



Is the relationship between oil-gas prices index and economic growth in Turkey permanent?

Mustafa Kırca^{*}, Şerif Canbay, Kerem Pirali

Diizce University, Akçakoca Bey Faculty of Political Sciences, Department of Economics, Düzce, Turkey

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ABSTRACT

Oil and gas are the most important inputs that countries use in their production process. For this reason, changes in oil-gas prices affect economic growth, which is the most important macroeconomic performance indicator. This study aims to investigate whether the relations between the oil-gas prices index and economic growth are permanent in Turkey, covering the period 1998Q1-2019Q4. For this purpose, the relationships between variables are first examined by Granger and Toda-Yamamoto causality tests with structural breaks. Then, we analyze whether the relationships between them are permanent using frequency domain causality tests based on these two tests. There is insignificant causality relationship between the variables according to Granger and the Frequency Domain Causality Test results based on this test. However, according to the results of the Toda-Yamamoto causality test with a structural break, there is a causality relationship from oil-gas prices to economic growth. According to the results of the Frequency Domain Causality Test based on this test, the permanent effect of oil-gas prices on economic growth is approximately five years.

1. Introduction

One of the macroeconomic indicators that policymakers care about most is the economic growth argument. Economists, on the other hand, search for various ways of keeping up with the trend of economic growth by using different tools such as export, import, technology, etc. variables. Nevertheless, it is important to note the existence of many inputs that affect the models proposed in the economy based on growth. In particular, access to energy resources and energy costs, both of which are indispensable factors of production, constitute the heaviest burden on economies. Especially after the Industrial Revolution, energy demand has increased since the use of oil became widespread, especially in the second half of the 19th century, and this energy consumption has accelerated both the industrialization and economic growth of countries. The fact that the use of oil and gas in the context of energy consumption is an important factor in economic growth has been discussed in many previous scientific studies (Zamani (2006); Abosedra et al. (2009); Apergis and Payne (2010); Kum et al. (2012); Ozturk and Al-Mulali (2015); Solarin and Ozturk (2016); Uzgören and Aslan (2019); Erdogan et al. (2019)).

In a world where the dependence of the countries on energy is increasing every day, it is not possible to ignore the effects of energy

demand on economic growth. The sudden and unexpected increase in prices (Hamilton, 2012: 17), combined with the reduction of oil supply by OPEC countries in the 1970s due to political reasons, negatively affected many economies, especially the United States. The energy used as a political weapon for the first time has had devastating effects on the entire economic system (Ediger and Berk, 2011: 2132) and the phenomenon of stagflation, which is not predicted by the Keynesian school and defined as the simultaneous increase of unemployment and inflation, has manifested itself in many economies. Scientific studies on the economic effects of energy prices and the amount of energy consumed also began to increase, especially after the oil crisis of the 1970s (Sarwar et al., 2017: 9).

According to the report of the International Energy Agency (2018: vii-ix), petroleum has the highest proportion of fossil fuels with a 32% share, accounting for 81% of the global energy supply. The expression of this ratio in a million tons of equivalent petroleum (mtep) is equal to 4403 mtep of global supply, which is 13761 mtep. Turkey imports 112.98 mtep (83%) of its 136.72 mtep total energy demand. 10% of gross domestic product (GDP) is used for energy import expenditures. These figures show that Turkey is severely dependent on energy and that energy is a major burden on its economy (IEA, 2018: II.147–148; Ediger and Berk, 2011: 2132). Therefore, fluctuations in energy prices and

^{*} Corresponding author.

E-mail addresses: mustafakirca52@gmail.com (M. Kırca), canbay.serif@gmail.com (Ş. Canbay), kerempirali@düzce.edu.tr (K. Pirali).

especially oil prices, are expected to have an impact on the country's economic growth.

As mentioned above, gas, along with oil, is one of the most important inputs that meet the energy needs in Turkey. An index follows oil and gas prices in Turkey. For this reason, this study aims to analyze the relationship between oil-gas prices index and economic growth. In line with this purpose, relations between variables were analyzed using data from the 1998Q1-2019Q4 period. Especially in terms of the methodology used, more reliable identification of the relationships between variables reveals the importance of this study. The reason is that the frequency domain causality test developed by [Breitung and Candelon \(2006\)](#), which is used to take into account all the time-series properties of variables, was redesigned in a stronger way. In addition, another significance of the study is the period studied. Referring to the analyzed period, it is known that it was a period during which Turkey's economy faced various economic crises. Moreover, this study differentiates from past studies as it is the first study to investigate whether the effects of shocks in oil and gas prices on economic growth are permanent. After the introduction chapter of the study, the theoretical framework and literature are examined, the next chapter introduces the data used in the analyzes, and the following chapters reveal the methodology and findings, respectively. Consequently, the research findings are discussed in detail in the conclusion chapter.

2. Theoretical framework

In this chapter of the study, the theoretical background of the effects of energy prices on economic growth is analyzed in particular with regards to the oil-gas prices. After theoretical explanations, past studies on the subject are reviewed. Finally, the differences of this study from the previous ones specifically conducted in Turkey are revealed.

In mainstream growth theory, factors of production are often classified in the form of capital, labor, and natural resources, and energy is not considered a primary variable in the production process. The price paid for energy is a financial transfer to the owners of production inputs, as are other embodied goods that are involved in the production process and are used in the manufactured product, which are considered secondary inputs. On the other hand, ecological, financial, and business economists with a different perspective emphasize the role of energy in the process of production and growth ([Stern, 2004: 36–37](#)).

When the economic effects of the oil price, which has the highest share of energy resource types, are analyzed, it is seen that there are direct and indirect economic impacts through many different channels. In particular, as in Turkey, the direct impact of oil price increases on developing countries importing energy with limited foreign exchange resources has a negative impact on the balance of payments ([Malik, 2007: 566](#)). An increase in the price of the energy consumed as an input in production processes creates a direct input cost increase while causing inflation on the costs of other inputs (such as raw materials, intermediate goods, consumables; shipping-transportation, and similar services; production factors such as labor and capital).

Similarly, as a result of the increase in energy cost, multidimensional negative effects such as a decrease in investments, decrease in stock prices, depreciation of the domestic currency, increase in unemployment, decrease in purchasing power, contraction in domestic demand, decrease in tax revenues are predicted to happen ([Malik, 2007: 561-62](#); [Jo et al., 2019: 179](#); [Cunado et al., 2015: 867](#)). Which of the transmission mechanisms considered in terms of the effects of the oil price on economic growth will be more effective may differ according to the countries and even the sectors studied ([Jo et al., 2019: 190](#)). The careful management of oil price shocks is critical, especially for developing countries with high economic fragility and energy imports, as it causes both demand and supply-side constriction effects.

From another point of view, in addition to the fact that economic development cannot be achieved at the required level in countries rich in natural resources, it is possible to observe a very strong economic

development trend in countries with scarce natural resources ([Erdogan et al., 2020a:1](#)). As well as the various economic factors that limit resource wealth-based growth ([Matsuyama, 1992](#); [Sachs and Warner, 1995](#)), the aspects of resource scarcity that promote economic development have been the subject of many studies. In particular, the opinions supported by internal growth models suggest that as the energy seen as a production factor becomes more costly compared to other production factors, energy-efficient production systems will be adopted, which encourages economic growth ([Stern, 2004: 45](#)).

According to [Bretschger \(2015: 30\)](#), keeping the other conditions constant, only the increase in energy prices and/or reduce the amount of energy consumed will have a negative impact on economic growth; however, when this short-run static analysis, where negative effects stand out, is expanded with dynamic analysis, some positive growth effects are expected to occur. [Hamilton \(2012: 19\)](#) claims that it is possible that the oil price declines could also have a negative effect on the economy. For instance, [Davis \(1987: 326–329\)](#), referring to [Ricardo's](#) book titled "On The Principles of Political Economy and Taxation" and published in 1817, suggests that changes in cost factors cause a reallocation of economic resources specialized in certain areas to other areas, fluctuations in unemployment figures, and decreased productivity, which was demonstrated through various empirical studies. Similarly, [Jo \(2012: 2–5\)](#) highlighted various findings in the literature that uncertainties affect economic activities negatively, and stated that even if the uncertainties in oil prices result in downward price movements, they affect the global industrial production negatively.

3. Literature review

There are many studies previously conducted on the economic effects of oil prices. In particular, in the aftermath of the OPEC-induced oil crises in the 1970s, studies on this matter have increased in quality and quantity. The first studies reviewed in the literature are those carried out in the USA. For example, in his study using the method of [Sims \(1980\)](#) in the USA, [Hamilton \(1983\)](#) stated that the economy, which grew by an average of 4% annually between 1948-1972, grew by 2.4% annually in the period of 1973–1981 following the oil crisis. He additionally argued that this was not by coincidence or due to a third variable affecting both variables, claiming that the rising of oil price led to the recession, as a result of sudden contractions in oil supply. [Mork \(1989\)](#), similar to [Hamilton's \(1983\)](#) study, conducted a review based on [Sims's \(1980\)](#) vector autoregressive (VAR) model. In the study's findings, he acknowledged that the economic effects of the rising of oil prices were generally negative and questioned whether there was a symmetrical economic recovery in the downward movements of prices. He stated that the economy was affected positively during periods when the price of oil dropped, but added that no statistically significant strong relationship could be determined. Based on this finding, he showed that the upward movements of the oil price differed in terms of the economic effects of the downward movements and drew attention to the asymmetric relationship. In the following period, there were further studies that did not support this argument ([Kilian and Vigfusson, 2011](#)), but there were more studies that supported it.

In his study with the Granger causality method on the macroeconomic effects of oil price shocks on the US economy, [Hooker \(1996: 196–197\)](#) observed that the effects of the oil price, which are claimed to have a strong impact on many macroeconomic variables, are gradually weakening. As expressed in the study, the three possible reasons for the emergence of this situation are as follows: (i) there have been significant structural breaks in most of the macroeconomic variables in the period since the oil crisis in 1973, (ii) oil prices before 1973 which are considered to be external, are now analyzed internally, and (iii) the effects observed in oil price increases and decreases are not symmetrical. In contrast, [Hamilton \(1996\)](#) argued that oil shocks depress demand for both consumption and investment goods, continue to affect the economy through many macroeconomic variables, and that analysis method

needs to be diversified to better understand the situation. He pointed out that oil supply cuts may occur due to the political turmoil, especially in oil-exporting countries, and emphasized that the economic effects of oil supply cuts can become more evident in such a situation.

In their study using the VAR model with data from the period 1965–1997, [Brown and Yucel \(1999\)](#) also found that increases in the oil price caused a decline in real GDP. [Kilian \(2009\)](#), the author of the latest study on this topic for the US economy, examined the impact of oil price shocks on GDP using the structural VAR model and noted that the impact was generally negative, but the impact channels and the impact process differed.

There are also many studies working with groups of countries to determine the relationship between oil prices and economic growth. In one of these studies, according to [Abeysinghe \(2001\)](#), the impact of oil prices on economic growth plays an important role for small economies, not for large economies in the study in which countries other than Indonesia, Malaysia, Philippines, Thailand, Hong Kong, South Korea, Singapore, Taiwan, China, Japan, USA, and OECD were involved and VARX method with the data of 1982Q1–2000Q2 was used. He also observed that the increase in oil prices had negative indirect effects even for net oil exporter countries.

[Jiménez-Rodríguez and Sánchez \(2005\)](#) carried out a multivariate VAR analysis using both linear and nonlinear models with data from some major industrialized OECD countries from 1972Q3 to 2001Q4 and determined the nonlinear effect of oil prices on real GDP. Especially oil price increases have been found to have a negative effect on the economic activities of other countries except for Japan. However, the impact of oil price shocks on GDP is seen as negative in the United Kingdom, which is an oil exporter, and positive in Norway.

[Cunado and Perez de Gracia \(2005\)](#) studied the effects of oil price on economic growth and inflation rates with the Granger causality tests using the data of 6 Asian countries (Japan, Singapore, South Korea, Malaysia, Thailand, and the Philippines) over the period 1975Q1–2002Q2. They noted that the cointegration relationship was not determined, that the effects were limited to the short-run, and that the effects on inflation were more significant and general than the effects on economic growth. [Lardic and Mignon \(2006\)](#) examined 12 European countries using the asymmetric cointegration approach using data from the period between 1970 and 2003. They concluded that there was an asymmetric cointegration between oil prices and GDP in all countries. Also, an increase in oil prices affected economic activity more than a decrease in oil prices.

[Blanchard and Gali \(2007\)](#) investigated the effect of changes in oil prices on the level of industrial production in the US, Germany, France, UK, Italy, and Japan, using a battery of rolling bivariate VARs and found out that the effect of changes in oil prices on the level of industrial production was weak.

[Ghalayani \(2011\)](#) analyzed the 2000–2010 data of G-7, OPEC, China, India, Russia with Granger causality test and found out that while there was no positive relationship between the oil prices in the petroleum exporting countries and growth, oil prices have a positive effect on economic growth in G-7 countries.

[Cashin et al. \(2014: 127–129\)](#) analyzed the effects of supply-and demand-driven oil price shocks using the Global VAR (GVAR) method on data from the 1979Q2–2011Q2 period of 38 countries, including the largest oil exporter countries. Consistent with the literature, they stated that it is very important for countries to be oil importers or exporters in determining the effects of price shocks. In particular, they noted that in the case of supply-side price shocks, the economic slowdown was observed in oil-importing countries, while the effects observed in oil-exporting countries were positive. On the other hand, demand-driven price increases result in economic recovery and inflationary pressures in almost every country.

[Katircioglu et al. \(2015\)](#) examined the effects of oil price on macroeconomic variables using Durbin–H panel cointegration tests with the data from 26 OECD countries for the period 1980–2011. They identified

the negative effects of oil prices on GDP, consumer price index, and unemployment. In this context, while the effects of oil price movements on GDP and unemployment were partially limited, the consumer price index was the most affected variable in 26 OECD countries analyzed in the study.

In his analysis using a time-varying structural vector autoregressive (TV-SVA) framework in which the sources of time variation are the coefficients and variance-covariance matrix of the innovations with the data of 1987Q2–2017Q2 of Brazil, Russia, India, China, and South Africa (BRICS) economies, [Nasir et al. \(2018\)](#) noted that the responses of national economies to oil price shocks differed significantly. They stated that not only the countries' oil importer (China, India, South Africa) or exporter (Russia, Brazil) but also the economies exporting or importing oil could react very differently to price shocks. Similar findings have also been confirmed by [Mo et al. \(2019\)](#) in the studies of the same countries over the period of 1996Q2–2018Q3 with wavelet-based quantile-on-quantile tests, and they commented that the energy policies of the countries and the general condition of the economy are determinant on the level of impact on oil price changes.

According to the results of the study conducted in Saudi Arabia using the data from 1969 to 2014, [Aloui et al. \(2018\)](#) concluded that volatility in the oil market had a statistically significant and negative effect on economic growth. In their study to determine the causality relationship between oil prices volatility and economic growth for the period 1970–2002 in Ghana, [Awunyo-Vitor et al. \(2018\)](#) found that the impact of the change in oil prices on economic growth in the long-run is statistically insignificant and there is a one-way causality relationship from the change in oil prices to economic growth. In another study of the Gulf Arab Countries Cooperation Council (GCC) countries (Bahrain, Qatar, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates) with the data of 1980–2016, [Nasir et al. \(2019\)](#) observed that oil price shocks have a statistically significant and positive effect on economic growth, although the degree of influence varies from country to country. Similarly, [Erdogan et al. \(2020b\)](#) conducted a new study for GCC countries with monthly data for the period 2007–2018 and the SVAR model and found out that volatility in oil prices negatively affects economic growth in most GCC countries.

As described at the beginning of the literature review, there are studies investigating the effects of oil prices on economic growth in different countries, similar to the studies conducted in the USA. Among them, [Papapetrou \(2001\)](#) analyzed the economic effects of oil price shocks through multivariate vector autoregression (VAR) approach in Greece, using monthly data from the period 1989:1–1999:6, and revealed that a significant part of the fluctuations in economic growth and employment could be explained by the price of oil. Moreover, oil price shocks had negative effects on industrial production and employment.

[Chang and Wong \(2003\)](#) found out that oil price shocks negatively affected Singapore's macroeconomic performance in their study conducted for the period 1978Q1 and 2000Q3 using the VECM method for Singapore's economy.

[Prasad et al. \(2007\)](#) examined the relationship between real GDP and oil prices using annual data from 1970 to 2005 for the Fiji Islands with the Granger causality test. The study's findings indicated that oil prices have a positive effect on real GDP.

In his study using autoregressive conditional heteroscedasticity (ARCH) models with monthly data from 2000 to 2008 in Japan's economy, [Hanabusa \(2009\)](#) identified a two-way causality relationship between economic growth and oil prices. [Yazdan et al. \(2012\)](#) concluded that oil prices are not the cause of economic growth in their study with Autoregressive Distributed Lag (ARDL)-Bounds testing approach with data from Iran over the period of 1980–2010. [Zhao et al. \(2016\)](#) conducted a study of the Chinese economy with the 1990–2013 period with the dynamic stochastic general equilibrium (DSGE) model. They concluded that oil price shocks have an impact on output level and inflation.

Likewise in this study, many previous studies were carried out focusing on various economic effects of oil prices (mainly the effects on inflation and balance of payments) which analyzes from the perspective of Turkey's economy (Levy, 1981; Ozlale and Pekkurnaz, 2010; Akcelik and Ozmen, 2014; Dedeoglu and Kaya, 2014; Akcelik and Ogunc, 2016; Kirca and Karagol, 2018). In the literature, the number of studies examining the effects of oil prices on economic growth in Turkey, which is the object of this study, is relatively limited. In one of these limited studies, Oksuzler and Ipek (2011) deduced that there was a positive and one-way causality relationship from oil prices to economic growth in their study with the vector autoregressive (VAR) model using the data of 1987:1–2010:9 period. Additionally, Ozsagir et al. (2011) examined the effect of oil prices on GDP throughout 1987 and 2007 with the VAR method and revealed that the change in oil prices had a positive effect on GDP growth. Also, in the study with the Fourier cointegration test analyzing Turkey's monthly data of the 1990–2016 period, Yilanci (2017) found out that there was no statistical relationship between oil prices and economic growth.

The results of the studies conducted in the literature reflect that oil prices affect economic growth. Besides, the effect of economic growth on oil prices is observed in some of the countries. Finally, there are results where there is no relationship between the two variables. As highlighted in the introduction chapter of this study, it differs in both the period studied and the econometric exercises used. In addition, in previous studies, an analysis was usually performed for a single frequency domain, while in this study, analysis is made for different frequency domains.

4. Data

In this study, these variables are used for the analysis; gross domestic product (chain linked volume index) (GDP) as the representative of economic growth, and crude oil and natural gas price index (domestic producer prices, 2003 = 100) (OIL) in the period of 1998Q1–2019Q4 period in Turkey. The data for the variables were collected from the Electronic Data Delivery System of The Central Bank of the Republic of Turkey (2020). The study uses logarithmic transformations of both variables. In addition, GDP data is seasonally adjusted using the Tramo/Seats method. Fig. 1 shows the original and adjusted (LGDP_t, LOIL_t) graphs of the variables used in the analysis. When the variables used in the analyses are examined, it is seen that there are structural breaks and trends in LGDP_t and LOIL_t. It should be considered that the findings will be more accurate by making analyses taking into account these situations.

5. Methodology

The relationship between oil-gas prices index and economic growth are analyzed using a three-stage process in this research. In the first stage, the stationary levels of the variables are determined using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and ADF unit root with a single break. In the second stage, it is tested whether there is a causality relationship between variables using the Granger causality test and Toda and Yamamoto (1995) causality test. Finally, the frequency domain causality test developed by Breitung and Candelon (2006) is used to decide whether the relationships between variables are permanent and/or temporary. Moreover, Breitung & Candelon (2006) causality test is performed based on the Granger causality test first, and secondly on the causality basis of Toda and Yamamoto (1995) as shown in Tastan's (2015) study. Thus, the study provides an opportunity to compare the findings from two different methods. In addition, the structural break dates and trend term derived from the ADF unit root test with a single break were added to the Vector Autoregressive (VAR) equation used in the causality test of Toda and Yamamoto (1995) as dummy variables. The following introduces these stages in order:

Stage 1. Unit Root Tests: In the time series analysis, the lagging levels of the variables should be determined first. Unit root tests are used to determine the level of lag. In this study, Augmented Dickey-Fuller (ADF) developed by Said and Dickey (1984) and PP tests developed by Phillips and Perron (1988) are used, which are frequently used in time series econometrics and expressed as traditional unit root tests. Both of these tests are “H₀: A unit root is present in a time series sample, and it is non-stationarity.” In order to test this hypothesis, τ statistics are obtained for both tests. If the calculated τ statistical value is greater than the critical values, the H₀ hypothesis is rejected. Otherwise, by variable differencing, a new τ statistic is obtained, and the hypothesis is tested. For example, if the series is stationary in “d.” difference, it means that this series is at the level of I (d). As Phillips and Perron (1988) stated, the PP unit root test is superior to the ADF unit root test. Besides, due to the structural breaks in the time series graphics in Fig. 1, an ADF unit root test with a single break was added to the study, taking into account the emphasis Perron (1989) made in this study. Perron (1989) describes that unit root tests, which do not take structural breaks into account if there is a structural break in variables, end in erroneous results. By considering this matter, the study included an ADF unit root test with a single break.¹ In the ADF unit root test with a single break, structural break dates are determined internally. Along with the ADF unit root test with a single break, the results of the ADF and PP tests can be crosschecked, and the significant structural break dates determined can be added to the tests to be used in the next stages.² Unlike the above unit root tests, in the ADF unit root test with a single break, “H₀: the data under structural break has a unit root and is non-stationary”. The decision-making process is similar to the ADF and PP tests. Stationary can be tested with the ADF, PP, and single break ADF unit root tests on constant-term and constant-trend term models (**model with a constant** or **model with a constant and a trend**). Another important point to consider is how to convert the structural breaks obtained from the single break ADF test into dummy variables. In this part, dummy variables for any model (**model with a constant** or **model with a constant and a trend**) are formed by giving a value of “0” before the break date and a value of “1” after the break date. Dummy variables were created for structural break dates determined in this study using constant-trend term models. The reason is that, as can be seen in Fig. 1, both variables have both constant and trend characteristics.

Stage 2. Granger Causality Test³ and Toda-Yamamoto Causality Test with Structural Break: Granger (1969) causality test is one of the most used methods in time series analysis. The basis of the causality tests developed later is also based on the Granger causality test. If we are not interested in the cointegration relationship between variables, whether there is the causality between the variables can be tested by the VAR(p) method developed by Sims (1980) using the stationary variables. While

¹ To better understand the test, Perron (1989, 2006), Perron and Vogelsang (1993) and Zivot and Andrews (1992) studies can be examined.

² In this study, break dates obtained from the ADF unit root test with a single break were added to Toda-Yamamoto and Frequency Domain Causality equations as exogenous variables.

³ If two or more variables are stationary at the same level, there may be a cointegration relationship between the variables. In this study, the cointegration test developed by Johansen (1988, 1991) and Johansen & Juselius (1991) was carried out due to the fact that LOIL_t and LGDP_t variables, which are the subject of the study, are stationary in I(1) degree. The reason is that in the Granger causality test, if there is cointegration relationship between the variables, causality test should be done by taking into account Vector Error Correction (VECM) models. If there is no cointegration relationship, causality test is performed by using the Vector Autoregressive Model (VAR) with the stationarity cases of the variables. According to the cointegration test results in Appendix 1, there is no cointegration relationship between LOIL_t and LGDP_t variables. Therefore, the first differences of variables are used in Frequency Domain Causality tests based on both Granger causality and Granger causality test.

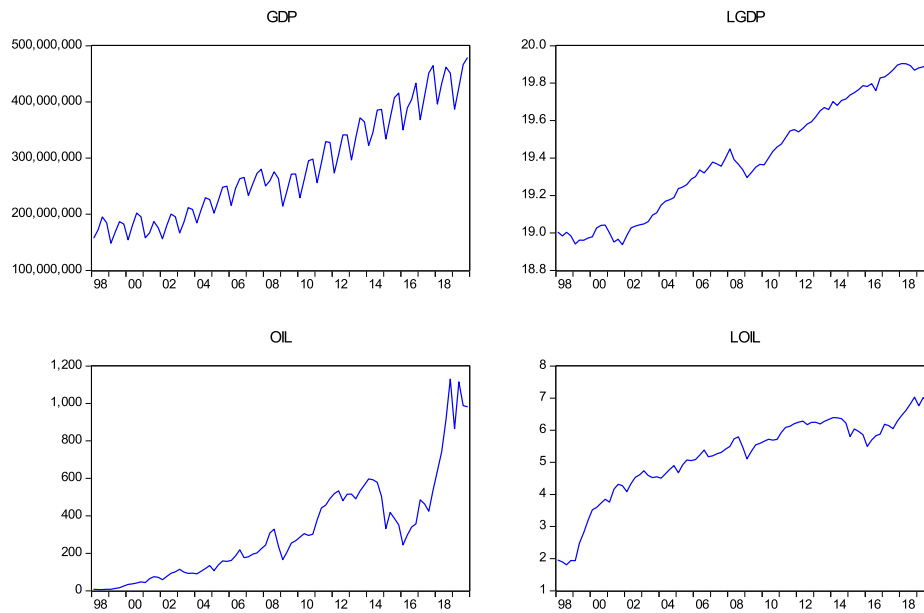


Fig. 1. Time series graphics of variables.

running the [Toda and Yamamoto \(1995\)](#) causality test, the VAR method developed by [Sims \(1980\)](#) is used. Moreover, although the basis of this test is based on [Granger \(1969\)](#) causality test, it has some advantages over this test. These are the fact variables can be stationary at different levels, and it is not necessary to perform cointegration testing before proceeding to causality analysis. Besides, if there is no cointegration relationship between variables, the Granger causality test is performed after differencing by checking how stable the variables are. There is no such requirement in the Toda-Yamamoto causality test. The most important advantage of this situation is that by differencing, the loss of long-run information that occurs in the series can be prevented. The VAR(p + d_{max}) model used in the Toda-Yamamoto causality test is shown in Equation (1). Additionally, in Equation (1), the dummy variables of the structural breaks obtained from the ADF unit root test with a single break⁴ were added as external variables, and the equality was extended. Besides, as emphasized before, since the variables are “trend” in the time series graphics, the trend variable is also added as an exogenous variable to the equation, as shown in Fig. 1. The purpose of adding dummy variables and trends as exogenous variables is to prevent misleading findings because these features are not taken into account in time series.

dummy variables, while δ shows the parameters of the trend term. u_{1t} and u_{2t} are the error terms of the relevant equation.

$$H_0 = \beta_{12,1} = \beta_{12,2} = \dots = \beta_{12,p} = 0, \text{ "LOIL}_t \text{ is not the cause of LGDP}_t \text{"}$$

$$H_0 = \beta_{21,1} = \beta_{21,2} = \dots = \beta_{21,p} = 0, \text{ "LGDP}_t \text{ is not the cause of LOIL}_t \text{"}$$

$$H_1 = \text{At least one } \beta \neq 0, \text{ "LOIL}_t \text{ is the cause of the LGDP}_t \text{" or "LGDP}_t \text{ is the cause of LOIL}_t \text{"}$$

In order to test hypotheses, the constraint test is applied to Wald test statistics, that is, coefficients specified in hypotheses. H_0 hypotheses are rejected if the probability values of the obtained test statistics are less than 10%, 5%, and 1%. In this case, it is determined that there is a causality relationship between the relevant variables. However, it is impossible to interpret whether the causality relationship derived from this test is permanent or temporary. For this reason, *Frequency Domain Causality Test Based on the Toda-Yamamoto Causality Test with Structural Break* was used to determine whether the causation relationship is permanent or temporary.

Stage 3. Frequency Domain Causality Test Based on Granger Causality and Toda-Yamamoto Causality with Structural Break Tests:

$$\begin{bmatrix} LGDP_t \\ LOIL_t \end{bmatrix} = \begin{bmatrix} \beta_0^{LGDP} \\ \beta_0^{LOIL} \end{bmatrix} + \begin{bmatrix} \beta_{11,1} & \beta_{12,1} \\ \beta_{21,1} & \beta_{22,1} \end{bmatrix} \begin{bmatrix} LGDP_{t-1} \\ LOIL_{t-1} \end{bmatrix} + \dots + \begin{bmatrix} \beta_{11, p+d_{max}} & \beta_{12, p+d_{max}} \\ \beta_{21, p+d_{max}} & \beta_{22, p+d_{max}} \end{bmatrix} \begin{bmatrix} LGDP_{t-p+d_{max}} \\ LOIL_{t-p+d_{max}} \end{bmatrix} + \begin{bmatrix} \alpha_{11,1} & \alpha_{12,1} \\ \alpha_{21,1} & \alpha_{22,1} \end{bmatrix} \begin{bmatrix} d2008q1_t \\ d2014q4_t \end{bmatrix} + \begin{bmatrix} \delta_{11} \\ \delta_{21} \end{bmatrix} trend + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \quad (1)$$

LGDP_t and LOIL_t in Equation (1) are the variables that are the subject of the analysis, as introduced previously. In the equation, β₀'s show the constant terms, while β's indicate the parameters. “p,” which is an index below these parameters, shows the appropriate number of lags for the equation and “d_{max}” expresses the maximum degree of integration determined by using the unit root test. α represents the parameters of the

[Breitung and Candelon \(2006\)](#) state that traditional causality tests cannot differ at different frequencies, as in [Geweke \(1982\)](#) and [Hosoya \(1991\)](#). Therefore, [Breitung & Candelon \(2006\)](#) developed the frequency domain causality test to determine the causality relationship for different frequencies. Long, medium and short run causality relationships between variables can be determined to utilize the test they developed. A long-run causality relationship means that the resulting causality is permanent, while a short-run causality relationship means that causality is temporary. For this reason, the frequency domain causality test is superior to the Granger causality with the VAR model [Granger \(1969\)](#) and [Toda-Yamamoto \(1995\)](#) causality tests. [Breitung](#)

⁴ The results of the ADF unit root test with a single break are seen in [Table 2](#).

Table 1
Traditional unit root test results.

Model with a constant				
Test:	ADF ^a		PP ^b	
Variable	t-statistic	Prob.	t-statistic	Prob.
LGDP _t	0.39	0.9817	0.33	0.9789
ΔLGDP _t	-8.65 ^c	0.0001	-8.65 ^c	0.0001
LOIL _t	-2.67	0.0834	-2.67	0.8260
ΔLOIL _t	-8.25 ^c	0.0001	-8.25 ^c	0.0001
Model with a constant and a trend				
Test:	ADF ^a		PP ^b	
Variable	t-statistic	Prob.	t-statistic	Prob.
LGDP _t	-4.50 ^c	0.0029	-3.27	0.0778
ΔLGDP _t	-	-	-8.64 ^c	0.0001
LOIL _t	-2.54	0.3057	-2.54	0.3047
ΔLOIL _t	-6.61 ^c	0.0001	-8.50 ^c	0.0001

^a The optimal lag length was determined using the Akaike information criterion method.

^b Bartlett Kernel and Newey-West Bandwidth were used.

^c 1% signifies stationary at a statistically significant level.

Table 2
ADF unit root test with a single break results.

Variable	Model with a constant			Model with a constant and a trend		
	t-statistic	Critical Value(5%)	Date of the break	t-statistic	Critical Value(5%)	Date of the break
LGDP _t	-1.48	-4.44	2009Q2	-3.76	-5.17	2008Q1
LOIL _t	-3.31	-4.44	2016Q3	-3.88	-5.15	2014Q4
ΔLGDP _t	-9.17*	-4.44	2009Q1	-8.89*	-5.17	2006Q2
ΔLOIL _t	-8.94*	-4.44	2001Q4	-9.38*	-5.17	2016Q1

* 5% signifies stationary at a statistically significant level.

and Candelon (2006) proposed a testing process based on a linear hypothesis on parameters belonging to variables, using the bivariate VAR model. Thus, it is stated that the test process can be generalized to examine multidimensional systems and cointegration correlations (Breitung and Candelon, 2006:364).

In this study, the Breitung and Candelon (2006) frequency domain causality test was conducted using the VAR(p) used in the Granger causality test and VAR(p + d_{max}) models shown in Equation (1). Additionally, one of the most important points to consider is the inclusion of structural breaks of variables in the relevant VAR(p + d_{max}) model as a dummy variable and trend as an exogenous variable. Thus, more accurate findings are obtained. Test statistics (ω) are achieved as much as the number of π (ω ∈ (0,π)). The test statistics for each ω are obtained thanks to the F test. The hypotheses for each frequency are as follows:

$$H_0 : R(\omega)\beta = 0,$$

$$\text{with } \beta = \left(\beta_1, \dots, \beta_p \right) \text{ and } R(\omega) = \begin{pmatrix} \cos(\omega) & \cos(2\omega) & \dots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \dots & \sin(p\omega) \end{pmatrix} \quad (2)$$

If the statistical test value of ω = 0.05 is significant, it shows that there is a long-run causality relationship, and if the statistical test value of ω = 1.5 is significant, then there is a medium-run causality relationship, and finally, if the statistical test value of ω = 2.5 is significant, then there is a short-run causality relationship. In addition, formula 2π/ω is used to calculate the duration of the causality relationship, as Tastan (2015:1161) indicates. In this formula, the wavelength is calculated by determining where ω is significant. In this way, it is calculated how many periods of the related causality relationship lasts.⁵ Finally, in this study, as in Toda-Yamamoto (1995) causality test, VAR(p + d_{max}) model

⁵ Detailed information about the test can be accessed from the studies of Breitung and Candelon (2006) and Tastan (2015).

is used in the frequency domain causality test; therefore, variable differencing is not conducted, and their original values are used, so there is no information loss. Frequency Domain Causality Test findings based on the Granger causality test using the VAR(p) model after the variables are stabilized are also included to show the difference between the variables.

6. Findings

In this chapter of the study, the findings obtained using the methods described above are included. The findings of unit root tests, Granger causality, and Toda-Yamamoto causality tests, and finally, frequency domain causality tests, respectively, are seen below.

Table 1 shows the ADF and PP unit root test results of variables. According to the ADF unit root test, the LGDP_t is stationary in the first difference of the constant model and in the value of the levels of the constant-trend model. LOIL_t is stationary in the first difference in both models. Based on the results of the PP unit root test, the two variables are stationary in their first difference at the 5% significance level. PP unit root test is a more robust test than the ADF unit root test; therefore,

it is possible to suggest that both variables are stationary at Level I(1), i. e., first differences. The results of the ADF unit root test with a single break, which is performed to determine both structural break dates and to provide the results of ADF and PP unit root tests, are shown in Table 2.

According to the ADF unit root test with a single break results in Table 2, both variables are I(1) in constant term and constant-trend term models. The dates of 2009Q2 in the constant value model of the LGDP_t variable level and 2008Q1 in the constant-trend model were determined as significant structural break dates. Both dates correspond to the period called the 2008 Global Crisis. The dates of 2016Q3 in the constant value model of the LOIL_t variable level and 2014Q4 in the constant-trend model were found out as significant structural break dates. The brake shown in the constant-trend model in the period 2014Q4 is evident when looking at the graphics drawn with the original values of the variable. It is known that the oil supply in the world has expanded, and stocks have increased gradually due to the successful efforts of the USA to extract oil from shale gas. Moreover, the expectation that the global economy will have a low growth rate pushed oil and gas prices down (BBC, 2014). In the study, dummy variables of the break dates obtained from constant-trend models were added to the VAR(p + d_{max}) model as exogenous variables, as shown in Equation (1).

Table 3 shows both the Granger causality test and the Toda-Yamamoto causality test with structural break results. Since the variables to be included in the VAR(p) model are stationary, the test was applied by differencing the variables. As a result of the test, it was found that there was no significant causality relationship between the variables. However, according to the results of the Toda-Yamamoto causality test using the VAR(p + d_{max}) model, which has many advantages compared to the Granger causality test and structural breaks are added as an exogenous variable, it was determined that there is a one-way causality relationship from LOIL_t to LGDP_t. This finding demonstrates the superiority of the Toda-Yamamoto causality test, as well as the importance of considering the time-series properties of variables

Table 3
Results of granger causality test and toda-yamamoto causality test with structural break.

Results of the Granger Causality Test			
Null Hypotheses	Calculated Statistics	Prob.	(p)
There is no causality from $\Delta LOIL_t$ to $\Delta LGDP_t$	4.41	0.4919	5
There is no causality from $\Delta LGDP_t$ to $\Delta LOIL_t$	8.32	0.1391	5
Results of Toda-Yamamoto Causality Test with Structural Break			
Null Hypotheses	Calculated Statistics	Prob.	(p + d_{max})
There is no causality from $LOIL_t$ to $LGDP_t$	16.70*	0.0194	7 + 1
There is no causality from $LGDP_t$ to $LOIL_t$	5.76	0.5676	7 + 1

*5% refers to the relationship of causality concerning significance. The p-value is the appropriate number of lags obtained by using the VAR model, and all conditions for VAR are provided in the VAR(p) model. The d_{max} value is the maximum degree of integration achieved by unit root tests.

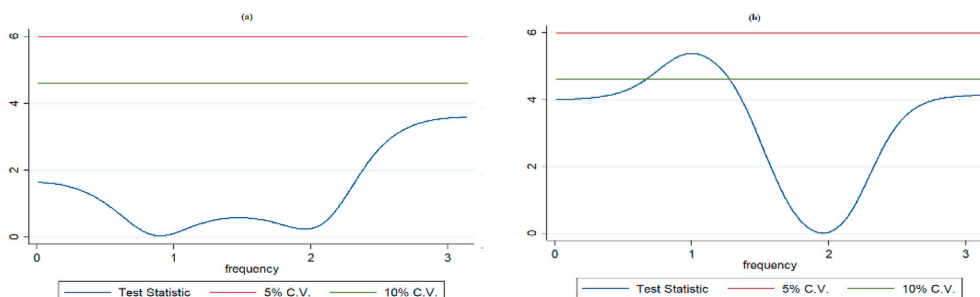


Fig. 2. Frequency domain causality test results based on the granger causality test: (a) From $\Delta LOIL_t$ to $\Delta LGDP_t$, (b) from $\Delta LGDP_t$ to $\Delta LOIL_t$.

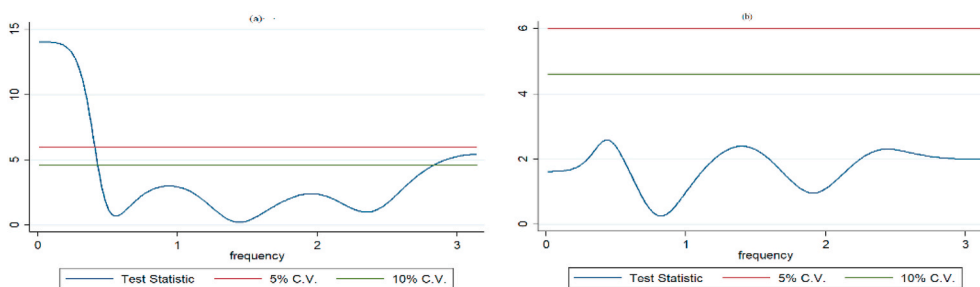


Fig. 3. Frequency domain causality test results based on the toda-yamamoto causality test with structural break: (a) From $LOIL_t$ to $LGDP_t$, (b) from $LGDP_t$ to $LOIL_t$.

(structural break, trend) in an equation such as VAR (p + d_{max}). Nevertheless, this finding of causality does not indicate whether or not there is causality for different frequencies as underlined in the methodology chapter. Accordingly, the Frequency Domain causality test was included in the study using equations used in Granger and the Toda-Yamamoto causality test with a structural break. Fig. 2 shows the results of the Frequency Domain Causality test based on the Granger causality test.

Fig. 2 shows the Wald statistics for $\omega \in (0, \pi)$ frequencies calculated using the frequency domain causality test based on the Granger causality test. It appears that the test statistics obtained to calculate the causality both from $\Delta LOIL_t$ to $\Delta LGDP_t$ and from $\Delta LGDP_t$ to $\Delta LOIL_t$ are not above the line representing 5% critical value for any ω value. In other words, there is no causal relationship between variables for the long, medium, and short-run. However, it should be noted that in this method, variables are analyzed using stationary and VAR(5) models. In order to obtain more reliable findings, Frequency Domain Causality results based on the VAR (7 + 1) model shown in Equation (1) are shown in Fig. 3.

Fig. 3 shows the Wald statistics for $\omega \in (0, \pi)$ frequencies calculated using the frequency domain causality test based on the Toda-Yamamoto causality test with a structural break. As a result of the analysis for causality from $LOIL_t$ to $LGDP_t$, the test statistic of $\omega = 0.05$ frequency, which shows long-run causality (Fig. 3-(a)), was calculated as 14.03. This test statistic is greater than the F table value, and the probability

value is 0.0009. The test statistic of the frequency $\omega = 1.50$, which indicates mid-run causality, is 0.31 and is less than the table value F. Also, the probability value is 0.8538. The test statistic of the frequency $\omega = 2.50$, which expresses short-run causality, is 1.66 and is less than the table value F. Its probability value is 0.4342. These findings mean that the effect of $LOIL_t$ on $LGDP_t$ is permanent. Besides, when the wavelength of the significant frequencies is examined, it is seen that $\omega \in (0, 0.33)$. Using the formula $2\pi/\omega$, it was calculated that a shock occurring in $LOIL_t$ affected $LGDP_t$ approximately $(2\pi/0.33)$ by 19.04 quarters. This value corresponds to approximately $(19.04/4 = 4.76)$ 5 years. Fig. 3-(b) shows that the calculated Wald statistics are not greater than the F table value. This means that there is no causality relationship from $LGDP_t$ to $LOIL_t$ in the long, medium, and short periods. As can be seen, the time-series properties of variables change in the findings when they are added to the relevant equations.

7. Conclusion

In this study, the relationship between oil-gas prices index and economic growth over the period of 1998Q1-2019Q4 in Turkey were investigated using frequency domain causality analysis based on two different approaches. Thus, the research aimed to show which of the two different approaches produced more accurate results. The first of these

approaches is the Granger causality test based on the VAR(p) model, and the second is the Toda-Yamamoto causality test with a structural break where structural break and trend are added to the VAR(p + d_{max}) model as dummy variables. It was found out that there is no causality relationship between the variables according to the Granger causality test and the Frequency Domain causality test based on this test. The most important case to note is the loss of information caused by the lack of consideration of many time-series properties of variables and the differencing of the variables. According to the Toda-Yamamoto causality test conducted in the next stage, there is a causality relationship from oil-gas prices index to economic growth. Also, the results of the Frequency Domain causality test based on the Toda-Yamamoto causality test with structural break conducted to show whether this causality relationship is permanent indicate that there is a permanent causality relationship from oil-gas prices index to economic growth. As a result of the analysis, this study revealed that a shock in oil-gas prices index affects economic growth for about 19 quarters; in other words, for about five years. As can be seen, the fact that the time-series properties of variables are included in the relevant equations also changes the results obtained.

It is seen that the findings obtained in studies examining the effects of changes in oil-gas prices on economic growth differentiate from one another. From a general perspective, it is observed that the findings that oil and gas prices affect economic growth are in the majority. The finding that oil-gas prices have an effect on economic growth is in line with the past research in the literature conducted by Hamilton (1983), Mork (1989), Papapetrou (2001), Chang and Wong (2003), and Zhao et al. (2016). For the studies conducted about Turkey, this study indicates similar results to the findings of Oksuzler and Ipek (2011). However, a situation that should not be forgotten is also related to the method used specific to this study. In particular, this paper was aimed to emphasize whether the relationship obtained in this study is permanent. Therefore, the findings obtained in this study are the first in the literature.

The research results should be interpreted economically as well as econometric interpretation. Economically, it is remarkable that a shock in the oil-gas prices in Turkey affects the economic growth in a long period of time, as much close as five years. Economic and political perspectives about a production input that has such a lasting effect on economic growth are of critical significance. It is not surprising that

changes in oil-gas prices in developing countries such as Turkey, which do not have energy resources (oil-gas), have a permanent effect on economic growth, especially through imports. Similarly, as Erdogan et al. (2020b) stated, its effect on economic growth is inevitable, especially since changes in oil prices affect both oil production and non-oil sectors. Moreover, the import dependence on energy, combined with volatility in oil-gas prices, also makes the country's many macroeconomic performance indicators in economic growth fragile. As it is known, Turkey has long been part of the Fragile Five countries. In this case, shocks in oil-gas prices may have a permanent effect. It can also be stated as another result that the decrease in oil-gas prices may have a positive effect on economic growth. With an epidemic such as COVID-19 emerging in China, the sharp falls in oil-gas prices may have a positive effect on economic growth in countries such as Turkey, which are energy importers and whose oil-gas price shocks are permanent, after the ending of the epidemic. However, how long it will be permanent or temporary in this occasion is surely controversial and the subject of other studies.

Consequently, policymakers need to develop energy policies, taking into account the permanence of oil-gas prices on economic growth. In order to reduce the permanence of shocks in oil-gas prices on economic growth, Turkey must turn to alternative energy sources for its macroeconomics performance over the long-run.

The effects of oil-gas prices are not only limited to economic growth. The question of whether the effect of oil-gas prices on other macroeconomics variables other than economic growth is permanent is an important research topic for future studies.

Author statement

Mustafa Kirca: **Supervision, Methodology, Formal analysis, Data curation, Validation, Writing- Original draft preparation, Investigation.** Şerif Canbay: **Conceptualization, Writing- Original draft preparation, Visualization, Investigation, Validation, Formal analysis.** Kerem Pirali: **Visualization, Investigation, Writing-Reviewing and Editing.**

Declaration of competing interest

None.

APPENDIX

Cointegration Test Results				
H ₀	λ-max	C.V. (%5)	Trace	C.V. (%5)
$r = 0$	14.90	19.38	24.17	25.87
$r \leq 1$	9.26	12.51	9.26	12.51

Note: r is the cointegration rank. C.V.: Critical Values. All assumptions of the VAR (1) model whose lag was determined by using information criteria were provided, and cointegration equations were selected according to the Schwarz Information Criterion. Since the calculated λ-max and trace statistics values are smaller than the values C.V., there is no cointegration relationship between variables.

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