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An Econometric Study on Oil Prices, Exchange Rate and Exports: A Case of Russia, Azerbaijan and Indonesia

Araştırma Makalesi /Research Article

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ABSTRACT: *After oil crisis in 1970s, discussions of the oil price effect on economies have accelerated. In addition to being a exhaustible energy source, the environmental pollution it generates has led many developed countries to shift towards renewable energy sources. Furthermore, fluctuations in oil prices and increased dependence on it have disruptive effects on national economies. All these factors pose a threat to countries with oil reserves and economies heavily reliant on the oil industry. This study, examines the relationship between oil prices, exports, and exchange rates in Russia, Azerbaijan, and Indonesia whose sum of oil consumption and production exceed that of Europe but have not been the primary focus of previous research. This study employs a panel causality test and encompasses data from 1996 to 2021. The findings indicate the existence of a unidirectional causality relationship from oil prices to both exports and exchange rates in the countries studied. Additionally, the research reveals a unidirectional relationship between exports and exchange rates.*

Keywords: *Oil prices, exchange rate, export, panel causality test*

Petrol Fiyatları, Döviz Kuru ve İhracat Üzerine Ekonometrik Bir Araştırma: Rusya, Azerbaycan ve Endonezya Örneği

ÖZ: *1970'lerdeki petrol krizinden sonra, petrol fiyatlarının ekonomi üzerine etkileri konusundaki tartışmalar hız kazandı. Petrol tükenebilir bir enerji kaynağı olmasının yanında ortaya çıkardığı çevre kirliliği birçok gelişmiş ülkeyi yenilenebilir enerji kaynaklarına yöneltmiştir. Ayrıca Petrol fiyatlarındaki dalgalanmalar ve dışa bağımlılığı arttırması ülke ekonomileri için istikrar bozucu etkiler doğurmaktadır. Bütün bunlar petrol rezervi bulunan ve ekonomileri büyük ölçüde petrol sanayiine bağlı olan ülkeler için tehdit unsuru oluşturmaktadır. Bu çalışmada toplam petrol üretimi ve tüketimi Avrupa'dan daha fazla olan ve önceki çalışmalarda genellikle fazla odaklanmayan Rusya, Azerbaycan ve Endonezya'da petrol fiyatları, ihracat ve döviz kuru arasındaki ilişkiyi incelemiştir. Panel nedensellik testlerinin kullanıldığı çalışma 1996-2021 dönemini kapsamaktadır. Analiz sonuçları ilgili ülkelerde petrol fiyatlarından ihracat ve döviz kuruna tek yönlü bir nedensellik ilişkisinin olduğunu göstermektedir. Ayrıca, ihracattan döviz kuruna doğru tek yönlü bir nedensellik ilişkisi olduğunu tespit edilmiştir.*

Anahtar Kelimeler: *Petrol fiyatları, döviz kuru, ihracat, panel nedensellik testi*

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1. Introduction

Energy undeniably stands as one of the paramount cornerstones of economies. Despite recent technological advancements that have facilitated the rise in alternative energy adoption, oil maintains its dominance as a primary energy source, boasting a staggering global market value of approximately over US$ 1.7 trillion (Nasir et al., 2018). Hence, being a main energy source of economic activities led scholars' focus on energy price movements and its relationship with the other economic indicators. For instance, the implications of monetary policy in response to shocks in oil price have been examined by Brown and Yücel (2002), Rahman and Serletis (2010) and Wen et al. (2019), and the economic growth and environmental effects of oil price and consumption have been studied by Martins et al. (2019) and Malik et al. (2020). Furthermore, being an energy source, oil is the most vital and traded commodity as it is commonly used in production processes (Nasir et al., 2019). Thus, a fluctuation in oil price affects economies via different ways (Wei and Guo, 2016; Sarwar et al., 2017; Lee et al., 2017). The magnitude of these effects can be triggered by the combination of exchange rate oscillations. As the US dollar (USD) is the dominant transactional currency in the oil markets worldwide, fluctuations in the USD exchange rate have an impact on oil traders (Reboredo and Rivera-Castro, 2013).

Oil holds a crucial position in national economies due to its pivotal role in production and transportation processes in economic activities. The increased demand for oil resulting from energy dependence during the Industrial Revolution makes it a significant factor impacting production costs (Sek et al., 2015). As a result, abrupt fluctuations in oil prices can greatly influence various economic aspects. Important factors like price levels, trade balances, exchange rates, and others can be strongly influenced by changes in oil prices (Basher, Haug, and Sadorsky, 2012; Le and Chang, 2013; Kim et al., 2020). Because of their significance in economic growth and development (Eyden et al., 2019; Akinsola and Odhiambo, 2020), it is especially important to comprehend the possible effects of fluctuations in oil prices on the economy. Therefore, it is crucial to analyze the possible implications of modifying the price of this key factor to develop appropriate economic policies.

Developed countries have transitioned to alternative energy sources due to oil's limited availability and environmental impact. However, numerous developing nations continue to heavily rely on oil as their main energy source, especially as their economies develop (Gibbons et al., 1989). It's essential to note that oil not only has finite resources, but also exposes energy-importing economies to vulnerability by tying them to foreign sources of energy (Wang et al., 2021). Fluctuating oil prices create economic instability in nations due to escalating energy costs that lead to inflation, negatively impacting growth and development (Akinsola and Odhiambo, 2020; Wang et al., 2022). This scenario also affects a country's competitiveness in international trade, compelling nations to explore alternative energy options and require the adoption of renewable resources.

When evaluating global developments from the perspective of oil-rich countries with oil-dependent economies, the effective utilization of this resource becomes a significant concern. The impact of abrupt changes in oil prices can have crucial consequences for the long-term growth performance of oil-dependent economies (Tausif et al., 2023; Sohag et al., 2023). The growth of these countries might be negatively affected by price changes in global markets, given the uncertainties and risks they bring forth (Guan et al., 2021). Conversely, the non-renewable quality of this resource and the resulting environmental pollution may lead to diverse policy pursuits. Hence, it is crucial to unveil these effects to determine the appropriate policies for long-term growth.

According to BP (2021) report, Russia, Azerbaijan and Indonesia produced 10667, 716 and 743 thousand barrels oil per day, respectively. At the same time, oil consumption of those three countries; 3238, 92 and 1449 thousand barrels oil per day, respectively. Considering to total oil production and consumption numbers of Europe which are 167.1 and 12788 thousand barrels oil per day, respectively, the importance of Russia, Azerbaijan and Indonesia can be seen. Moreover, after Paris climate agreement have been signed, increase in investment of renewable energy and usage of electric vehicles shows that oil industry and oil-exporter countries will suffer from this increase in the near future (Covington, 2017). In addition, environmental concerns about fossil fuels, especially oil, and the likelihood of strict regulations and emission standards for industrial consumption may also cause to a decline in domestic oil demand. Thus, this study aims to investigate and clarify the relationship among oil price, exchange rates and export in Russia, Azerbaijan and Indonesia. For this purpose, panel causality test has been used with the yearly data from 1996 to 2021.

The primary contribution of this paper can be briefly summarized as follows: First, it addresses a notable gap in the existing literature by elucidating the intricate relationship between oil prices, exchange rates, and exports. While previous studies have mainly focused on the correlation between oil prices and economic growth, this study stands out by delving into the interrelated dynamics of oil prices, exchange rate fluctuations, and export patterns. Establishing the causal relationship between oil prices, exports and exchange rates contributes to the development of strategies to ensure economic and financial stability in these countries. Second, it is worth noting that prior research has predominantly centered on the impact of oil prices on economic growth within the context of OPEC, China, and the USA. However, the specific cases of Russia, Azerbaijan, and Indonesia have been relatively underrepresented in the existing literature. Consequently, it would be beneficial for policymakers to focus on oil exporting countries such as Russia, Azerbaijan, and Indonesia and to examine the dynamics of their economies. Thus, the study aims to open more avenues of research for other countries. Since, any fluctuation in oil price or oil demand in the future not only affects OPEC, China or USA, but also other countries. Even though the study covers only Russia, Azerbaijan and Indonesia, the same inference can be made other oil exporter and

importer countries as well. When considered from this point of view, the study will provide policy makers with a new perspective to for the future of their economy.

The structure of the paper has 5 parts. After introduction section, in section 2, we present a comprehensive literature review to describe previous studies in the field. Section 3 is a brief outline of the methodology of this study in relation to our research objective. The empirical results are shown and their implications are discussed in section 4. At the last section, we conclude the study and offer policy implications based on our findings.

2. Relationship between Oil Price, Exchange Rate and Exports

The impact of oil prices on exchange rates has been a subject of extensive discussion, particularly within the context of nations that either import or export oil. Rising oil prices result in an increase in the commodity prices of countries that import oil, subsequently leading to higher exchange rates in these importing nations. However, these effects may vary in the short and long run owing to direct and indirect effects. Initial research findings on this subject demonstrate a significant connection between oil prices and exchange rates. Within the primary studies examining these impacts, Krugman's research in (1980) and (1983) identified that the initial stage of rising oil prices had adverse effects on the balance of payments in oil-importing countries. The income earned by the oil exporting country can be transferred back to the importing country due to the goods to be purchased from the importing country. Under such circumstances, the short-term and long-term consequences of oil price fluctuations on the exchange rate could be subject to alterations. Likewise, Golub (1983), a prominent researcher in this field, underscored that a surge in oil prices results in heightened income for oil-exporting nations while causing a decline in oil-importing countries, ultimately influencing exchange rates. In the following studies, Trehan (1986), Amano and Norden (1998), Camarero and Tamarit (2002) found long-run relationships among oil prices and exchange rates.

When looking at the most recent studies regarding oil price and exchange rate: (Volkov and Yuhn, 2016) have undertook a comprehensive investigation to assess the repercussions of oil price shocks on exchange rate dynamics in five significant oil-exporting nations: Norway, Canada, Brazil, Russia, and Mexico. Their study has utilized a Vector Error Correction Model (VECM) and an impulse response model, making use of data spanning from 1998 to 2012. The results of their research indicate that oil price shocks have a notable guidance on exchange rate volatility in Brazil, Russia, and Mexico. However, this influence seems to be less pronounced in Norway and Canada. In addition, the study shows that it would take a considerably longer period of time for the exchange rates in Russia, Brazil and Mexico to return to their original equilibrium levels after such shocks, compared to the relatively faster adjustment observed in Norway and Canada. Hussain et al. (2017) have employed the detrended cross-correlation approach (DCCA) to examine the interconnected volatility of oil prices and exchange rates across 12

Asian countries during the period from 2006 to 2016. The primary objective is to provide insights for shaping effective trade policies, fiscal, monetary and inflationary, and trade policies in these nations. The empirical results of the study substantiate the existence of co-movements between oil prices and exchange rates. Furthermore, the analysis reveals a relatively weak negative cross-correlation among oil prices and exchange rates in this context. Kumar (2019) have investigated the asymmetric consequences of oil price fluctuations on exchange rates in India. This investigation has utilized both the Hiemstra and Jones nonlinear Granger causality test and a nonlinear ARDL model, analyzing data from 1994 to 2015. The findings based on the Hiemstra and Jones test has revealed compelling evidence of a bidirectional nonlinear link among oil prices and exchange rates. Moreover, the findings derived from the ARDL model indicated that positive oil price shocks from the preceding month had a positive effect on exchange rates, and conversely. In another notable research, Lin and Su (2020) have applied ARDL approach to evaluate data from 2005 to 2019 for BRICS countries. This study has uncovered two discernible outcomes resulting from oil price shocks, depending on whether a country functions as a net oil importer or exporter. The study's findings suggest that exchange rates show a noticeable response to oil shocks, but predominantly at higher frequencies. Notably, China stands out as the only country where the significance of exchange rate fluctuations in response to oil price shocks is significantly lower than in the other BRICS countries. Saidu et al. (2021) have examined the dynamics of oil prices and exchange rates in African net oil importing countries. Specifically, the study covered Côte d'Ivoire, Kenya, Ghana, South Africa, Morocco, and Senegal, using both ARDL and nonlinear ARDL approaches with data spanning from 1983 to 2018. The research has unveiled the co-movements of variables and clarified both the long-term and short-term relationships among them. Notably, the empirical findings underscore that adverse oil price shocks exert a more pronounced influence on exchange rates compared to positive shocks, a pattern evident from the analysis results. In their study, Garzón and Hierro (2022) have investigated the influence of oil prices on the euro/dollar exchange rate and its subsequent impact on the inflation rate in the euro area. After estimating the augmented Phillips curve, they have identified a positive association between the exchange rate and oil prices.

Conversely, fluctuations in energy prices, which are integral to production and exports, can significantly disrupt the balance of payments for nations that rely on oil imports. In this case, the balance of trade may deteriorate as imported goods become more expensive. The main study analyzing the impact of oil price shocks on the balance of trade was conducted by Agmon and Laffer (1978). In this study, it was found that oil price shocks disrupt the balance of trade in the first stage. However, the authors also found that the deterioration in the trade balance disappears in the long run. Considering recent studies on oil prices and exports: Baek et al. (2019) have used nonlinear ARDL aprroch on data from 2007 to 2016 for four OPEC partners which are Saudi Arabia, Venezuela, Iran, and Nigeria. The

results show that although in the short run, alterations in oil prices do not results in asymmetrical effects on the trade balance, asymmetric effects on the trade balance inresponse to oil price has been found in the long run. Mukhtarov et al. (2020) have showed the how economic indicators including economic growth, inflation, export and exchange rate have been effected by oil price in Azerbaijan by using VECM and Johansen cointegration method to the data covering from 2005 to 2019. The results show that oil price has an adverse influence on the exchange rate, whereas it has a negative effect on economic growth, exports and inflation. Zhaoa et al. (2021) have investigated how renewable energy sector, macroeconomy and environment effected by oil price fluctuation for 2015 benefiting from CGE model in China. Their findings show that renewable energy sector is positively affected by raise in oil price, however, GDP and exports of China are negatively affected by the same oil price increase. Yildirim and Arifli (2021) have focused on Azerbaijan economy as a small oil exporting economy to clarify how change in oil price effect the economy. Their study covers from 2006 to 2018 and VAR model has been used in the study. It has been found that an oil price decline negatively effects Azerbaijan economy by leading trade balance deficit. Dagar and Malik (2023) have emphasized important of the export and its relationship between economic variables for the economies. Pakistan has been chosen as a sample country and export of Pakistan with top 5 partners has been investigated by using quantile-on-quantile regression approach. The study shows that positive relationship between oil prices in export of Pakistan for the year from 2003 to 2020. For the same country, Nazir et al. (2023) have conducted a study covered from 2013 to 2021 about how oil price affect exchange rate. According to the study, there is no impact of oil price on exchange rate, but oil price and exchange rate have a volatility connection. An econometric study about oil price and exchange rate has been conducted by Kisswani and Fikru (2023) for ESEAN-5 countries by applying OLS and QR methodologies to data from 1970 to 2022. The results show that asymmetric effect of oil price not homogenous, so oil price change should be divided to part as positive and negative to investigate oil price effect on exchange rate in the future studies.

Besides exchange rates and exports, oil prices are strongly linked to other economic indicators. The effects of the oil crisis of the 1970s and 1980s have tended most scholars to focus on oil price effects on economies; thus, there are plenty of applied studies in literature. Hamilton (1983) has applied Granger causality to demonstrate the effect of oil price shocks on the economy of USA in his inaugural work, in which Hamilton proved that an increase in oil price has had a more restricted macroeconomic effect after 1973 than it would have had before the 1973. After the study of Hamilton (1983), several scholars conducted studies for different industrial countries. To demonstrate, Burbidge and Harrison (1984) have indicated that industrial productions were negatively affected by oil price shocks in, the Federal Republic of Germany, the U.S., Japan, the U.K., and Canada applying VAR model to data range from January 1961 to June 1982. Hooker (1996) has showed that the correlation among oil prices, economic activity appears weaker by applying

Granger causality test in the U.S. data obtained since 1985. According to Schmidt and Zimmermann (2007) the macroeconomic impacts has decreased in time as estimated by their VAR model which calculates impulse response to oil price shocks for the quarterly data from 1975 to 2006 in Germany.

When examining the most recent studies on oil prices and the overall economic variables: The study that shows the relationship between output and oil price in the eight net oil producer African countries has been conducted by Omolade et al. (2019). They have applied SVAR model to the data between 1980 and 2016. The results show that a decrease in oil price leads to increase in the output amount. The paper of Akhmad et al. (2019) has indicated how economic growth, inflation, and poverty have been effected by change in oil price in Indonesia using VAR method. Time series data from 1980 to 2017 have been used in the study and the results show an increase in oil price has a negative effect on economic growth and has a positive impact on inflation, which could have a permanently negative effect in the long term. In addition to negative effect on economic growth, an increase in oil price has a positive impact on poverty in a short term as well. Overall result is that Indonesia's economy has adversely been affected by an increase in oil price. Almutairi (2020) has indicated that the oscillation in economic growth and unemployment rate in response to oil price in Saudi Arabia by applying SVAR model to the data from 1999 to 2015. The results demonstrate that the primary determinant of the fluctuations in economic growth and unemployment rate in the S. Arabian economy is the price of oil. The study of Balashova and Serletis (2020) has showed the nexus between the oil price and production in agriculture, mining, manufacturing, and gas, electricity, and water distribution, construction, transport, trade (retail and wholesale) by applying Granger causality test. The results indicates that while overall Russian economic activities have been positively affected by increase in oil price, mining negatively responses to a positive shock in oil prices.

3. Data and Methodology

In this study, a preliminary assessment is conducted to ascertain the causal relationships between oil prices, exchange rates, and exports. To determine these causal relationships, cross-section dependence and unit root tests are essential for the series under consideration. The cross-sectional dependence (CSD) test is initially applied to the series to guide the choice of the appropriate unit root test. If the unit root test results indicate that the series are stationary at the level, it becomes possible to proceed with causality analysis without engaging in cointegration analysis.

Nonetheless, the study's models require a priori tests to be conducted in order to facilitate causality analysis. In cases where there is evidence of CSD and heterogeneity within the models, the conventional Granger test cannot be effectively utilized. This limitation arises because the standard Granger causality test does not account for CSD and operates under the assumption of homogeneity.

In this study, the panel causality test developed by Dumitrescu and Hurlin (2012) is employed. This test is based on addressing the potential drawbacks of the standard causality test and is used in conjunction with the outcomes of a priori tests. Importantly, unlike the Granger causality test, this test accommodates the heterogeneity assumption. Furthermore, Dumitrescu and Hurlin (2012) have demonstrated that this test exhibits robustness against CSD in their empirical simulations.

3.1. Data

This study, examines the relationship between oil prices, exports, and exchange rates. The causality relationship among oil price, exchange rate and exports has been analyzed for the period 1996-2021 in the study. For application of the study, a panel data set consisting of Russia, Azerbaijan and Indonesia, which have an important place in oil production and consumption in the world, has been created. Oil price (OIL) is obtained from World Bank Commodity Price Data, while exports (EXP) and exchange rates (ER) are obtained from World Bank World Development Indicators (WDI) database. In the analysis of the study, the natural logarithms forms of OIL and ER variables have been used while the EXP variable is included in the study as a ratio. As it can be seen on the Table 1, oil price and exchange rate measurement unit are US$, but exports of the countries have been calculated as a percentage of their own GDP to provide more coherent results for each country. Information in details about the variables which have been used in the study is shown in Table 1.

Table 1. The Sources of the Variables and Description

Name of the variable	Symbol of the variable	Measurement unit	Source of the variable
Oil Price	OIL	Crude oil, Brent ($/bbl)	World Bank Commodity Price Data
Export	EXP	Exports of goods and services measured by % of GDP	World Bank WDI
Exchange Rate	ER	Official Exchange Rate, period average	World Bank WDI

3.2. Methodology

3.2.1. CSD and homogeneity test

This study has used the CSD test developed by Breusch and Pagan (1980) which gives more reliable results in the case of T>N. This test (BP-LM) is calculated according to equation (1).

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \ \sim X^2_{\frac{N(N-1)}{2}} \quad (1)$$

Where $\hat{\rho}_{ij}$ is the correlation coefficient among the residuals which are obtained from the OLS calculation, the basic hypothesis (H_0) of the BP-LM test, which shows the $\chi 2$ distribution for T→∞ with N fixed, is "no correlation between residuals" (Pesaran, 2004).

In order to check the homogeneity of slope coefficients, delta tests developed by Pesaran and Yamagata (2008) have been used in the study. In two delta ($\tilde{\Delta}$) tests, the basic hypothesis (H_0), which is slope coefficients are homogeneous, has been tested against the alternative hypothesis (H_1), which is slope coefficients are heterogeneous, when T and N → ∞ and √N/T →∞. Among these tests, the deviation-corrected delta test is recommended for small samples:

$$\tilde{\Delta}= \sqrt{N}\left(\frac{N^{-1}\,\tilde{S}-k}{\sqrt{2k}}\right)\sim\chi_k^2 \tag{2}$$

$$\tilde{\Delta}_{adj}= \sqrt{N}\left(\frac{N^{-1}\,\tilde{S}-E(\tilde{z}_{it})}{\sqrt{var(\tilde{z}_{it})}}\right)\sim N(0,1) \tag{3}$$

3.2.2. Panel Unit Root Test

For this study, the stationarity of the series has been tested by means of the CIPS test of Pesaran (2007). Pesaran (2007) CADF unit root test uses an augmented form of the ADF regression with lagged cross-sectional averages. Eliminating the correlation between units is the main advantage of this regression. In addition, after estimating the CADF regression, the CIPS statistic is obtained for the whole panel. The CIPS statistic for the whole panel is made of the averages of the lagged t-statistics (CADFi) (Tatoğlu, 2013).

$$CIPS= CADF_i = \frac{\sum_{i=1}^{N} CADF_i}{N} \tag{4}$$

The basic hypothesis (H_0) that the series has a unit root is rejected if the calculated values of the CIPS test statistic are greater than the critical values in the table in absolute terms (Pesaran, 2007).

3.2.3. Panel Causality Test

Since Granger (1969) causality test takes homogeneity into account, it is not a correct approach to use this test for heterogeneous panels. For heterogeneous panel models, several causality tests have recently been developed. One of these tests is the Dumitrescu and Hurlin (2012) panel causality test (D-H), based on the Granger (1969) causality test, which accounts for both heterogeneity in the models and CSD.

Two stationary variables, X and Y, have been modelled in the following way:

$$Y_{it} = a_i + \sum_{k=1}^{K} \gamma_i^{(k)}\, Y_{it-k} + \sum_{k=1}^{K} \beta_i^{(k)} X_{it-k} + \varepsilon_{it} \tag{5}$$

In equation (5), for each individual i = 1... N, at time t = 1... T, and while (k) represent identical lag orders for all units of the panel, the autoregressive parameters $\gamma_i^{(k)}$ and the regression coefficients slopes $\beta_i^{(k)}$ differ between groups.

H_0: $\beta_i = 0$ i= 1, … , N (6)

where $\beta_i=\left(\beta_i^{(1)}, \dots, \beta_i^{(k)}\right)$, and the basic hypothesis (H_0) of this test is all individual vectors of β_i are equal to zero, so this represents no causality form X to Y.

H_1: $\beta_i = 0$ i = 1, …… , N_1 (7)

$\beta_i \neq 0$ i = N_1 + 1, …… , N_2 + 2, …… , N

Under the alternative hypothesis (H_1) with N_1<N, there is no causality from X to Y. Where N_1 is unknown but meets the following condition 0≤ N_1/N<1, since if N_1=N, the alternative hypothesis (H_1) is equivalent to the basic hypothesis (H_0) which is no causality for any individuals for the panel. The rejection of the basic hypothesis (H_0) indicates that the model is heterogeneous and β_i is valued according to the units. The rejection of the basic hypothesis (H_0) is an indication that there is a causal relationship between the two variables in at least one unit in the panel. Equations (8), (9) and (10) show the tests developed to establish causality:

$$W_{N,T}^{HNC} = \left(\frac{1}{N}\right)\sum_{i=1}^{N} W_{i,T} \tag{8}$$

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}\left(W_{N,T}^{HNC} - K\right)} \tag{9}$$

$$Z_N^{HNC} = \frac{\sqrt{N\left[W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} E(W_{i,T})\right]}}{\sqrt{N^{-1}\sum_{i=1}^{N} var(W_{i,T})}} \tag{10}$$

where ($W_{i,T}$) is the individual Wald statistic calculated for each unit to test the basic hypothesis (H_0) for the causality analysis. $\left(W_{N,T}^{HNC}\right)$ is the mean of the calculated individual Wald statistics for each unit. Thus, it can be obtained Wald statistics for the whole panel thanks to equation (8). In addition, Dumitrescu and Hurlin (2012) suggest the following: if T>N, use the $Z_{N,T}^{HNC}$ test statistic shown in equation (9) and if T<N, use the (Z_N^{HNC}) test statistic shown in equation (10).

4. Empirical Results

This study uses panel causality test to analyze the relationship among oil prices, the exchange rate and exports. However, before proceeding to the causality analysis, the CSD test and then stationarity of the variables has been checked by 2. generation unit root test. Finally, tests of the homogeneity and cross-sectional dependence of the models are carried out and the results on causality are presented.

Table 2. Test Results of CSD

Variables	BP-LM
lnOIL	78.000***
EXP	12.947***
lnER	40.448***

***, shows the significance at the 1% level.

Table 2 indicates the results of the CSD test for the variables used in the study. The results show that the basic hypothesis (H_0) which is there is no correlation between residuals is rejected for all variables at 1% significance level. According to this result, there is CSD in the variables. Thus, 2. generation panel unit root tests must be used. Therefore, the CIPS panel unit root test has been applied and the results are presented in Table 3.

Table 3. Test Results of CIPS Panel Unit Root

Variables	CIPS Test Statistics	Critical Values		
		10%	5%	1%
lnOIL	2.61***	-2.21	-2.33	-2.57
EXP	-2.23*			
lnER	-5.21***			

*** and * shows the significance at the 1% and 10% levels, respectively.

According to the results obtained from Table 3, the CIPS statistical values of all variables used in the study are greater in absolute value than the critical values determined by Pesaran (2007). This indicates that the basic hypothesis (H_0) which is there is a unit root in the series is rejected and the variables are stationary at I(0). Hence, it is possible to conduct causality analysis without performing cointegration analysis. However, so as to determine the type of causality test, CSD and homogeneity tests has been performed for the models and the findings of CSD as well as homogeneity tests are presented in Table 4.

Table 4. The Results of CSD and Homogeneity Test

Direction of causality	BP- LM	$\tilde{\Delta}$	$\tilde{\Delta}_{adj}$
lnOIL→EXP	18.430***	11.760***	12.474***
EXP→lnOIL	27.54***	10.290***	10.914***
lnOIL→lnRATE	42.720***	19.033***	20.188***
lnRATE→lnOIL	65.980***	10.997***	11.664***
lnRATE→EXP	12.390***	9.745***	10.336***
EXP→lnRATE	32.30***	21.037***	22.313***

***, shows the significance at the 1% level.

The results presented in Table 4 indicate that all models employed in this study exhibit CSD. The BP-LM test findings demonstrate that the null hypothesis (H_0), suggesting no correlation among the residuals, is rejected at a significance level of 1%. In other words, the delta test results reject the null hypothesis (H_0) of homogeneous slope coefficients at the 1% significance level, indicating that the slope coefficients are indeed heterogeneous. Consequently, considering these outcomes from Table 4, the chosen causality test should account for both CSD and heterogeneity. Therefore, in this study, we utilize the panel causality test of D-H, known for its robustness to CSD and applicability to heterogeneous panels, and the results are presented in Table 5.

Table 5. D-H (2012) Panel Causality Analysis

Direction of causality	Lag	W-bar	Z-bar	p-value
lnOIL→EXP	**3**	**15.398**	**8.767*** **	**0.000**
EXP→lnOIL	1	0.805	-0.238	0.811
lnOIL→lnRATE	**2**	**3.978**	**1.713***	**0.086**
lnRATE→lnOIL	1	1.8259	1.011	0.311
lnRATE→EXP	6	7.020	0.510	0.609
EXP→lnRATE	**2**	**13.670**	**10.106*** **	**0.000**

*** and * shows the significance at the 1% and 10% levels, respectively.

In the panel causality analysis, lags number was determined according to the Akakike criterion as suggested by Lopez and Weber (2017). In addition, Z-bar statistics are interpreted since T>N in this study. The outcomes of the panel causality tests, as displayed in Table 5, indicate the presence of unidirectional causality. Specifically, there is a unidirectional causality running from oil prices to both exports and exchange rates. Simultaneously, there exists unidirectional causality from exports to exchange rates. These findings highlight the influence of oil price fluctuations on exports and exchange rates in countries like Russia, Azerbaijan, and Indonesia, which hold significant positions in global oil production and consumption. On the other hand, any increase or decrease in exports in these countries affects the exchange rate. These findings from the study are consistent with Singhal et al. (2019), Thuy and Thuy (2019), Malik and Umar (2019), Chkir et al. (2020), and Simamora and Widanta (2021).

5. Conclusion

Despite the increasing demand for energy, oil is still heavily relied upon as the main source of energy. However, sudden changes in oil prices greatly affect the global economy and environment. As a result, many countries are shifting from non-renewable resources to renewable energy sources due to their depletion and the pollution caused by fossil fuels such as oil. Environmental worries have increased criticism of fossil fuels, causing developed nations to lead agreements and negotiations, resulting in a worldwide move towards cleaner energy sources like

solar, wind, and wave energy. All nations must address the threat of global warming caused by energy consumption. This shift is of particular importance to oil-exporting countries.

Russia, Azerbaijan, and Indonesia have economies heavily reliant on oil activities due to their oil reserves. This leaves them at risk of being adversely affected by fluctuations in oil prices on the global market. Identifying the channels through which sudden changes in oil prices will impact these countries' economies is crucial in designing effective policies to prevent potential risks. In this study, the relationships between oil prices and these two variables, exchange rate and export, have been examined. Panel causality test have been applied to data from 1996 to 2021 for Russia, Azerbaijan and Indonesia. Two type relationships which are unidirectional causality from oil prices to both exports and exchange rates as well as unidirectional causality from exports to exchange rates have been determined in the study for the entire panel.

The study shows that oil price fluctuations lead to changes in exports and exchange rates. Considering the other factors, such as the full application of the Paris Climate Agreement by all parties, or any political chaos in oil-rich countries, such as the Arab Spring events in the last decade, the pressure on the use of fossil energy sources and the export of fossil energy may increase over time. This pressure may inevitably affect exchange rate associations through exports. Therefore, policy makers should shift their energy sources from fossil energy to its alternatives such as renewable energy sources including solar and wind energy sources, etc. In particular, net oil exporters Russia and Azerbaijan need to start investing in renewable energy from now on. Increasing investment in renewable energy can be a key a net oil exporter, can protect itself from export deficits by prioritizing investments in alternative energy sources in the short term. In this way, Indonesia's local currency fluctuations can be slowed down.

As energy resources play a crucial role in the growth and development of countries, their effective and efficient use is a critical factor. The sample countries should allocate the use of oil effectively and invest the revenues generated productively. However, given the limited availability of natural oil resources and their environmental impact, the adoption of renewable energy sources becomes essential. Ensuring a sustainable energy supply can promote economic continuity and international competitiveness. Investing in non-oil sectors is another step that can reduce the vulnerability of oil-dependent economies. By reducing their dependence on oil, these economies can reduce their exposure to fluctuations in global oil prices.

In summary, reducing dependence on oil revenues and promoting growth in other sectors in these countries can mitigate the effects of these economic shocks and support sustainable development. At the same time, investing in renewable energy sources is important both to ensure environmental sustainability and to increase diversity in the energy sector. On the other hand, increasing foreign exchange reserves is important to reduce the impact of oil price fluctuations on exchange

rates. Exchange rate management policies should be carefully monitored to protect against exchange rate fluctuations. The implementation of such policies is of critical importance in order to mitigate the negative effects of oil price fluctuations and to ensure economic stability.

As oil remains the most widely used energy source, the economies of nations heavily rely on it. Variations in oil prices have distinct repercussions on both oil-exporting and oil-importing countries worldwide, through a range of channels. Future studies should focus on the industries in these countries to determine which sectors are most likely to be affected by changes in oil prices. This will allow more comprehensive policy recommendations to be made.

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