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Symmetric and asymmetric causality between current account balance and oil prices: The case of BRICS-T

The main aim of the study is to examine the symmetric and asymmetric relationship between oil prices and the current account balances of BRICS-T countries covering the period from 2003:Q1 to 2017:Q2. In the study, Hacker and Hatemi-J (2006) for the symmetric causality test and Hatemi-J (2012) for the asymmetric causality test are used to test the relationships between the variables. The symmetrical causality test results support that there is unidirectional causality from Brazil's current account balances to oil prices and there is unidirectional causality from oil prices to Turkey's current account balances. On the other hand, asymmetrical causality test results support that there are many causal relationships between the variables shock. There is causality from positive oil price shock to South Africa's positive current account balances shock, from negative oil price shock to Russia, China, and Turkey's negative current account balances shocks and to Russia, India, and Turkey's positive current account balances shocks. Besides, there is causality from Brazil's negative current account balances shock to both positive and negative oil prices shocks. Also, it is seen that there is causality from India's positive current account balances shock to negative oil prices shock. Policy-makers should consider the impact of the shocks in oil prices on the current account to evaluate any policy, especially for Russia, China, India and Turkey.

Keywords: oil prices; current account balance; symmetric causality; asymmetric causality; BRICS.
JEL classification: Q40; F32; C22.

1. Introduction

The international economic transactions have started to grow in importance in line with the phenomena of globalization and financial liberalization. In addition to trade in goods and services between countries, international asset investments also reach significant levels. According to (Kenen, 2000), the balance of payments, where international transactions are recorded, consists of two main accounts: Current account and capital account. In the International Monetary Fund's «Balance of Payments and International Investment Position Manual» (IMF, 2009), the balance of payments consists of current account, capital and financial account, and the net errors and omissions account. In the balance of payments current account, there are sub-items such as trade in goods, services trade, wage payments, investment revenues and current transfers,

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and in this respect, the current account represents the real sector of the economy in a sense. Current account contains important data for the business community and the public. For example, foreign trade accounts, which are one of the sub-items of the current account, are the most appropriate accounts to be used in cross-country comparisons. This is because; the changes in these accounts clearly reveal the changes in productivity, technological developments and the competitiveness with other countries (Seyidoğlu, 2009). The current account includes export and imports of goods and services, income receipts and income payments, and unidirectional transfers. The net value of flows of goods, services, income and unidirectional transfers is the current account balance. If a country has a current account surplus, then its foreign assets are growing faster than its foreign liabilities. If a country has a current account deficit, then its foreign liabilities are growing faster than its foreign assets (Pugel, 2015).

The dynamics of the current account balance relies on the development levels of the countries, their social and political structures and the natural resources. As a result of the national income equation, export-import, savings-investment and government revenues-government expenditures are the most important determinants of the current account balance. However, there are many other variables that have the power to influence this balance through different channels. These include real exchange rates, interest rates, energy prices, inflation rates and financial development levels of countries (Karagöl, Erdoğan, 2017).

In line with the advancing technology, energy use in the modern world is increasing. Despite this increase in energy use, there is a constant amount of energy resources in the world. Energy use is quite important for the growth of economies and development of countries. This position requires an effective and efficient use of energy. For this, policymakers bring saving measures for energy use through a number of policy instruments and continue to seek renewable energy sources for sustainable development. However, the increase and decrease in energy prices deeply affect the national economies. An increase in energy prices for an energy-exporting country is considered a positive indicator for the external balance of that country. However, the same increase is a negative indicator for the external balance of an oil importing country. Therefore, every country's economy, whether it is an energy exporter or an energy importer, is affected by fluctuations in oil prices. The oil prices fluctuating for various reasons in recent years (Fig. 1) have caused serious changes in the external balances of countries.

All of this makes investigating the relationship between the current account balance and oil prices worthwhile.

In this study, the symmetric and asymmetric relationship between the current account balance and the oil prices were analyzed by using the data of BRICS-T countries (Brazil, Russia, India, China, South Africa, and Turkey). The acronym BRIC has been first used in 2001 in Goldman Sachs by economist Jim O'Neill for the growing economies of Brazil, Russia, India, China, which represent a significant share of the world's population and production. Since the first Summit held at the Heads of State level in Yekaterinburg in 2009, the depth and scope of the dialogue between the members have been expanded with the inclusion of South Africa in this acronym (BRICS) in 2011. As a new and promising political-diplomatic entity, BRICS is more than an acronym, which serves the purpose of enhancing transnational cooperation and strengthening economic-political governance[2]. Some countries are known to be in the wait list to be a member of the BRICS. In addition to South Korea and Mexico, Indonesia, Argentina and Turkey are

[2] See http://brics2019.itamaraty.gov.br/en/about-brics/what-is-brics.

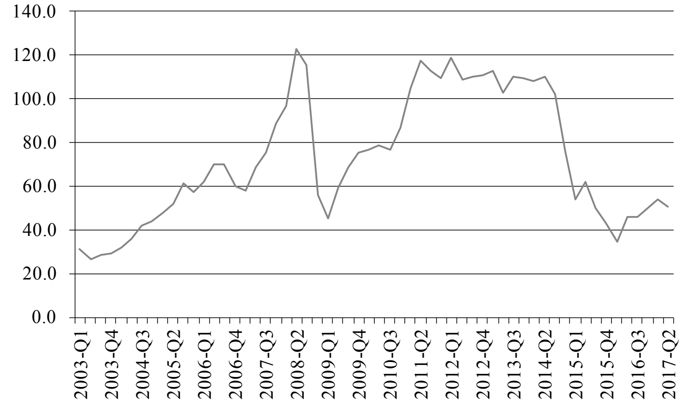

Fig. 1. Crude oil price

Source: Federal Reserve Economic Data (https://fred.stlouisfed.org/).

also included in this list (Koeing, 2017). Indeed, Turkey has applied to be a full-fledged member of the BRICS, and this issue is still on the table (Korybko, 2018).

According to The World Bank 2014 data, Brazil imports about 13% of its total energy, India — 34%, China — 15% and Turkey — 74%, while Russia is energy exporter by 84%, and South Africa is by 14% (Russia, especially in natural gas, and South Africa in coal). As for the oil production in the world, Russia ranks third, following the USA and Saudi Arabia as of 2017. Still in the top 10, China is ranked 7th, and Brazil is in the 9th. South Africa and Turkey are the 41st and 56th in oil production, respectively. In the case of oil consumption, China ranks 2nd, following the USA in the first place, followed by India in 4th, Russia in 5th, Brazil in 6th, South Korea in 10th and Turkey in 26nd (The US Energy Information Administration, https://www.eia.gov/).

Current account balances in BRICS-T countries as a percentage of GDP are shown in Fig. 2. While energy importer Russia and China, having a trade advantage, have current account surplus, the developing countries of the group, namely the Brazil, India, South Africa and Turkey

Fig. 2. Current Account Balance as % of GDP for BRICS-T

Source: The Organisation for Economic Co-operation and Development (OECD).

have a current account deficit. It would not be wrong to say that BRICS-T has a heterogeneous structure. In addition to comparative tests performed on the presence of symmetric and asymmetric relationship between current account balance and oil prices, this study also reveals the similarities (or differences) of Turkey with BRICS countries in terms of the relationship between Turkey's current account balance and oil prices.

2. Literature review

2.1. Review of theoretical literature

The increase in international economic and commercial interactions has brought a different set of theoretical approaches to the balance of payments and the current account balance. The Elasticity Approach has been started in 1945 and followed by the Absorption Approach, Mundell–Fleming Model, Monetarist Approach, and Intertemporal Approach (Karagöl, Erdoğan, 2016).

According to the Elasticity Approach, the factor determining international trade is the stationary price elasticity of supply and demand under the assumption that the level of international expenditure and revenue is constant (Tiryaki, 2002). Alexander (1952), who proposed Absorption Approach, has investigated the effects of devaluation on foreign trade and in doing so used not only price elasticity but also the sum of price and income elasticity. The Mundell–Fleming Model systematically analyzes the role of international capital mobility in determining the effectiveness of macroeconomic policies under alternative exchange rate regimes (Frenkel, Razin, 1987), however, the Monetarist Approach states that the balance of payment problems are due to inflationary reasons and credit expansion. The cause of inflationary process is the change in money supply (Obstfeld, 2001). The Intertemporal Approach, which began to spread in the 1980s, sees the current account balance as a result of forward-looking dynamic savings and investment decisions (Obstfeld, Rogoff, 1995). On the other hand, national income equality provides evidence of the link between foreign trade balance and budget and investment-saving balance. The equation for national income is as follows (Mithun, Muthuku, 2017):

$$Y = C + I + G + NX . \tag{1}$$

In equation (1), the sum of consumption expenditures (C), investment expenditures (I), government expenditures (G) and export-import difference $(X - M)$, i.e. the net exports (NX), represent the national income (Y). We can also write the national income equality as the sum of consumption, savings and taxes (T). In this case:

$$Y = C + S + T. \tag{2}$$

If we combine equations (2) and (1):

$$S = I - T + G + (X - M). \tag{3}$$

We can rewrite equation (3) as follows:

$$(X - M) = (S - I) + (T - G). \tag{4}$$

In equation (4), $(X - M)$ is the current account balance, $(S - I)$ is the saving-investment balance, and $(T - G)$ is the public sector budget balance. In this case, it would not be wrong to say that the current account balance depends on the savings and investment levels of the economies and the income and expenditures of the public sector. Here, the left side of the equation shows the external balance and the right side shows the internal balance. Accordingly, if an external balance of a country is negative, that is, if there is an external deficit, then there is a saving deficit and/or a budget deficit in that country. Co-occurrence of the current deficit and the budget deficit is called twin deficit, and co-occurrence of current account deficit, budget deficit and savings deficit are called triplet deficit in the literature.

There are different approaches regarding the impact of oil prices on the current account balance. Of these, the Supply Channel Approach states that oil is a production input and will affect supply. As a consequence of the fact that oil is a production input, changes in the production decisions due to the increase or decrease in oil prices disrupt the trade balance, which is called Terms of Trade Approach. The Monetary Channel Approach states that the intervention of the monetary authorities to the deterioration in the foreign trade balance (while oil prices are increasing) will increase the recessionist pressure. The Demand Channel Approach states that the price elasticity of demand for goods produced by oil will affect demand. The shifting demand towards other goods will also disrupt the trade balance. The Financing Channel Approach assumption is that increase in oil prices will increase profitability in oil exporting countries (Bayat et al., 2013).

According to another distinction, it is stated that oil supply shocks, oil demand shocks and total demand shocks are effective on oil and non-oil trade balance. The smaller the oil share used in production in an oil supply shock and the greater the flexibility of substitution between oil and other production factors, the lower the response of real oil prices. An interruption in oil supply will directly affect oil importing countries. The impact of the oil market-specific demand shocks on the real oil price and the external balance is the same as the oil supply shocks. The main difference is that such shocks may have a greater and lasting effect than oil supply shocks. The impact of aggregate demand shocks is different. The aggregate demand shock tends to cause non-oil foreign trade deficits (independent of the oil share) as well as the foreign trade deficit in oil importing countries, due to the rise in oil prices. The Valuation Channel is the approach stating that change in asset prices affects the current account balance, in response to the oil supply and demand shocks. According to this approach, oil exporters will keep some of their assets in the form of assets in the oil-importing economies (or vice versa). Under the assumption that oil prices are increasing, such an asset diversification allows transfer of some of the profits and increased wealth of oil-importing countries towards oil-importing countries (Kilian et al., 2009).

2.2. Review of related empirical literature

There are many studies investigating the relationship between current account balance and oil prices, one of its most important determinants. Aristovnik (2007), Barnes et al. (2010) and Gosse, Serranito (2014) found a positive and strong relationship between current account balance and oil prices. Morsy (2012), who examined 74 countries engaged in oil trade, discussed that there is a negative relationship between the current account balance and oil prices for oil exporting countries and a positive relationship for oil importing countries. Garsviene and Butkus (2014) emphasized the existence of a positive but weak relationship between the current account balance and the oil prices by making a distinction between developed and developing countries, while emphasizing that the current account balance is determined not by external, but by internal factors.

Tufail and Qurat-ul-Ain (2012), in their study for D-8 countries, suggested that the rise in oil prices affected the current account deficit positively in oil-exporting countries and negatively in oil-importing countries. And, Huntington (2015) emphasized that oil exports is an important factor in explaining the current account balance, but that oil imports is insufficient to explain the current account balance. In his study, analyzing oil exporting countries, Allegret et al. (2014) stated that the current account deficit in financially underdeveloped countries is significantly affected by oil prices, and this effect decreases as financial development increases. In their analysis on 28 oil exporting countries and 40 oil exporting countries, Rafiq and Sgro (2016) stated that a reduction in oil prices (the quantity effect is greater than the price effect) is a useful development for the external balances of oil exporting countries, but they also stated that this decrease has a negative effect on the external balance in oil importing countries. In this case, considering the current account balance of oil importing countries, a fixed oil price is more desirable than the decrease in the oil prices.

Bayraktar et al. (2016) tested the relationship between oil prices and current account balance for Fragile Five (Brazil, Indonesia, South Africa, India, Turkey). In his study, while determining a significant and negative relationship between oil prices and current account balance, he reported the existence of one-way Granger Causality from oil prices towards the current account balance in the short term. Syzdykova (2017) concluded that oil prices have a significant explanation power on the current account balance in all BRIC countries.

Gnimassoun et al. (2017) have discussed the impact of oil supply and demand shocks on the current account balance separately. Accordingly, while an oil supply shock has no significant impact on the current account balance, an oil demand shock has a positive and significant impact, which tends to increase over time. While the tendency of spending oil revenues for imports has a negative effect on current account balance via oil demand shock channel, this effect can be reversed by the degree of development of financial markets and proper management of foreign exchange reserves.

Yalta and Araç (2017) have examined asymmetric relationship between oil prices and current account balance. Accordingly, while the current account balance reacts to the changes in oil prices asymmetrically in the short term, an asymmetric relationship between the variables in the long run seems improbable. There are other studies that distinguish short and long term finding, while analyzing the relationship between the two variables. In their study on Turkey, Bayat et al. (2013) emphasize the existence of a one-way negative relationship from oil prices towards foreign trade deficit in the medium term, and point out that the medium-term relationship vanishes in the long-term. Beşel (2017) mentioned a long-term and one-way causality relationship between the two variables. Longe et al. (2018) state that oil prices have a positive impact on the current account balance of Nigeria in the short-term and negative impact in the long-term. And, Arouri et al. (2014), in their study analyzing the economy of India, showed that oil prices are a leading indicator for current account balance in the short, medium and long term.

3. Data

In this study, the relationship between the current account balances (ca) and oil prices (oil) of the BRICS-T countries are examined for the period 2003:Q1–2017:Q2. The data on the current account balance variable were obtained from OECD and the data on the oil price variable were obtained from the Federal Reserve Bank of St. Louis (FRED) database. Current account balances (ca) are shown using country names. That is to say *brazil* refers to Brazil's current account balance, *russia* refers to the Russia's current account balance, *india* refers to the India's current account balance, *china* refers to the China's current account balance, *safrica* refers to the South Africa's current account balance and *turkey* refers to the Turkey's current account balance. Time series graphs of variable data are shown in Fig. 3. When the graphs are analyzed, it is seen that both the oil prices and the current account balance data of the countries are subject to breaks and they are changing constantly (with decreases and increases). Considering this situation is expected to increase the reliability of the analysis to be performed.

4. Methodology

The dynamic relationship between oil_t and ca_t were investigated using time series methods. In this study, the relationships between variables are examined separately for each country. Such relations are presented in five stages. In the first stage, the stationary levels of the original values of the variables were determined by Augmented Dickey–Fuller (ADF), developed by Said and Dickey (1984), Phillips–Perron (PP), developed by Phillips and Perron (1988), and finally by double-break unit root test, developed by Lee and Strazicich (2003). In the second stage,

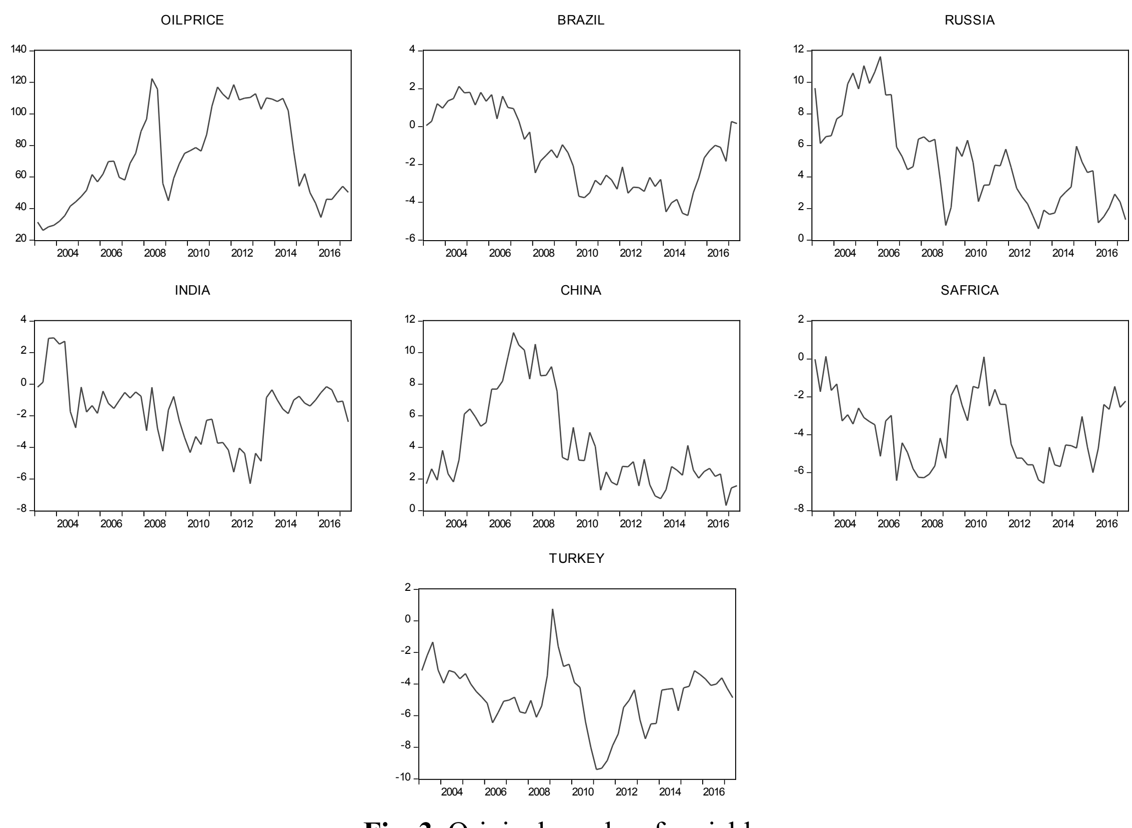

Fig. 3. Original graphs of variables

symmetrical causality relationship between variables are examined by using Hacker and Hatemi-J (2006) causality test. In the third stage, the variables are divided into positive and negative components. In the fourth stage, the stationarity levels of the components of the variables were determined using ADF and PP unit root tests. In the fifth stage, the causality relationships between positive and negative components/shocks were investigated by using asymmetric causality analysis developed by Hatemi-J (2012). Information about these methods and why these methods were selected are as follows:

4.1. Unit root tests

In time series analysis, it is necessary to test the stationarity of the variables. Stationarity of variables is examined in order to avoid the pseudo-regression problem that may arise and to determine the analysis to be used in the later stages. Stationarity levels of the variables are examined by ADF unit root test which has been developed by Said and Dickey (1984) and frequently used in time series analysis, and by PP unit root test, developed by Phillips and Perron (1988). The purpose of using two tests together is that the PP test is more resistant to autocorrelation and changing variance than the ADF test. Thus, more reliable results are obtained. The null hypothesis of both tests is that the variables are not stationary, i.e. they have a unit root. If the absolute values of test statistics calculated in the tests are less than the critical values, $\mathbf{H_0}$ cannot be rejected. In this case, the differences of the variables can be taken and the tests can be checked again to determine the stationarity levels. For example, if the absolute value of the statistics calculated at the first difference of the variable is greater than the critical values, then $\mathbf{H_0}$ is rejected and the variables become $I(1)$ (stationary at the first difference)[3].

In addition, a double-break unit root test, developed by Lee and Strazicich (2003), was used as the third unit root test to control the results of ADF and PP unit root tests. This is because the series of the variables shown in Fig. 3 have fragile structures. Perron (1989) suggested taking them into account when performing a unit root test in case of structural breaks in the variables examined. This is because failure to take into account the structural breaks leads to false results. Therefore, the breaks in the series of variables are determined as internal by the unit root test of Lee and Strazicich (2003), one of the structural break unit root tests developed. The unit root test is performed for fixed and constant-trend models. The hypotheses of the test are as follows.

$\mathbf{H_0}$: *The variable is not stationary with two-breaks. (There is a unit root with two-breaks.)*
$\mathbf{H_1}$: *The variable is stationary with two-breaks. (There is no unit root with two-breaks.)*

For testing hypotheses, Lee and Strazicich (2003) have developed Lagrange Multipliers (LM) test statistic. If the calculated LM statistics is greater than the critical values as given by Lee and Strazicich (2003), then $\mathbf{H_0}$ is rejected, leading to the conclusion that the series is stationary. In the opposite case, $\mathbf{H_0}$ cannot be rejected[4]. The maximum degree of integration of our variables was determined by using these three tests.

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[3] Detailed information about the tests can be found in the studies by Said and Dickey (1984) and Phillips and Perron (1988).

[4] Detailed information about the test can be obtained from Lee and Strazicich (2003).

4.2. Hacker and Hatemi-J symmetric causality test

Since the symmetrical causality analysis developed by Hacker and Hatemi-J (2006) is based on the Toda–Yamamoto (1995) causality test, it has superior aspects such as unnecessary cointegration between variables and varying degrees of stationarity of variables. Unlike the Toda–Yamamoto test, Hacker and Hatemi-J (2006) have renewed the analysis using bootstrap. Let's start by explaining the Toda–Yamamoto analysis. As Hacker and Hatemi-J (2006) pointed out, expected relationship between the variables in Toda–Yamamoto causality test is as follows:

$$\begin{bmatrix} ca_t \\ oil_t \end{bmatrix} = \begin{bmatrix} \partial_0^{ca} \\ \partial_0^{oil} \end{bmatrix} + \begin{bmatrix} \partial_{11,1} & \partial_{12,1} \\ \partial_{21,1} & \partial_{22,1} \end{bmatrix} \begin{bmatrix} ca_{t-1} \\ oil_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} \partial_{11,p+d_{\max}} & \partial_{12,p+d_{\max}} \\ \partial_{21,p+d_{\max}} & \partial_{22,p+d_{\max}} \end{bmatrix} \begin{bmatrix} ca_{t-p+d_{\max}} \\ oil_{t-p+d_{\max}} \end{bmatrix} + \begin{bmatrix} w_{1t} \\ w_{2t} \end{bmatrix}. \quad (5)$$

As seen in the equation (5), the Toda–Yamamoto causality test is based on the estimation of Vector Autoregressive Model (VAR) developed by Sims (1980). The model is $VAR(p+d_{\max})$. All ∂ refers to coefficients' matrices. The 'p' in the parameter vectors indicates the appropriate number of lags for the model, and '$d_{\max}$' represents the maximum degree of integration. The appropriate lag number, 'p', is determined by using the information criteria in the VAR model[5]. The maximum degree of integration is determined by taking into account the stationarity levels of the variables. Following the determination of p and $d_{\max}$ values, the following hypotheses are tested on the $VAR(p+d_{\max})$ model:

H₀ : $\partial_{12,1} = \partial_{12,2} = \ldots = \partial_{12,p} = 0$, "$oil_t$ is not the cause of ca_t";

H₀ : $\partial_{21,1} = \partial_{21,2} = \ldots = \partial_{21,p} = 0$, "$ca_t$ is not the cause of oil_t";

H₁ : At least one $\partial \neq 0$, "oil_t is the cause of the ca_t" or "ca_t is the cause of oil_t".

These hypotheses are tested by applying the constraint test as in the Granger Causality Test. In addition, MWALD statistic is obtained through some changes in Wald statistics. The calculated MWALD statistical value has a χ^2 distribution (Hacker, Hatemi-J, 2006). However, as stated by Hacker and Hatemi-J (2006), this assumption may not be valid in some cases, and there may be a problem of heteroscedasticity in the model. Hacker and Hatemi-J (2006) use the bootstrap method to solve this problem and obtain the critical values of the test by the bootstrap method (Hacker, Hatemi-J, 2006). All this means that this method is superior to other symmetrical causality tests.

4.3. Hatemi-J asymmetric causality test

The asymmetric causality test developed by Hatemi-J (2012) is based on the symmetric causality test developed by Hacker and Hatemi-J (2006). The basic idea underlying the development of this test is that the relationships between the variables cannot always be symmetric. In other words, all the relationships between the variables are not fully revealed in the analysis performed

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5 These criteria include Akaike Information Criterion (AIC), Schwartz Bayesian Criterion (SC), Hatemi-J Information Criterion (HJC). In this study, the appropriate lag (p) value was determined by considering HJC information criterion.

using the original forms of variables. For this reason, Granger and Yoon (2002) first developed a cointegration test (hidden cointegration). In this cointegration test, analysis is made by using the positive and negative components of the variables (cumulative shocks). Hatemi-J (2012), for the same reason, developed Hacker and Hatemi-J (2006) causality test, and separated cumulative shocks of variables as in the study by Granger and Yoon (2002). This is called Hatemi-J (2012) asymmetric causality test. The only difference between the asymmetrical causality test and symmetric causality test is that the causality test is performed by using the positive and negative components of the variables (cumulative shocks), not the original forms of the variables.

According to Hatemi-J (2012), two variables, such as ca_t and oil_t, of which causality relationship between them is investigated, are defined as follows within the framework of random-walk:

$$ca_t = ca_{t-1} + e_{1t} = ca_0 + \sum_{i=1}^{t} e_{1i}\,, \tag{6}$$

and

$$oil_t = oil_{t-1} + e_{2t} = oil_0 + \sum_{i=1}^{t} e_{2i}\,. \tag{7}$$

The ca_0 and oil_0 in the definition of the variables indicate the initial values of the variables, e_{1i} and e_{2i} represent the terms deflecting the variables from 'white noise', i.e. the sum of the shocks present in the variables. These shocks are defined as follows (Hatemi-J, 2012):

$$e_{1i}^{+} = \max(e_{1i},0),\ e_{2i}^{+} = \max(e_{2i},0) \qquad \text{(positive shocks of both variables)},$$

$$e_{1i}^{-} = \min(e_{1i},0),\ e_{2i}^{-} = \min(e_{2i},0) \qquad \text{(negative shocks of both variables)},$$

and

$$e_{1i} = e_{1i}^{+} + e_{1i}^{-}, \quad e_{2i} = e_{2i}^{+} + e_{2i}^{-}.$$

The ca_t and oil_t variables are redefined in the following equations:

$$ca_t = ca_{t-1} + e_{1t} = ca_0 + \sum_{i=1}^{t} e_{1i}^{+} + \sum_{i=1}^{t} e_{1i}^{-} \tag{8}$$

and

$$oil_t = oil_{t-1} + e_{2t} = oil_0 + \sum_{i=1}^{t} e_{2i}^{+} + \sum_{i=1}^{t} e_{2i}^{-}. \tag{9}$$

Finally, the cumulative shocks obtained here are expressed as new variables indicating positive and negative shocks of the variables and are shown as follows:

$$ca_t^{+} = \sum_{i=1}^{t} e_{1i}^{+},\ ca_t^{-} = \sum_{i=1}^{t} e_{1i}^{-},\ oil_t^{+} = \sum_{i=1}^{t} e_{2i}^{+},\ oil_t^{-} = \sum_{i=1}^{t} e_{2i}^{-}\,, \tag{10}$$

where ca_t^{+} is cumulative positive shocks of the current variable, ca_t^{-} is cumulative negative shocks of current deficit variable, oil_t^{+} is cumulative positive shocks of oil price variable, and finally oil_t^{-} is cumulative negative shocks of the second variable. Current account balance variable of each country used in the study was separated into shocks as in the above process. For example, the positive/negative shocks of Brazil's current account balance variable are shown as follows: $brazil_t^{+/-}$. Similar notations will be used for other countries.

$$\begin{bmatrix} ca_t^{+/-} \\ oil_t^{+/-} \end{bmatrix} = \begin{bmatrix} \lambda_0^{ca^{+/-}} \\ \lambda_0^{oil^{+/-}} \end{bmatrix} + \begin{bmatrix} \lambda_{11,1} & \lambda_{12,1} \\ \lambda_{21,1} & \lambda_{22,1} \end{bmatrix} \begin{bmatrix} ca_{t-1}^{+/-} \\ oil_{t-1}^{+/-} \end{bmatrix} + \ldots + \begin{bmatrix} \lambda_{11,p+d_{\max}} & \lambda_{12,p+d_{\max}} \\ \lambda_{21,p+d_{\max}} & \lambda_{22,p+d_{\max}} \end{bmatrix} \begin{bmatrix} ca_{t-p+d_{\max}}^{+/-} \\ oil_{t-p+d_{\max}}^{+/-} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix}. \quad (11)$$

The λ_0 is the constant term in the model (11), and other λ refers to parameter matrices. And, v_t is the error term of the model. The process after this stage is similar to that of Hacker and Hatemi-J (2006) causality test process (Hatemi-J, 2012). Here, causality analysis is performed using a model like VAR(p). As mentioned above, the value 'p', which expresses the appropriate lag, is determined using the HJC information criterion. In addition, analysis should be performed by considering the stationary levels of shocks of variables. The ADF unit root test was used to investigate the stationarity of the shocks.

The following 8 hypotheses can be tested with the help of this causality analysis.

1st Null Hypothesis: $\lambda_{12,1} = \lambda_{12,2} = \ldots = \lambda_{12,p} = 0$. There is no causality from Positive Oil Price Shock (oil_t^+) to Positive Current Account Balances Shock…

2nd Null Hypothesis: $\lambda_{12,1} = \lambda_{12,2} = \ldots = \lambda_{12,p} = 0$. There is no causality from Positive Oil Price Shock (oil_t^+) to Negative Current Account Balances Shock (ca_t^-).

3rd Null Hypothesis: $\lambda_{12,1} = \lambda_{12,2} = \ldots = \lambda_{12,p} = 0$. There is no causality from Negative Oil Price Shock (oil_t^-) to Positive Current Account Balances Shock (ca_t^+).

4th Null Hypothesis: $\lambda_{12,1} = \lambda_{12,2} = \ldots = \lambda_{12,p} = 0$. There is no causality from Negative Oil Price Shock (oil_t^-) to Negative Current Account Balances Shock (ca_t^-).

5th Null Hypothesis: $\lambda_{21,1} = \lambda_{21,2} = \ldots = \lambda_{21,p} = 0$. There is no causality from Positive Current Account Balances Shock (ca_t^+) to Positive Oil Price Shock (oil_t^+).

6th Null Hypothesis: $\lambda_{21,1} = \lambda_{21,2} = \ldots = \lambda_{21,p} = 0$. There is no causality from Positive Current Account Balances Shock (ca_t^+) to Negative Oil Price Shock (oil_t^-).

7th Null Hypothesis: $\lambda_{21,1} = \lambda_{21,2} = \ldots = \lambda_{21,p} = 0$. There is no causality from Negative Current Account Balances Shock (ca_t^-) to Positive Oil Price Shock (oil_t^+).

8th Null Hypothesis: $\lambda_{21,1} = \lambda_{21,2} = \ldots = \lambda_{21,p} = 0$. There is no causality from Negative Current Account Balances Shock (ca_t^-) to Negative Oil Price Shock (oil_t^-).

In the case of rejection of these hypotheses, sub-hypotheses indicate that there is a causal relationship between the mentioned shocks. With the use of the asymmetric causality analysis, the originating shocks present in the causality relationship in symmetric causality relationship between oil_t and ca_t can be seen. In addition, the use of asymmetric causality test developed by Hatemi-J (2012) is of importance since the asymmetric causality relationship between the variables in the study have not been analyzed before.

5. Empirical results

In this part of the study, firstly the results of traditional and structural break unit roots of the original values of the variables were addressed. Table 1 shows that the oil_t variable is $I(1)$ for all models according to both ADF and PP unit root test results. When the current account balance variables of the countries are examined, it is seen that $india_t$, $safrica_t$ and $turkey_t$ variables are $I(0)$ for constant model according to ADF test results. In addition, the $safrica_t$ variable is $I(0)$ considering the constant model, on the basis of the PP unit root test result. Apart from this, considering the constant model, the stationarity level of the current account balance variables of other countries is $I(1)$, according to the PP unit root test results. According to the ADF test results of the constant-trend model, $brazil_t$ and $safrica_t$ are $I(2)$. However, according to the PP test results stronger than the ADF, the current account balance variables for all countries are $I(1)$. As can be seen, according to traditional unit root test results, the maximum degree of integration between these variables is 1. However, a third unit root test was included in order to determine this maximum degree of integration. The reason for this is to prevent statistical errors that may arise due to the structural changes in the variables.

Table 1. Traditional unit root test results

Variable	ADF test**		PP test***	
	Test statistic	*P*-value	Test statistic	*P*-value
		Constant Model		
oil_t	–1.903	0.328	–1.940	0.312
Δoil_t	–5.948*	0.001	–5.467*	0.001
$brazil_t$	–1.120	0.701	–1.449	0.551
$\Delta brazil_t$	–9.650*	0.001	–9.612*	0.001
$china_t$	–1.766	0.3930	–1.693	0.429
$\Delta china_t$	–8.569*	0.001	–8.586	0.001
$india_t$	–2.938*	0.047	–2.807	0.063
$\Delta india_t$	—	—	–9.762*	0.001
$russia_t$	–1.030	0.736	–2.003	0.284
$\Delta russia_t$	–5.621*	0.001	–7.700*	0.001
$safrica_t$	–2.977*	0.043	–3.145*	0.028
$\Delta safrica_t$	—	—	—	—
$turkey_t$	–3.024*	0.038	–2.591	0.100
$\Delta turkey_t$	—	—	–6.455*	0.001
		Constant-trend Model		
oil_t	–1.481	0.834	–1.539	0.804
Δoil_t	–6.165*	0.001	–5.964*	0.001
$brazil_t$	–0.278	0.985	–0.867	0.9525
$\Delta brazil_t$	–1.200	0.898	–9.768*	0.001
$\Delta\Delta brazil_t$	–5.153*	0.001	—	—
$china_t$	–2.572	0.2941	–2.572	0.294
$\Delta china_t$	–6.911*	0.001	–8.835*	0.001

End of Table 1

Variable	ADF test**		PP test***	
	Test statistic	*P*-value	Test statistic	*P*-value
$india_t$	–3.062	0.125	–2.969	0.149
$\Delta india_t$	–5.501	0.001	–9.761*	0.001
$russia_t$	–3.130	0.110	–3.202	0.094
$\Delta russia_t$	–5.566	0.001	–7.622*	0.001
$safrica_t$	–2.888	0.174	–2.930	0.160
$\Delta safrica_t$	–2.608	0.278	–11.021*	0.001
$\Delta\Delta safrica_t$	–6.588*	0.001	—	—
$turkey_t$	–2.962	0.151	–2.573	0.293
$\Delta turkey_t$	–6.480*	0.001	–6.417*	0.001

Notes. * indicates stationarity with a 5% level of statistical significance.
** — the appropriate number of lags was determined using the t information criterion.
*** — Bartlett Kernel and Newey–West Bandwidth were used.

Table 2 shows the results of two-breaks unit root tests developed by Lee and Strazicich (2004)[6]. According to the results of the test, all variables except for $russia_t$ the constant model are *I*(1), considering the constant model. According to the results of the constant-trend model, oil_t is *I*(1) as well. However, it is observed that the current account balance of some countries is *I*(0). Therefore, since the relation of the oil_t variable with the current account balance of the countries studied will be investigated, the maximum degree of integration (d_{max}) can be determined as 1. This is because the other variables are not more stationary than the *I*(1) according to the PP and Lee–Strazicich unit root tests, which are more powerful than ADF.

Table 2. Lee and Strazicich two-breaks unit root test results

Variable	Calculated test statistic	5% critical value**	Break date 1	Break date 2
		Constant Model		
oil_t	–3.083	–3.842	2008:Q3	2013:Q1
Δoil_t	–6.626*	–3.842	2007:Q3	2012:Q4
$brazil_t$	–2.969	–3.842	2011:Q4	2012:Q4
$\Delta brazil_t$	–10.636*	–3.842	2009:Q4	2014:Q4
$china_t$	–2.962	–3.842	2009:Q1	2016:Q3
$\Delta china_t$	–8.645*	–3.842	2009:Q4	2010:Q3
$india_t$	–3.616	–3.842	2008:Q2	2012:Q4
$\Delta india_t$	–7.394*	–3.842	2010:Q4	2011:Q4
$russia_t$	–5.313*	–3.842	2008:Q4	2011:Q3
$\Delta russia_t$	—	—	—	—
$safrica_t$	–3.839	–3.842	2013:Q3	2015:Q3
$\Delta safrica_t$	–10.781*	–3.842	2010:Q1	2015:Q2

6 When the break dates obtained from the test result are examined, it is seen that the first breaks are close to the 2008 Global Financial Crisis.

End of Table 2

Variable	Calculated test statistic	5% critical value**	Break date 1	Break date 2
$turkey_t$	–3.500	–3.842	2009:Q2	2014:Q4
$\Delta turkey_t$	–6.487*	–3.842	2007:Q1	2010:Q4
		Constant-trend Model		
oil_t	–5.340	–5.67	2008:Q2	2011:Q2
Δoil_t	–7.937*	–5.59	2007:Q4	2009:Q1
$brazil_t$	–6.372	–5.67	2009:Q2	2010:Q3
$\Delta brazil_t$	—	—	—	—
$china_t$	–5.579*	–5.59	2007:Q3	2009:Q1
$\Delta china_t$	–	—	—	—
$india_t$	–6.509*	–5.65	2007:Q4	2013:Q1
$\Delta india_t$	—	—	—	—
$russia_t$	–5.869*	–5.67	2008:Q4	2012:Q3
$\Delta russia_t$	—	—	—	—
$safrica_t$	–6.044*	–5.65	2008:Q4	2015:Q4
$\Delta safrica_t$	—	—	—	—
$turkey_t$	–5.515	–5.67	2008:Q3	2011:Q1
$\Delta turkey_t$	–7.758*	–5.59	2008:Q2	2009:Q1

Notes. * indicates stationarity with a 5% level of statistical significance.
** — critical values were taken from Lee and Strazicich (2003, p. 1084).

After the $d_{\max}$ information obtained from the unit root test results, the causality relationship between the oil prices and the current account balance of the countries were investigated by Hacker and Hatemi-J (2006) bootstrap symmetric causality analysis. Table 3 shows the results

Table 3. Hacker and Hatemi-J (2006) bootstrap symmetric causality test results

Null Hypotheses	MWALD	Critical value	Lags
There is no causality from oil_t to $brazil_t$	4.349	6.559	3
There is no causality from $brazil_t$ to oil_t	10.134*	6.364	3
There is no causality from oil_t to $russia_t$	2.384	3.991	2
There is no causality from $russia_t$ to oil_t	0.148	4.201	2
There is no causality from oil_t to $india_t$	10.678	6.459	3
There is no causality from $india_t$ to oil_t	1.533	6.445	3
There is no causality from oil_t to $china_t$	0.449	4.236	2
There is no causality from $china_t$ to oil_t	0.017	4.100	2
There is no causality from oil_t to $safrica_t$	0.341	3.978	2
There is no causality from $safrica_t$ to oil_t	0.257	4.112	2
There is no causality from oil_t to $turkey_t$	17.282*	6.465	3
There is no causality from $turkey_t$ to oil_t	2.795	6.428	3

Notes. * Indicates a causality correlation with a 5% level of significance.
p (appropriate lag value) was selected according to the Hatemi-J Information Criteria.
d_{max} (maximum degree of integration) = 1.

of this model. When looking at the results, we see a unidirectional causality relationship from $brazil_t$ to oil_t (from the current account balance of Brazil to the price of oil), and a unidirectional causality from oil_t to $turkey_t$ (from oil prices to Turkey's current account balance). There is no significant symmetric causality relationship between the current account balances of other countries and oil prices. Although there are no symmetrical relations, there may be asymmetric causality relationship between the variables. Therefore, in the rest of the study, asymmetric causal relationships between variables were examined with the causality analysis developed by Hatemi-J (2012).

In order to examine the asymmetrical causality relationships between the variables, the cumulative components/shocks of the variables must be obtained first. As indicated in the methods section, the cumulative components/shocks of the variables were obtained and shown in Fig. 4. After this stage, Hacker and Hatemi-J (2006) causality test process is followed. Therefore, stationarity levels of the variables need to be determined first.

Table 4 shows the ADF and PP unit root test results of the components/shocks of the variables. The use of only ADF and PP tests is due to the elimination of structural breaks in the components/shocks of the variables as seen in Fig. 4. According to both ADF and PP unit root test results, all variables are $I(1)$. Since the variables were $I(1)$, $d_{\max} = 1$ was added to the models, where the asymmetric causality relationship was examined.

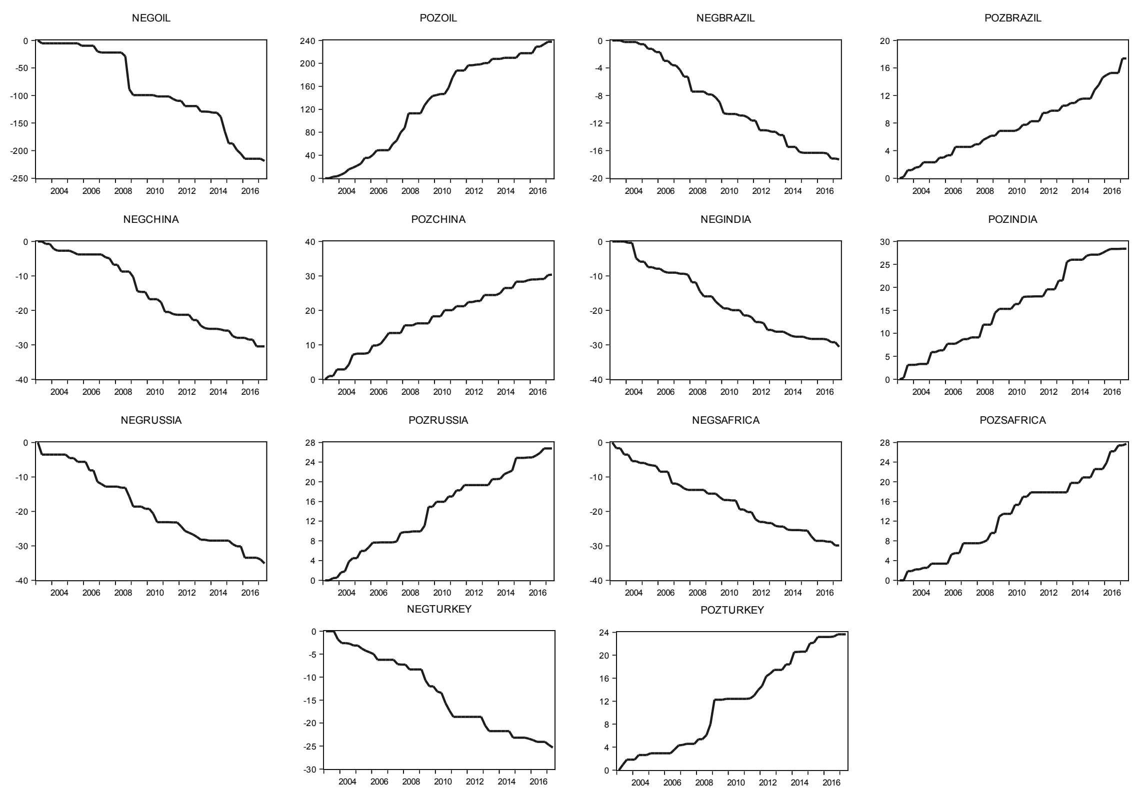

Fig. 4. The plots of the components

Table 4. Traditional unit root test results. Constant-trend Model

Variable	ADF**		PP***	
	Test statistic	Probability	Test statistic	Probability
oil_t^-	–2.888	0.173	–2.190	0.485
Δoil_t^-	–5.746*	0.001	–5.655*	0.001
oil_t^+	–0.599	0.975	–0.741	0.964
Δoil_t^+	–6.437*	0.001	–6.401*	0.001
$brazil_t^-$	–1.937	0.622	–1.914	0.634
$brazil_t^-$	–8.956*	0.001	–8.956*	0.001
$brazil_t^+$	–1.207	0.899	–0.740	0.964
$brazil_t^+$	–9.319*	0.001	–9.764*	0.001
$china_t^-$	–1.634	0.432	–1.803	0.689
$\Delta china_t^-$	–7.754*	0.001	–7.754*	0.001
$china_t^+$	–2.166	0.498	–2.259	0.448
$\Delta china_t^+$	–8.889*	0.001	–26.454*	0.001
$india_t^-$	–1.494	0.820	–1.545	0.801
$\Delta india_t^-$	–7.880*	0.001	–7.885*	0.001
$india_t^+$	–2.921	0.163	–3.027	0.134
$\Delta\ india_t^+$	–8.828*	0.001	–8.866*	0.001
$russia_t^-$	–2.367	0.392	–2.450	0.350
$\Delta russia_t^-$	–4.823*	0.001	–8.009*	0.001
$russia_t^+$	–2.608	0.278	–2.695	0.242
$\Delta russia_t^+$	–8.035*	0.001	–8.039*	0.001
$safrica_t^-$	–3.417	0.059	–3.327	0.072
$\Delta safrica_t^-$	–6.231*	0.001	–10.231*	0.001
$safrica_t^+$	–2.469	0.341	–2.493	0.330
$\Delta safrica_t^+$	–3.617*	0.038	–9.038*	0.001
$turkey_t^-$	–1.857	0.663	–1.440	0.838
$\Delta turkey_t^-$	–6.125*	0.001	–6.044*	0.001
$turkey_t^+$	–2.650	0.260	–2.213	0.473
$\Delta turkey_t^+$	–6.141*	0.001	–6.125*	0.001

Notes. * indicates stationarity with a 5% level of statistical significance.
** — the appropriate number of lags was determined using the *t* information criterion.
*** — Bartlett Kernel and Newey–West Bandwidth were used.

The results of the asymmetric causality test after determining the maximum degree of integration ($d_{max} = 1$) are shown in Table 5. According to the results, causality relationship was found from the positive shock of oil prices to positive shock of South Africa's current account balance, from the negative shock of oil prices to negative shocks of current account balances of Russia, China, and Turkey, and to positive shocks of current account balances of Russia, India, and Turkey. In addition, there is a causal relationship from the negative shock of Brazil's current account balance to both positive and negative shocks of oil price. Finally, it is seen that there is a causal relationship from India's positive shock of current account balance to negative shock of oil price. These findings were observed to be differ from the results of the symmetric causality analysis. Table 3 shows only the causality relationship between current account balance and oil price for Turkey and Brazil. The asymmetric causality test showed that asymmetric relationships exist between the variables for other countries.

Table 5. Hatemi-J (2012) asymmetric causality test results

Null Hypotheses	Countries					
	Brazil	Russia	India	China	South Africa	Turkey
There is no causality oil_t^+ to ca_t^+	—	—	—	—	✔	—
There is no causality oil_t^- to ca_t^-	—	✔	—	✔	—	✔
There is no causality oil_t^- to ca_t^+	—	✔	✔	—	—	✔
There is no causality oil_t^+ to ca_t^-	—	—	—	—	—	—
There is no causality ca_t^+ to oil_t^+	—	—	—	—	—	—
There is no causality ca_t^- to oil_t^-	✔	—	—	—	—	—
There is no causality ca_t^- to oil_t^+	✔	—	—	—	—	—
There is no causality ca_t^+ to oil_t^-	—	—	✔	—	—	—

Notes. ✔ Indicates a causality correlation with a 5% level of significance.
p (appropriate number of lags) was selected according to the Hatemi-J Information Criteria and $d_{max} = 1$.

6. Conclusion

According to the Hacker and Hatemi-J (2006) symmetric causality analysis results performed in this study to investigate the relationships between current account balance and oil prices for BRICS-T countries, a unilateral causality relationship from oil prices towards Turkey's current account balance, and a causality relationship from Brazil's current account balance towards oil prices was found. However, due to the fact that the symmetric causality relationship does not take into account the asymmetrical relationship between the variables, Hatemi-J (2012) asymmetric causality test was performed, and different relations were found between the oil price and the components/shocks of the countries' current deficits. This shows the importance of asymmetric relationship in econometric analysis. This difference between the symmetric causality test and the asymmetric causality test is one of the important findings of the study. Indeed, there are asymmetric rather than symmetric causalities from the oil prices towards current account balances of the countries, except Turkey, and the results obtained for Turkey are consistent with the study by Kırca and Karagöl (2018). Despite the differences in this sense, Turkey shows similarities with the BRICS countries in terms of asymmetric causality relationship. Although the subject of this study is not indicative alone, it still provides substantial evidence for Turkey's participation among the BRICS countries.

The most interesting findings of the study are the causality relationships from the shocks in the current account balance of Brazil towards the oil price shocks and from the positive shock of the current account balance in India towards the oil price negative shocks. According to the report published by the International Energy Agency (2013, p. 363), in the last 10 years, larger oil fields have been discovered in Brazil compared to other countries. Accordingly, it would not be wrong to say that Brazil's newly discovered and increasing oil supply and exports have an impact on world oil prices. The resulting asymmetric causality relationship can be attributed to this fact. The impact of the positive shock in India's current account balance on the negative shock of oil prices may be due to the fact that India is the largest oil market in the world. Presence of causality from the negative shock of oil prices towards the positive shock of India's current account balance is also a remarkable finding. This shows the importance of oil prices for India. Although Russia is a major oil producer and exporter in the world, there is no symmetric or asymmetric causality relationship from Russia's current account balance towards oil price. The reason for this is that Russia was among the major oil exporters and supplying oil for years. In other words, this can be considered normal since Russia has an oil market that shapes its economy at present. The findings of other countries are similar, and there is asymmetric causality relationship from oil prices to the current account balances of countries. The impact of the shocks in oil prices on the shocks of the current account balance confirms that oil prices are one of the strong determinants of the current account balance (Aristovnik, 2007; Barnes et al., 2010; Gosse, Serranito, 2014; Karagöl, Erdoğan, 2016).

As a result, the existence of asymmetric relationship is of importance for the BRICS-T countries, although the symmetric relationship between the oil prices and the current account balance are not intense. Current account balance of the countries that have new petroleum sources discovered and have a share in the total oil imports has an impact on oil prices. Policy-makers should consider the significant impact of shocks in oil prices on the current account to evaluate any policy, especially for Russia, China, India and Turkey.

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