necessary to decompose the errors orthogonally to isolate the shocks (Love & Zicchino, 2006). In this context, the study deals with the impulse-response functions to reveal the reaction of one variable on another variable with the contribution of innovations. The variance decompositions are shown in the study. Variance decompositions show how many per cent of the change in a variable over time is due to itself and other variables. Variance decompositions indicate the size of the total effect (Magazzino, 2016).

Panel Granger Analysis

After the PVAR model is estimated, the causality between the variables is examined with the panel Granger approach. The null hypothesis that the coefficients in all lags of an endogenous variable are equal to zero is analysed using the Wald test (Abrigo & Love, 2016). In the panel Granger causality test, the variables are analysed in pairs within the scope of the analysis. Each variable should be used as a dependent in PVAR

Table 2. Pesaran (2004) cross dependence test

Variables	CD test statistic	Prob.
ENERGY	13.62	0.00**
FDI	1.98	0.04*
FD1	10.41	0.00**
FD2	10.04	0.00**
TRADE	5.41	0.00**
GDP	15.17	0.00**

Note: **, * signify 1%, 5% significance levels, respectively. The series are analyzed by taking their logarithms.

models. Whether the variables of foreign direct investments, FDs, economic growth, and trade cause EC is examined depending on the equations (5) and (6) below. These two equations are PVAR equations created for different indicators (stock market development and banking sector development) of FD. The variables in the equations are stationary.

$$\mathrm{DLENERGY}_{it} = \alpha_0 + \sum_{k=1}^{K} \varphi_k \mathrm{DLFD1}_{it-k} + \sum_{k=1}^{K} \beta_k \mathrm{DLTRADE}_{it-k} + \sum_{k=1}^{K} \gamma_k \mathrm{DLGDP}_{it} + \sum_{k=1}^{K} \delta_k \mathrm{DLFDI}_{it-k} + \varepsilon_{it} \quad (5)$$

$$\mathrm{DLENERGY}_{it} = \alpha_0 + \sum_{k=1}^{K} \varphi_k \mathrm{LFD2}_{it-k} + \sum_{k=1}^{K} \beta_k \mathrm{DLTRADE}_{it-k} + \sum_{k=1}^{K} \gamma_k \mathrm{DLGDP}_{it} + \sum_{k=1}^{K} \delta_k \mathrm{DLFDI}_{it-k} + \varepsilon_{it} \quad (6)$$

In the PVAR model, which is expressed as i country and t time in equations (5) and (6), is EC; $FD1_{it}$ is banking sector development; $FD2_{it}$ is stock market development; FDI_{it} is foreign direct investments; $TRADE_{it}$ is the ratio of total foreign trade to gross domestic product. μ_i indicates unobserved country-specific effects, and ε_{it} is the error term. For the PVAR models, the lag length, denoted by K and the appropriate lag length is determined by the Schwarz information criteria. The results of the causality tests are shown in Table 6.

4. RESULTS

4.1. Cross-Sectional Dependence and Panel Unit Root Test

Unit root tests are performed in panel data series. The inclusion of panel data series that are stationary provides better results in the analysis. For series with cross-section dependence, panel unit root tests are used, which takes into account. For this reason, it is first examined whether the series have cross-sectional dependence. Table 2 shows the results of the Pesaran (2004) cross-sectional dependence test. According to the results, the null hypothesis is rejected for all variables. Accordingly, it is seen that all variables are cross-sectional dependence.

Pesaran (2007) panel unit root test is applied for the variables with cross-sectional dependence. Pesaran (2007) panel unit root test results are shown in Table 3. The results show that all variables have unit roots at the level. If the first difference of the variables at different significance levels is taken, it is concluded that the variables are stationary. During the analysis period, all variables except the FD2 variable are stationary at the first difference at 1% significance level according to both constant and constant and trend unit root test.

Table 3. Pesaran (2007) panel unit root test

Variables	Level		First Difference	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
ENERGY	-2.659**	-2.196	-3.280**	-3.353**
FD1	-2.072	-2.483	-3.981**	-4.564**
FD2	-3.971**	-4.913**	-4.574**	-4.529**
TRADE	-2.130	-2.519	-3.574**	-3.391**
FDI	-2.109	-2.526	-5.301**	-5.413**
GDP	-2.239*	-2.214	-3.182**	-3.375**

Note: The maximum lag is set as 4, and the BG lag is set as 8. **, * signify 1%, 10% significance levels, respectively. The series are analyzed by taking their logarithms.

4.2. Impulse-Response Functions - Graphical Analysis

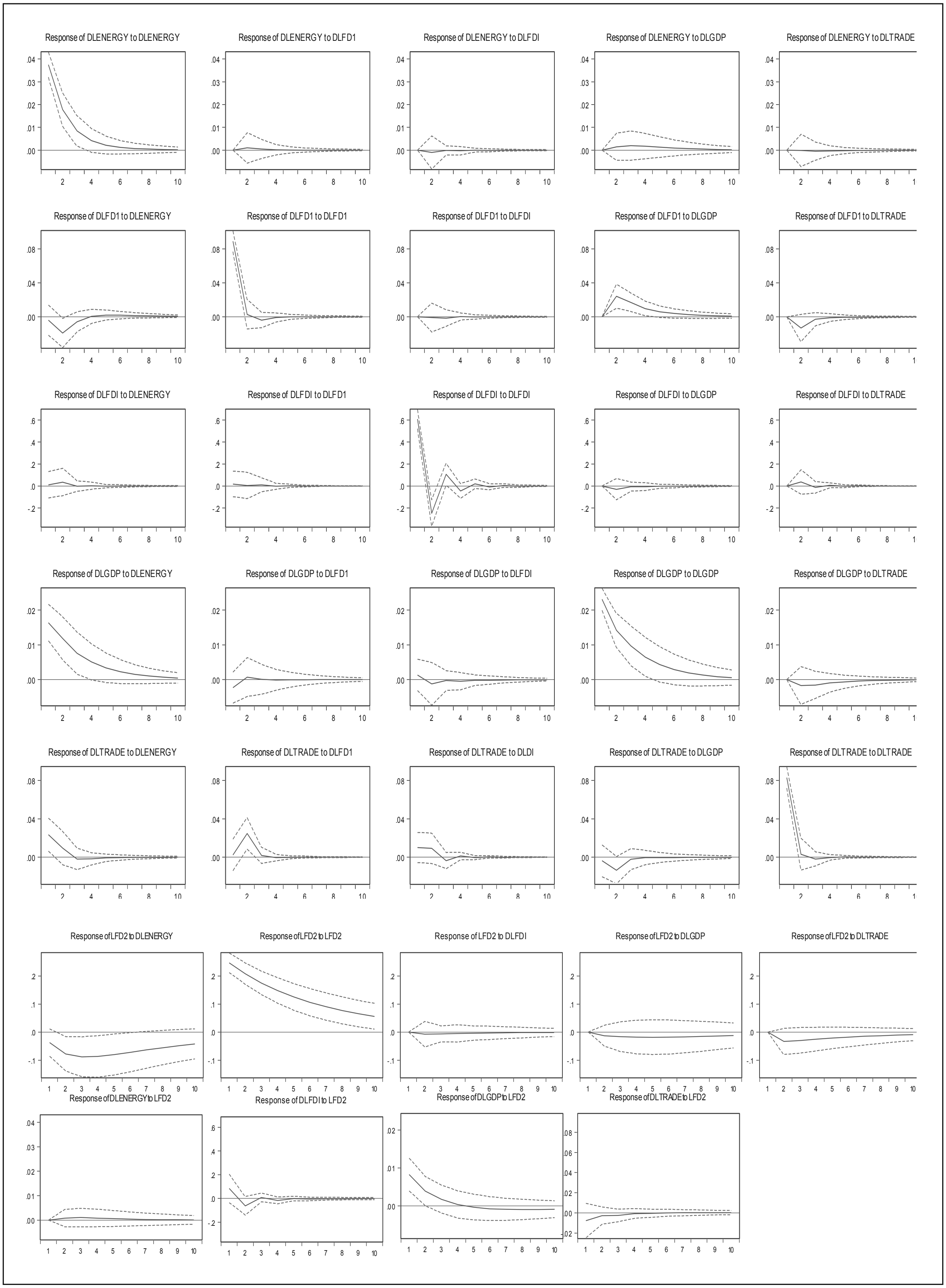
Impulse-response functions are analysed for PVAR models created with different FD indicators in the study. Figure 1 shows graphs of impulse-response functions. Standard errors of impulse-response functions and confidence intervals are calculated with Monte Carlo simulations. The lines on either side of the impulse-response represent the limits with 1000 replicates of the Monte Carlo simulation at the 5% significance level. Graphs of impulse-response functions and error bands by Monte Carlo simulation at 5% significance level are given in Figure 1. The horizontal axis in Figure 1 shows the reaction of 10 years, and Figure 1 shows that the responses of the variables converge to zero in the time interval.

According to the PVAR model established with the banking sector development (DLFD1), graphs of impulse-response functions are given. The first graphs show how EC (DLENERGY) responds to shocks in banking sector development, foreign direct investment (DLFOREIGN), economic growth (DLGDP), trade (DLTRADE) and EC variables. Accordingly, the EC responses to a standard deviation shock in the DLFD1 increase in the second year and reach zero after the fourth year. On the contrary, when a standard deviation shock occurs in DLFDI, the responses of DLENERGY are negative in the second year and then steadily approach zero. The responses of DLENERGY to a standard deviation shock in DLGDP increase in the second year and then decrease steadily after the fourth year.

The graphs shown in the second row in Figure 1 show the responses of the DLFD1 to the shocks in the variables. DLFD1 responds negatively to the DLENERGY, primarily until the fourth year, and the responses are positive in the following years. The responses of DLFD1 to the shocks in DLGDP and DLTRADE variables are different. While the responses of DLENERGY to the shock in DLGDP are a positively significant increase in the second year, the shock in DLTRADE is negative in the second year. The responses of DLENERGY to shocks in DLGDP shows a decreasing trend in the positive area. The responses of DLENERGY to shocks in DLTRADE have approached zero after the fourth year.

The responses of DLFDI to a shock in each variable in the study is shown in the third row of graphs in Figure 1. When a standard deviation shock occurred in DLENERGY, DLFDI1, and DLTRADE variables, the responses of the DLFDI are positive. The responses of DLFDI to the shocks in these variables approaches zero in a short time. The DLFDI variable responses negatively to the shock of the DLGDP until the third year, and then it is found to be equal to zero from four to ten years.

Figure 1: Impulse responses for pvar of dlenergy, DLGDP, DLFD1, LFD2, DLFDI, DLTRADE



The fourth-row graphs in Figure 1 show the responses of DLGDP to shocks in each variable. As seen in the first graph, when a DLENERGY shock occurs, the response of DLGDP is positive and shows a decreasing trend. When a shock occurs in DLFD1, DLGDP responses are negative in the first year and equal to zero after reacting positively in the second year. However, to a shock in DLFDI, DLGDP responses positively in the first year and negatively in the second year. The responses of DLGDP to a shock in DLTRADE are negative and equal to zero in the sixth year. The responses of DLTRADE are initially positive to the shocks in DLENERGY, and these responses turn negative between 3-4 years. DLTRADE responses to a shock in DLFD1 shows a significant positive increase in the second year and stabilize after the third year. DLGDP responses negatively to the shocks of DLTRADE.

The last two rows represent the impulse-response functions with the stock market development (LFD2) variable representing FD. The responses of DLENERGY to the shock in LFD2 start in the positive area and approach zero, showing a decreasing trend. The responses of LFD2 to a standard deviation shock in DLFDI are negative up to the fourth year and equal zero between 5-10 years. LFD2 responses are negative to the shock in DLGDP. Similarly, the LFD2 responses are negative to the shock in DLTRADE in the second year and then approach zero.

The last row of Figure 1 shows the graphs of the responses of variables when a shock occurs in LFD2. The responses of DLENERGY show a positive regularity when a shock occurs. In contrast, the responses of DLTRADE to a shock in LFD2 are negative until the third year and become equal to zero in the following years. In response to this shock, DLGDP responses are initially positive and then negative after the fourth year. DLFDI responses are positive to the shock of LFD2 in the first year, and these responses become negative in the second year. In the following years, the decrease shows fluctuations and becomes equal to zero with the fifth year.

4.3. Variance decompositions

Tables 4–5 show the values of variance decomposition for two indicators of FD for BRICS. These tables give the variance decomposition results of a five-year period for the variables. These results include the findings for the variables in each group. The standard errors value in the variance decomposition results of DLENERGY for the PVAR model with DLFD1 ranges from 0.037 to 0.043. The second variable that explains the variation in DLENERGY over the five years is DLGDP. Accordingly, it is seen that the DLGDP, which explains the variation in DLGDP with values from 0% to 0.584%. The variation in DLFD1 explains 99.802% for the first year by itself, and this rate decreases to 83.089%. The variance decomposition shows that DLGDP explains 10.432% of the variations in DLFD1. DLENERGY explains 4.865% of the variations in DLFD1.

The values in the third group in Table 4 show the variance decomposition values of DLFDI. The variation in DLFDI explains 98.024% for the five years by itself. It is seen that the explanation rates of the other variables explaining the change in DLFDI are close to each other. The variations in DLFDI are the DLENERGY of 0.316% at the end of five years; 0.217% is explained by DLGDP and 0.3415% by DLTRADE.

The values in the fourth group shown in Table 4 give the variance decomposition of the DLTRADE. According to the results, the variation in DLTRADE values decreases from 91.131% to 80.488%. The second variable that explains the change in trade is DLENERGY. The DLENERGY explains the variation in DLTRADE with values from 7.292% to 7.556%. The DLFD1 explains that the variation in the DLTRADE variable takes values between 0.069% and 7.253%. Other variables explain the variation in the DLTRADE variable between 0.187% and 2.322%.

Table 4. Variance decomposition (FD1)

Period	SE.	DLENERGY	DLFD1	DLFDI	DLGDP	DLTRADE
Variance decomposition of DLENERGY						
1	0.037	100.000	0.000	0.000	0.000	0.000
2	0.042	99.759	0.059	0.057	0.124	0.001
3	0.042	99.535	0.070	0.055	0.329	0.011
4	0.043	99.367	0.070	0.059	0.489	0.015
5	0.043	99.270	0.070	0.059	0.584	0.017
Variance decomposition of DLFD1						
1	0.089	0.198	99.802	0.000	0.000	0.000
2	0.095	4.294	87.316	0.011	6.441	1.938
3	0.097	4.508	84.257	0.040	9.234	1.961
4	0.098	4.466	83.424	0.039	10.116	1.955
5	0.098	4.485	83.089	0.041	10.432	1.953
Variance decomposition of DLFDI						
1	0.609	0.037	0.090	99.873	0.000	0.000
2	0.661	0.323	0.080	99.087	0.204	0.306
3	0.670	0.316	0.100	99.040	0.209	0.335
4	0.671	0.315	0.102	99.027	0.216	0.340
5	0.671	0.316	0.102	99.024	0.217	0.341
Variance decomposition of DLTRADE						
1	0.087	7.292	0.069	1.321	0.187	91.131
2	0.093	7.497	7.241	2.159	2.329	80.774
3	0.093	7.518	7.255	2.304	2.377	80.546
4	0.093	7.551	7.255	2.319	2.378	80.497
5	0.093	7.556	7.253	2.322	2.381	80.488
Variance decomposition of DLGDP						
1	0.028	33.157	0.669	0.220	65.954	0.000
2	0.034	35.372	0.514	0.290	63.574	0.250
3	0.036	35.615	0.454	0.262	63.265	0.404
4	0.037	35.692	0.432	0.265	63.159	0.452
5	0.038	35.732	0.422	0.262	63.112	0.472

Note: Percent of variation in the column variable (5 periods) explained by the dlenergy, dlfd1, dlfdi, dlgdp, dltrade. SE denotes standard errors.

Table 5. Variance decomposition (FD2)

Period	SE.	DLENERGY	DLFD1	DLFDI	DLGDP	DLTRADE
Variance decomposition of DLENERGY						
1	0.038	100.000	0.000	0.000	0.000	0.000
2	0.042	99.741	0.040	0.065	0.154	0.001
3	0.042	99.512	0.066	0.066	0.319	0.003
4	0.043	99.359	0.072	0.072	0.426	0.006
5	0.043	99.277	0.073	0.073	0.484	0.008
Variance decomposition of LFD2						
1	0.250	2.176	97.824	0.000	0.000	0.000
2	0.336	6.490	92.357	0.046	0.137	0.971
3	0.391	9.873	88.518	0.061	0.269	1.279
4	0.428	12.310	85.837	0.061	0.395	1.397
5	0.454	14.032	83.952	0.060	0.509	1.447
Variance decomposition of DLFDI						
1	0.607	0.051	1.918	98.030	0.000	0.000
2	0.660	0.323	2.522	96.686	0.154	0.314
3	0.669	0.315	2.475	96.727	0.159	0.325
4	0.671	0.322	2.517	96.657	0.269	0.335
5	0.671	0.321	2.515	96.658	0.170	0.335
Variance decomposition of DLTRADE						
1	0.091	7.260	0.704	1.581	0.022	90.43
2	0.092	7.644	0.768	2.570	0.739	88.279
3	0.093	7.655	0.839	2.623	1.050	87.833
4	0.09	7.644	0.842	2.652	1.154	87.708
5	0.093	7.646	0.843	2.652	1.195	87.664
Variance decomposition of DLGDP						
1	0.029	34.524	8.522	0.008	56.946	0.000
2	0.034	36.440	7.312	0.531	55.454	0.263
3	0.036	37.558	6.716	0.532	54.858	0.336
4	0.037	38.245	6.391	0.559	54.460	0.345
5	0.038	38.651	6.250	0.558	54.197	0.343

Note: Percent of variation in the column variable (5 periods) explained by the dlenergy, lfd2, dlfdi, dlgdp, dltrade. SE denotes standard errors.

Table 6. Panel granger causality tests results

For FD1			For FD2		
Equation	**Excluded**	**Statistics**	**Equation**	**Excluded**	**Statistics**
DLENERGY			**DLENERGY**		
	DLFD1	0.484 (0.487)		LFD2	0.573 (0.449)
	DLTRADE	0.230 (0.632)		DLTRADE	0.494 (0.482)
	DLFDI	0.095 (0.758)		DLFDI	0.194 (0.660)
	DLGDP	0.259 (0.611)		DLGDP	0.017 (0.898)
	All	1.118 (0.891)		All	0.915 (0.922)
DLFD1			**LFD2**		
	DLENERGY	2.862 (0.091)*		DLENERGY	0.589 (0.443)
	DLFDI	0.598 (0.439)		DLFDI	0.082 (0.775)
	DLTRADE	5.405 (0.020)**		DLTRADE	1.590 (0.209)
	DLGDP	13.852 (0.000)***		DLGDP	0.465 (0.495)
	All	17.565 (0.002)***		All	3.220 (0.522)
DLFDI			**DLFDI**		
	DLFD1	0.002 (0.967)		LFD2	0.487 (0.485)
	DLENERGY	1.236 (0.266)		DLENERGY	0.312 (0.577)
.	DLTRADE	0.416 (0.519)		DLTRADE	0.001 (0.971)
	DLGDP	1.524 (0.217)		DLGDP	0.027 (0.870)
	All	5.384 (0.250)		All	4.551 (0.337)
DLTRADE			**DLTRADE**		
	DLFD1	5.746 (0.017)**		LFD2	2.611 (0.106)
	DLENERGY	7.440 (0.006)***		DLENERGY	0.607 (0.436)
	DLFDI	2.114 (0.146)		DLFDI	0.099 (0.753)
	DLGDP	0.008 (0.929)		DLGDP	0.343 (0.558)
	All	18.227 (0.001)***		All	5.007 (0.287)
DLGDP			**DLGDP**		
	DLFD1	1.068 (0.301)		LFD2	1.549 (0.213)
	DLENERGY	0.435 (0.510)		DLENERGY	0.017 (0.896)
	DLFDI	0.648 (0.421)		DLFDI	0.668 (0.414)
	DLTRADE	0.441 (0.507)		DLTRADE	1.338 (0.247)
	All	1.956 (0.744)		All	2.372 (0.668)

Note: ****, **, * signify 1%, 5% and 10% significance levels, respectively. Numbers in parentheses are p-values.*

The values shown in the fifth group in Table 5 are the variance decomposition of DLGDP. The results show that the variation in DLGDP decrease from 65.954% to 63.112% by itself. The rate at which DLENERGY explains the variation in DLGDP is at an important level. Accordingly, the explanation of DLENREGY takes values between 33.157% and 35.732%.

The variance decomposition results for FD (LFD2), which represents the stock market development, are given in Table 5. In the first group, values of DLENERGY are shown. The results indicate that the variation in DLENERGY is explained mainly by itself. The ratio of explanation of DLENERGY by DLGDP reaches 0.484%. LFD2 explains the changes in DLENERGY from 0% to 0.073%. DLFDI and DLTRADE variables explain the variation in LFD2 with a low ratio ranging from 0% to 0.073%.

The explanation ratio of changes in LFD2 by DLENERGY increased from 2.176% to 14.032%. The variation in LFD2 ranged from 97.824% to 83.952% by itself. It is seen that the ratio of explanation of these changes by the DLTRADE is 1.447% at the end of five years. The results in the third group shown in Table 5 are variance decomposition of DLFDI. Accordingly, most of the variation in DLFDI is explained by itself. Table 5 shows that the ratios of the other variables explaining the variation in DLFDI take values between 0% and 2.522%.

It is seen that the variation in the DLTRADE variable explains 96.658% - 98.030% by itself. DLENERGY explains the variation in the DLTRADE variable with values between 0.051% and 0.321%. The ratio of the other variables to explain the variation in the DLTRADE varies between 0% and 2.515%. In the last group, the variance decomposition of DLGDP is shown. The ratio of the variation in DLGDP decreased from 56.946% to 54.197% by itself, increasing from 34.524% to 38.651% by DLENERGY. LFD2 explains the variation in DLGDP between 8.522% and 6.250%.

Panel Causality Analysis

The panel Granger causality is used to examine the relationships among EC, FD (banking sector and stock market developments), foreign direct investment, total trade and economic growth variables. Panel Granger causality analyses the estimation of bivariate variables. In this context, the direction of causality between the variables is investigated with the panel Granger causality test. The panel Granger causality test results, performed separately for different FD indicators, are shown in Table 6. This table's first and second columns show the causality between DLFD1, LFD2, and other variables.

Panel Granger causality results show that DLENERGY has a one-way causal relationship to DLFD1. The test results show that DLENERGY is not the cause for DLGDP. On the contrary, there is no evidence that the DLFD1 is the cause for DLENERGY. The results indicate that the causality from DLGDP to DLFD1 is significant at 1% significance level. The results of Table 6 indicate bidirectional causality between the DLTRADE and DLFD1. The results show that DLFDI does not have any causal relationship with the other variables. In the second column of Table 6, no causality is found between the LFD2 and the other variables.

5. CONCLUSION

The paper aims to investigate the impact of FD indicators on EC using the PVAR model and causality analysis. For this purpose, BRICS countries are examined from 1994 to 2017. The variables of FD indicators, the stock market development and the banking sector development are used in the analysis of the study. The robustness of the findings is tested with two FD measures and explanatory variables, such as trade and economic growth, in the model. Pesaran's (2007) unit root test is used because the series have cross-section dependence. In the test results, which are performed in two different ways as constant, constant and trend, it is seen that all were stationary when the first difference is taken, except for the FD2 variable. Afterwards, two different PVAR models estimated by the GMM method are analysed. The panel Granger causality test supports the study results to reveal the causal relationships between the variables and the impulse-response and variance decomposition. Panel Granger causality results emphasize a causality between banking sector development and EC, trade and economic growth variables. In the literature, Iyke, 2015; Esen & Bayrak, 2017; Aydin & Esen, 2018; Asteriu and Spanos 2019; Pradhan et al. 2019; Ho & Iyke 2020 and Wang et al. 2022 have been found to reach similar results. The one-way causality finding we obtain from DLENERGY to DLFD1 is supported by the results obtained in the literature (Furuoka, 2015; Shahbaz et al., 2016; Ma & Fu, 2020; Nkalu et al., 2020; Nguyen et al., 2021; Thebuho, 2022; Ahmad et al., 2022; Saygın ve Iskenderoglu, 2022). Zeren and Koc (2014) conclude unidirectional causality from EC to the banking sector development in their study examining the 1971–2010 period for Malaysia, Mexico and the Philippines. Bekhet et al. (2017) investigated the relationship between EC and FD. They found similar results to our study for Oman, United Arab Emirates and Israel according to short-run causality results. Raghutla and Chittedi (2020) find unidirectional causality from economic growth to banking sector development in India, and these results are similar to our study. However, no causality findings are found between stock market development and other variables. It can be concluded that EC may contribute to FD in BRICS countries depending on the banking sector's development. This situation can show that banking sector development is more effective than stock market development within the scope of BRICS.

The impulse response results show a positive EC response to a standard deviation shock in the banking sector and the stock market. The response of the banking sector development to a standard deviation shock in EC is negative until the fourth year, like the results in the stock market development. It is concluded that the responses of FD indicators, economic growth and EC to a standard deviation shock in trade are negative, while the response of foreign direct investments follows a positive course (Ali et al., 2015; Riti et al., 2017; Destek, 2018; Ouyang & Li, 2018; Gomez ve Rodriguez, 2019; Yue et al., 2019).

Variance decomposition analyses show that EC has a low rate in explaining the banking sector development, whereas it has a relatively higher rate in explaining the stock market development. Other variables have a very nominal rate in the explanation rate of EC. It is emphasized here that economic growth has the most significant explanation rate. Both analyses show that the variable that explains economic growth at a high rate is EC.

In order to make energy infrastructure investments for BRICS, policymakers may need to make some adjustments to FD. The causality relationship between banking sector development to EC highlights energy-related demand in BRICS countries. Findings indicate that banking sector development is based on energy, which means that EC drives FD. It is seen that economic growth in BRICS is supported by banking sector developments rather than stock market developments. Sadorsky (2011) emphasized that FD consists of increases in countries' activities such as banking, stock market and foreign direct investment. At this point, the banking sector development will also contribute to the stock market development. In this respect, as the study of Chiu and Lee (2020) emphasized, it will be a natural result that the banking sector's development will impact EC. Since the financial sector can affect EC, it can be supported by the right policies to foster a stable financial system.

The relationship between EC and FD has been the subject of many studies in the literature. Also, there is no consensus in the literature. This is because developing countries have different economic structures. In this context, we recommend that especially developing countries should take precautions against the shocks that may occur in the global financial markets and energy sector. The findings of this study for BRICS will also have beneficial results for other developing countries. The study discusses the impact of FD indicators on EC with additional explanatory variables using a panel data approach. Each country can be evaluated separately when examining BRICS in future studies. Thus, we recommend re-exploring the subject for each country by including different factors in the analysis for further studies.

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Učinak kretanja tržišta dionica i bankarskog sektora na potrošnju energije u BRICS-u: dokazi temeljem panel vektorske autoregresivne analize

Sažetak

Energija je važan resurs u gospodarskom razvoju zemalja. Iako se koristi kao input u proizvodnji, također ima važno područje uporabe i u potrošnji. Iz tih su razloga čimbenici koji utječu na korištenje energije bili predmet mnogih studija. Ova studija ispituje utjecaj financijskog razvoja (FD) na potrošnju energije (EC) u zemljama BRICS-a (Brazil, Rusija, Indija, Kina i Južna Afrika). U studiji su varijable EC, FD, gospodarski rast, izravna strana ulaganja i ukupna robna razmjena (% BDP) za razdoblje 1994. – 2017. ispitane uz pomoć PVAR (engl. panel vector autoregressive) modela. Prema nalazima, postoji jednosmjerna veza između EG-a i gospodarskog rasta i razvoja bankarskog sektora.

Ključne riječi: Financijski razvoj, potrošnja energije, bankarski sektor, panel kauzalnost, panel vektorski autoregresivni model