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Asymmetric effects of oil prices and oil revenues on Iran's economic growth: Vector auto-regression (VAR): A nonlinear approach

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Abstract

Oil, the main source of energy and the engine of economic growth is an essential input to the production process, whose consumption has increased significantly with the modernization of the economy. This study aims to investigate the asymmetric analysis of oil prices and oil revenues in Iran. In this regard, four models were examined. In the first two models, the impact of oil prices and revenues was estimated on the economic growth, and then the impact of oil prices and revenues on economic growth without oil was estimated using the nonlinear Autoregressive Distributed Lag (NARDL) model. The results of the study for the period 2018-2000 indicate that oil prices and oil revenues have an asymmetric effect on oil economic growth, but have a symmetrical effect on oil-free economic growth.

Keywords: oil price, oil revenue, economic growth, asymmetric effects, non-linear autoregressive distributed lag (NARDL)
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1 Introduction

Oil is the main source of energy in the world. Currently, there are more than 100 oil-exporting countries worldwide. Oil prices affect both oil exporters and importers. They also influence producers and the level of production costs. The economies of some countries are highly dependent on oil and petroleum products. That is why research on oil and its role in the economy is of great importance. Oil factors affect political and economic processes. It also affects price levels, inflation, economic recovery, financial markets, stock markets and economic growth in general. At the same time, it is effective in the formation and development of renewable energy sources. However, these interactions are mutual, and it can be said that some non-oil factors also impact oil production and the development of the oil sector. Oil prices and their formation are determined by the demand and supply of fuel in the world market [22].

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Despite various international agreements on clean energy and low-carbon futures, oil is the world's leading source of energy. The International Energy Agency predicts a growing global demand for crude oil by 2040, citing a lack of alternatives to oil in three areas road transportation, air transportation, and petrochemicals. The current dependence for most countries is such that all goods and services of the national economy are affected by fluctuations in crude oil prices. Oil price instability has always been of interest to economists and politicians. According to Lardic and Mignon [28], higher oil prices, at macro levels, slow down production by increasing costs and worsening trade conditions for oil-importing countries in addition to causing inflation and declining consumption. Changes in oil prices also create unemployment and affect a country's monetary policy because the demand for money increases and increased interest rates lead to decreased investment [10].

Given the relationship between oil prices and economic growth, there is a wealth of literature that has been around since the oil shock of the 1970s. Several theoretical models that attempted to explain the role of oil in macroeconomic variables were proposed by Rasche and Tatom [41], Bruno and Sachs [9], and Hamilton [17, 18]. They estimated the relationship between oil shocks and various macroeconomic variables mainly through nonlinear patterns. From a practical point of view, these models have proven the fact that economic fluctuations in the face of oil shocks have not produced any positive results except in a few exceptional cases such as Hooker [21]. Other researchers include Mork [32], Mory [34], Mork et al. [33], Frederer [15], Hamilton [18], Huntington [23], Brown and Yücel [8], and Lardic and Mignon [27, 28], who supported the fact that the effects of the oil can be modelled nonlinearly.

For example, Frederer [15] explained the mismatch of economic activity through redistribution of resources among different economic sectors or reduced investment due to uncertainty in the oil market [10]. Although the asymmetric effect of oil price shocks on the macro-economies of oil-exporting countries has well been established theoretically [5, 6, 15, 18] and empirically [19, 20, 29, 32], the economic origin and explanation of asymmetric effects on oil-exporting countries are still unknown. These topics are rarely discussed in the energy economics literature. The nature of oil price shock transmission channels and economic structure in oil-exporting developing countries is one of the most important reasons for explaining the asymmetric effect of oil price shocks on the macroeconomy. It is theoretically accepted that lower oil prices will hurt economic activity compared to higher oil prices. This can be explained by the Dutch disease theory, which states that developing oil-exporting countries are not expected to take full advantage of rising oil prices due to changes in the economic structure in favour of the booming oil sector versus the trading sector [31]. Therefore, the change in the economic structure can be justified by the real increase in the foreign exchange earnings of oil exporters. In addition, the partial benefits of rising oil prices are attributed to the low economic absorption capacity, which characterizes most developing oil-exporting countries, making them more vulnerable to oil price shocks [46].

Another important reason for the asymmetric impact of oil prices on the macroeconomy in the development of oil-exporting countries is the important role played by the public sector in these countries, which supports it through investment and the main stimulus of economic activities [14]. For example, the launch of a large number of huge investment projects by government officials (a fiscal policy projected for the cycle) during periods of rising oil prices has caused the economy to become too active, and since these countries are mainly facing low economic absorption, it is going to lead to higher inflation [46]. On the other hand, following the fall in oil prices, several investment projects remain unfinished or completely abandoned. When this is accompanied by austerity to reduce the expected budget deficit, it will slow down economic activity [13]. However, these negative effects of falling oil prices can be mitigated by revenues from foreign exchange reserve funds established by almost all oil-exporting countries. In these countries, these revenues are used to stabilize economic activity in periods when oil prices have fallen. Empirical evidence for the short-term asymmetric impact of oil prices on macroeconomics in the economic development of oil-exporting countries is limited to some Gulf Cooperation Council (GCC) countries, Iran, Nigeria and Russia [24].

Traditionally, Iran is one of the oil-exporting countries. In addition to being the basis of many social and political events, this raw material has significantly affected various economic variables such as labour market, import and export, government budget, industry and agriculture, and even the social and cultural structure since the beginning. Consumption type, heavy urbanization, change in the composition of national production from agriculture to services and industry and many changes in the last century are directly or indirectly dependent on oil. In this regard, we will first discuss the theoretical foundations, research background and then the model. In the end, there are the results of model estimation, conclusions and recommendations.

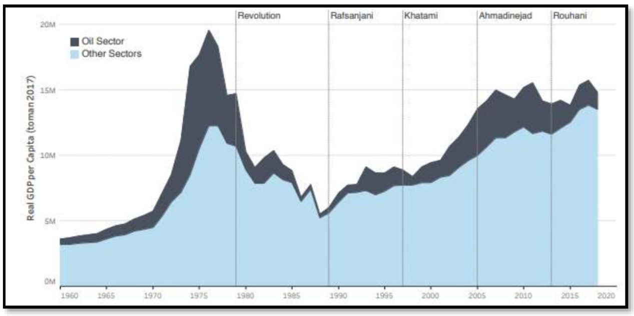

Figure 1: Economic growth with and without oil in Iran in from 1960 to 2018 [3]

2 Theoretical foundations

2.1 Comparison of economic growth with and without oil in Iran in from 1960 to 2018

Fig. 1 shows the real GDP per capita between 1960 and 2018 and its breakdown into oil and non-oil sectors. During two decades leading up to the Islamic Revolution, per capita GDP in Iran increased almost fivefold due to massive oil revenues and simultaneous industrialization. The combination of the economic mismanagement of the new revolutionary government, the cost of war, the decline in oil exports and revenues, and extremely rapid population growth (about 4% per year) led to a sharp decline in GDP per capita. Between 1989 and 2005, the economy expanded by an average of 6.5% per year, while the population growth slowed to about 1.5%, leading to an average growth of 5% GDP. Since then, Iran's per capita GDP has remained almost uniform, somewhat resembling that of the Soviet Union recession. While real GDP per capita can be used to understand the general trend of the economy and living standards, it does not reveal anything about the distribution of income among different sections of society.

Despite 40 years of claiming equality, Iran's income inequality is enormous. A new study estimates that the top 10% of the population in Iran earns about half of total income, while the share of income which goes to the next 40% of the population (often referred to as the middle class) and the bottom 50% is almost 35% and 15%, respectively. Finally, although the data are not available to measure wealth inequality in Iran, it is almost certain that wealth is significantly more concentrated than income, especially capital gains, inheritance, and property taxes in Iran have not practically been zero. By comparing Iran and other countries with similar levels of income inequality, it seems likely that the top 10% of Iran's population owns 60% or even 70% of private capital. The analysis of Iran's economic growth over the past half century shows that, among the three sources of production growth (capital, labor and productivity), the increase in capital inputs has by far had the largest share. For example, between 2000 and 2015, on average, the growth of capital inputs contributed 3.2% to Iran's GDP growth, while the collective share of labor inputs and the productivity of all factors was 0.6%. Fig. 2 shows the annual growth rate of capital in Iran since 1960. As can be seen, the trend of net capital formation has changed in contemporary Iran. Due to the widespread flow of crude oil, the formation of Iranian capital in the decade leading up to the 1979 revolution was very high. In the first decade of the Islamic Republic, the rate of net capital formation declined rapidly, reaching about 2% of total capital by the end of the war. In the period known as Reconstruction and Reform, the ratio of net capital formation to national capital before falling back to the lowest levels over the past decade has increased by about 5% per year. Today, net capital formation has reached its lowest point since 1960 [2].

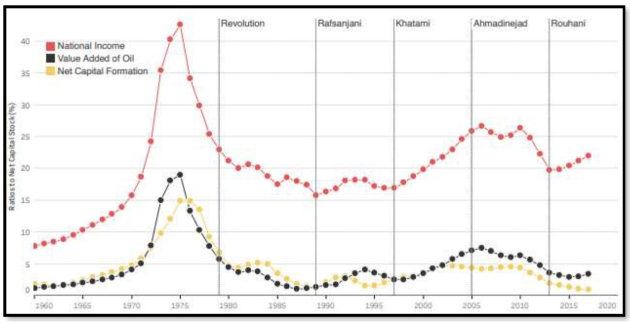

Figure 2: Capital trends in Iran between 1960 and 2018 [3]

2.2 Research background

Research on energy production as a distinctive factor in the economy began when the world witnessed the first oil shock, the rise in oil prices in 1973. Since then, economists have conducted extensive studies to assess the flexibility of production functions, especially energy.

2.2.1 International studies

Akinsola and Odhiambo [1] studied the impact of oil prices on economic growth in seven countries of Ethiopia, Gambia, Mali, Mozambique, Senegal, Tanzania and Uganda. Using the panel-ARDL, they examined the effect of oil prices on economic growth in the short and long term. Findings show that oil prices do not have a significant effect on the economic growth in the short term for this group, but a negative effect in the long term. However, the short-term coefficients of each country show that oil prices have a significant but mixed effect on economic growth in these seven countries. Therefore, they investigated the asymmetric effect of oil prices and economic growth using NARDL and breaking down oil prices into negative and positive changes. Finally, they used the panel error correction model for five countries, which showed that the short-term impact factors are negative and statistically significant.

Cantavella-Jordá [10] examined the asymmetric impact of crude oil prices on real GDP per capita between 1945 and 2018 in Spain. She states that the breakdown of oil prices into positive and negative partial amounts in (NARDL) allows the examination of the results of oil price fluctuations in international markets. The impact of these movements on GDP per capita is primarily long-term, because the results of rising oil prices in the long run than the short term has a greater impact on GDP per capita.

Eregha and Mesagan [12] examined the impact of oil resources abundance and budget deficit on GDP per capita growth in selected African oil countries between 1980 and 2017. They analyzed Algeria, Angola, Egypt, Libya and Nigeria using a dynamic heterogeneous panel approach. The results show that oil production is positive for GDP growth, except in Nigeria. Oil has a negative impact on the growth in Algeria, Angola, Egypt and Libya. Net oil exports also have a negative impact on short-term and long-term GDP growth in Angola, Egypt, Libya and Algeria, but in Nigeria it has a positive impact. Finally, deficit financing is growing in Algeria and Egypt, but is declining in Libya, Nigeria and Angola.

Yasmeen et al. [48] examined the short-term and long-term relationship between oil price volatility and real sector growth in Pakistan. They analyzed the four major sectors of the economy (generation, electricity, transportation and communications, and animal husbandry) to find any relationship. In this regard, they have used the annual time series data of selected sections during the years from 1976 to 2017. ARDL was used to study the relationship between economic sectors and oil price fluctuations. Experimental results show that changes in oil prices have a negative impact on the production, animal husbandry and electricity in the short and long term, while a significant positive effect is observed in transportation and communications.

2.2.2 Domestic studies

Sayadi and Khoshkalam [42] examined the relationship between oil revenues and the components of aggregate demand, as well as the dynamics between effective government capital expenditures and the country's non-oil GDP by explaining the inefficiency nature of government investments. They used Bayesian Vector Autoregressive (BVAR) model to select the prior function of the BVAR model during the seasonal period from the first quarter of 1990 to the first quarter of 2017 using RMSE and Theil indices. The findings of the research based on the impact-response functions of the model show that, with the increase in oil revenues, the aggregate demand components are accompanied by an increase, with the largest increase in current government expenditures. The response of oil-free GDP to an increase in government capital expenditures was examined under three scenarios (Base, optimistic and pessimistic). The research findings show that, with a positive impulse in effective government capital expenditures, the country's oil-free GDP increases under all three scenarios. The largest increase in the country's oil-free GDP under an optimistic scenario corresponds to the lowest level of investment inefficiency or the highest level of investment management index.

Tak Rousta et al. [45] emphasized the importance of OPEC countries' national security index. Accordingly, the impact of national security shocks on oil prices and other oil shocks (including oil supply shock, global industrial demand shock, etc.) on economic growth and inflation of OPEC countries was seasonally studied using panel VAR between 2008:1 and 2016:4. According to the findings, among the oil shocks, those oil price shocks, that are caused by the national security shocks of OPEC countries, have the most significant impact on the economic growth of OPEC countries; While these shocks do not lead to significant inflation in these countries. Oil supply shocks could also slightly boost OPEC economic growth and inflation, yet these increases are not significant. Other oil price shocks, without affecting the economic growth of OPEC countries, only lead to increased inflation in these countries.

Seifollahi [43] investigated the asymmetric effect of oil price uncertainty on economic growth, using the GMM from 1961 to 2015 in oil exporting and importing countries. The uncertainty index caused by oil price fluctuations is first obtained using EGARCH. Findings show that the effect of oil price uncertainty on economic growth in both groups of countries is asymmetric. The results of fitting of the dynamic panel model by GMM method also indicate that oil price uncertainty has a negative and significant effect on the economic growth in both exporting and importing countries. The effect of positive shocks on economic growth is greater than that of negative ones. In both types of countries, the economic growth rate of a previous period, investment growth, real exchange rate and population growth rate have a positive relationship with economic growth.

3 Introduction of model

Non-linear Autoregressive Distributed Lag (NARDL) model is used to investigate the relationship of asymmetry between a set of variables. Nonlinear ARDL was developed by Shin et al. [44]. Nonlinear ARDL is the asymmetric form of the linear ARDL model by Pesaran et al. [37], which is used to investigate the positive and negative effects of independent variables on the dependent variable in the long and short run. The difference between the ARDL and NARDL models is that the former does not consider the option of negative and positive changes of independent variables that have different effects on the dependent variable. The latter not only examines the nonlinear relationship that independent variables may have on the dependent variable, but also makes it possible to examine the accumulation in a single equation framework. NARDL also has other features that distinguish it from other time series models, such as the flexibility of the autoregressive model with nonlinear distribution intervals around the accumulation of variables. Another advantage of this model is the option of investigating the hidden accumulation between dependent and independent variables, which leads to the avoidance of ignoring any relationship that is not significant in a typical linear model and ultimately has better performance in small samples [25]. In this study, NARDL is used to investigate the existence of a long-term asymmetric relationship between oil prices and oil revenues with GDP and non-oil GDP in Iran using macro variables such as exchange rate, inflation rate and government spending. Accordingly, the general form of the model is inspired in the form of equations (3.1) to (3.4):

$$gdp_t = \beta^+ lpoil_t^+ + \beta^- lpoil_t^- + \omega lcpi_t + \tau er_t + \rho g_t + \varepsilon_t \tag{3.1}$$

$$ngdp_t = \beta^+ lpoil_t^+ + \beta^- lpoil_t^- + \omega lcpi_t + \tau er_t + \rho g_t + \varepsilon_t \tag{3.2}$$

$$gdp_t = \beta^+ lroil_t^+ + \beta^- lroil_t^- + \omega lcpi_t + \tau er_t + \rho g_t + \varepsilon_t \tag{3.3}$$

$$ngdp_t = \beta^+ lroil_t^+ + \beta^- lroil_t^- + \omega lcpi_t + \tau er_t + \rho g_t + \varepsilon_t \tag{3.4}$$

Here, gdp and $ngdp$ are dependent variables, and $I(1)$. Also, $poil$ is the price p of oil, $roil$ is oil revenues, cpi is consumer price index, er is real foreign exchange rate, g is government spending, and ε_t is Error Term. Here, oil prices and oil revenues are divided into positive and negative parts. NARDL for investigating the effect of oil prices and oil revenues on economic growth is as following (Eq. (3.5) to Eq. (3.8)):

$$gdp_t = \sum_{j=1}^{p} \emptyset gdp_{t-j} + \sum_{i=0}^{q} (\theta_i^+ lpoil_{t-i}^+ + \theta_i^- lpoil_{t-i}^-) + \sum_{i=0}^{q} \omega_i lcpi_{t-i} + \sum_{i=0}^{q} \tau_i er_{t-i} + \sum_{i=0}^{q} \rho_i g_{t-i} + \varepsilon_t \tag{3.5}$$

$$ngdp_t = \sum_{j=1}^{p} \emptyset gdp_{t-j} + \sum_{i=0}^{q} (\theta_i^+ lpoil_{t-i}^+ + \theta_i^- lpoil_{t-i}^-) + \sum_{i=0}^{q} \omega_i lcpi_{t-i} + \sum_{i=0}^{q} \tau_i er_{t-i} + \sum_{i=0}^{q} \rho_i g_{t-i} + \varepsilon_t \tag{3.6}$$

$$gdp_t = \sum_{j=1}^{p} \emptyset gdp_{t-j} + \sum_{i=0}^{q} (\theta_i^+ lroil_{t-i}^+ + \theta_i^- lroil_{t-i}^-) + \sum_{i=0}^{q} \omega_i lcpi_{t-i} + \sum_{i=0}^{q} \tau_i er_{t-i} + \sum_{i=0}^{q} \rho_i g_{t-i} + \varepsilon_t \tag{3.7}$$

$$ngdp_t = \sum_{j=1}^{p} \emptyset gdp_{t-j} + \sum_{i=0}^{q} (\theta_i^+ lroil_{t-i}^+ + \theta_i^- lroil_{t-i}^-) + \sum_{i=0}^{q} \omega_i lcpi_{t-i} + \sum_{i=0}^{q} \tau_i er_{t-i} + \sum_{i=0}^{q} \rho_i g_{t-i} + \varepsilon_t \tag{3.8}$$

where $\emptyset$ is the coefficients of dependent variable lags, θ_i^- and θ_i^+ are asymmetric coefficients of independent variable intervals, and ε_t is error term with average of zero and variance of one. By limiting the parameters, the linear ARDL model can be obtained, $\theta^+ = \theta^-$.

3.1 Static test

Static test is one of the most well-known tests in the econometric literature, which can be checked using various tests such as the Augmented Dicker Fuller (ADF) or the Phillips-Perron test. Dickey and Fuller [11] proposed ADF test to study AR(p) trend in variables. Perron [36] pointed out that the single root problem in these variables may lead to biased experimental results. Similarly, Kim and Perron [26] argued that traditional unit root tests give ambiguous results due to low explanatory power and poor distribution, because structural failures occur asymmetrically not only in the null hypothesis but also in the opposite hypothesis [35]. Augmented Dicker Fuller (ADF) is used here to study the stationary condition of variables. Accordingly, the real exchange rate variable (er) is stationary, but other variables are stationary with their first-order difference. Given that the variables are all stationary at their level and first-order difference, and none of the variables are stationary at their second-order difference, we can easily estimate the NARDL.

Table 1: Stationary Test Results

Variable		**Statistic**	**Probability**
Oil-free economic growth	$NGDP$	-0.85	0.7974
First difference of oil-free economic growth	$\Delta NGDP$	-4.10	0.0018
Economic growth with oil	GDP	-1.42	0.5678
First difference of economic growth	ΔGDP	-5.05	0.0001
Government spending	G	-1.47	0.5404
First difference of government spending	ΔG	-8.44	0.0000
Real exchange rate	ER	-4.10	0.0017
Consumer Price Index	$LCPI$	-0.02	0.9524
First difference of Consumer Price Index	$\Delta LCPI$	-3.40	0.0137
Oil Price	$LPOIL$	-2.39	0.1476
First difference of Oil Price	$\Delta LPOIL$	-3.09	0.0312
Oil Revenue	$LROIL$	-1.84	0.3569
First difference of Oil Revenue	$\Delta LROIL$	-2.97	0.0432

4 Model estimation results

4.1 Model 1: The impact of oil prices on economic growth with oil

4.1.1 Bounds Test

Two methods are used to investigate the existence of a long-run relationship between variables. The first one consists of calculating a statistical t-test from the null hypothesis $p = 0$ (no longrun relationship) versus the alternative $p < 0$ in the research equations. The second test is Pesaran et al. Test [38] in which its null hypothesis is formed according to the fact that there is no long-term relationship, $H_0 : P = \theta^+ = \theta^- = \alpha = \sigma = 0$. In the corresponding null hypotheses, these two tests do not have standard asymptotic distributions. According to the null hypothesis, there are no asymptotic standard distribution tests for both, which complicates the task. However, it is better to use the Pesaran test, which considers the two critical limits of I (0) and I (1). According to Table 2, statistic of the Pesaran test (10.46) is greater than both high and low critical limits of I (0) and I (1) in four levels of probability of 1%, 2.5%, 5% and 10%, confirming the existence of a long-term relationship in the model of the impact of oil prices on economic growth.

Table 2: Boundary Test Results

F-statistic	**Probability**	**I(0)**	**I(1)**
13.8	10%	2.08	3
	5%	2.39	3.38
	2.5%	2.7	3.7
	1%	3.06	4.15

Table 3 shows the results of long-term and short-term models. The economic growth of the dependent variable and oil price (POIL), government spending (G), real exchange rate (ER) and consumer price index (CPI) were selected as independent variables of the model. We also break down oil prices into positive and negative components to examine the impact of each sector on Iran's economic growth. The results of short-term and long-term model indicate a significant effect of all variables except the real exchange rate. Accordingly, in the long run, a positive oil shock has a negative impact on economic growth, which could be related to the Dutch disease. On the other hand, the negative impact of oil price shock on economic growth is positive. Another variable in the study is the government spending, which has a negative impact on economic growth with oil. Increasing government spending reduces savings in the economy and increases the interest rates. This can lead to less investment in infrastructures and reduced economic growth. Also, in the long run, the consumer price index as a representative of inflation has had a positive effect on the economic growth. With rising inflation, people often prefer to convert their assets from money to physical capital, which stimulates economic growth and improves economic growth in the country.

Table 3: Short-term and Long-term Results

Variables	**Coefficient**	**Standard deviation**	**t-Statistic**	**Probability**
Long-term model (1,0,0,1,0,3)				
LPOIL_POS	-54.56616	10.00322	-5.454859	0.0000
LPOIL_NEG	49.45921	20.04633	2.467244	0.0164
G	-6.919187	2.502271	-2.765162	0.0075
ER	0.021216	0.041470	0.511596	0.6108
LCPI	78.56878	19.93384	3.941478	0.0002
C	-146.2249	72.43691	-2.018652	0.0479
Short-term Model (1,0,0,1,0,3)				
GDP(-1)	-0.328816	-0.328816	-6.865176	0.0000
LPOIL_POS	-17.94224	3.898458	-4.602394	0.0000
LPOIL_NEG(-1)	16.26299	5.866708	2.772081	0.0073
G	-2.275141	0.902168	-2.521858	0.0143
ER	0.006976	0.013350	0.522551	0.6031
LCPI(-1)	25.83469	6.337771	4.076306	0.0001
D(GDP(-1))	0.294332	0.084207	3.495349	0.0009
D(GDP(-2))	0.202022	0.090631	2.229049	0.0294
D(LPOIL_NEG)	-60.82283	12.77905	-4.759575	0.0000
D(LCPI)	-134.6100	48.50515	-2.775170	0.0073

4.1.2 Error correction model (ECM)

ECM refers to the rate of adjustment to equilibrium after a short-term shock. Also, the long-run relationship is stable when the ECM coefficient is negative and statistically significant. Table 4 shows the results of ECM. Accordingly, in each period, about 32% of imbalances disappear, and we move towards long-term equilibrium.

Table 4: Error Correction Model

	Coefficient	Probability
ECT (-1)	-1.32	0.0000

4.1.3 Symmetry test

The Symmetry Test, developed by Shin et al. [44], is used to examine the symmetry between oil prices and economic growth. The asymmetry simply shows that the "positive" and "negative" analyses have different effects on the dependent variable. In the present study, Wald Test is used to investigate the asymmetry. Table 5 shows the results of this test. Given that the null hypothesis shows symmetry and the alternative asymmetry, the former is rejected and asymmetry is confirmed.

Table 5: Symmetry Test Results

Period	χ^2 **Statistic**	**Probability**	**Condition**
Short-term	9.02	0.0027	Asymmetry
Long-term	3.91	0.0480	Asymmetry

4.1.4 Structural stability test

Structural stability test of long-term and short-term coefficients was run using cumulative sum (CUSUM) and CUSUMQ. The stability of regression coefficients is evaluated by stability tests, and they can show whether the regression equation is stable over time. This test is suitable for time-series data. CUSUM and CUSUMQ statistics are drawn at the critical 5% boundary. If the graph is placed within this confidence interval, the stability is confirmed. Given that both tests are within the 5% confidence interval, the effect of oil prices on economic growth is sustainable.

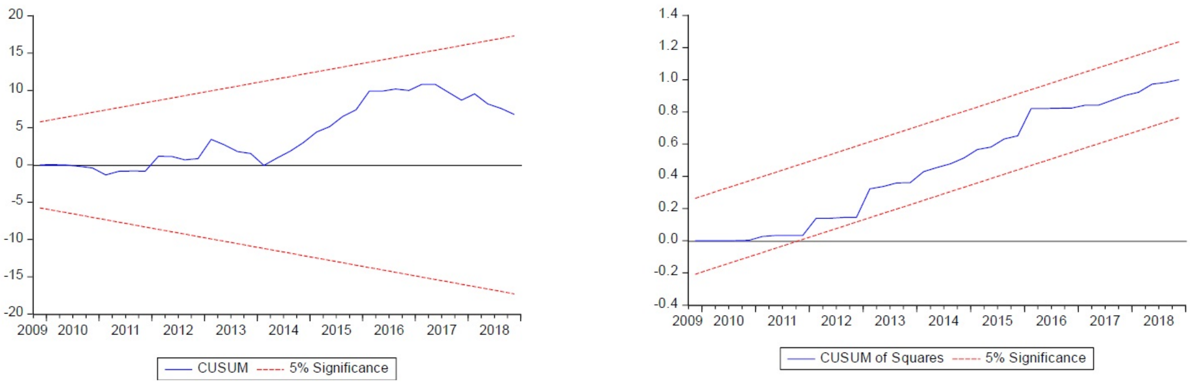

Figure 3: Stability Test

4.1.5 Diagnostic tests

To evaluate the robustness of the model, normality test, Ramsey test, heterogeneity test, and auto-regression test were performed. The results of normality, Arch and LM tests indicate that the model is normal, homogeneous and non-correlated. The Ramsey test also confirms the functional form of the model.

Table 6: Diagnostic Test Results

Test	**Normality**	**Ramsey**	**Arch heterogeneity**	**LM**
Probability	0.59	0.35	0.84	0.84

4.2 Model 2: The impact of oil prices on the economic growth without oil

4.2.1 Bounds test

As mentioned earlier, given the combination of static and non-static datasets, it is best to test the existence or absence of a long-run relationship between variables with the help of bounds tests [44]. Based on the results of the bounds test in Table 7, the null hypothesis, which claims lack of long-term relationship, cannot be accepted because the large critical values and reliability at all levels are less than the F-statistic values. Therefore, there is a long-term relationship among the variables in the model. Based on this result, it is necessary to estimate the short-term and the long-term relationship.

Table 7: Bound Test Results

F-statistic	**Probability**	**I(0)**	**I(1)**
13.8	10%	2.08	3
	5%	2.39	3.38
	2.5%	2.7	3.7
	1%	3.06	4.15

Table 8 shows the results of short-term and long-term model of the effect of oil prices on the economic growth without oil. According to the results, in the long run, all variables and, in the short term, except for the negative oil shock, other variables had a significant effect on the oil-free economic growth.

Positive and negative oil shocks had a negative effect on the oil-free economic growth. Inflation and economic growth are also negatively correlated, as higher price levels make people have less purchasing power. For this reason, consumers demand fewer goods. Decreased demand for goods will lead to the production of fewer goods and lower levels of production and economic growth.

Government spending has also slowed the economic growth. If government spending is financed through tax increases or budget deficits and borrowing, the crowding-out effects of government spending on private consumption and investment are expected to neutralize the positive effects of increasing government spending and the negative effects of reducing consumption and investment. Overall, increasing government spending will not have a positive effect on production and long-term economic growth. Finally, the effect of the exchange rate on economic growth in the long run is negative and can be due to the fact that, in developing countries, the cost of importing intermediate goods, used as input to production, increases with the rise in the exchange rate, leaving negative effect on the production and growth

Table 8: Short-term and Long-term Results

Variables	Coefficient	Standard deviation	t-Statistic	Probability
Long-term model (0,4,1,4,0,4)				
LPOIL_POS	-1.230414	0.455153	-2.703297	0.0093
LPOIL_NEG	-2.312691	0.998005	-2.317314	0.0245
LCPI	-3.598040	0.927867	-3.877754	0.0003
G	-0.611067	0.165285	-3.697042	0.0005
ER	-0.007326	0.002163	-3.386522	0.0014
C	28.46705	4.093730	6.953817	0.0000
Short-term Model (0,4,1,4,0,4)				
C	30.51476	5.062230	6.027930	0.0000
NGDP(-1)	-1.071933	0.110367	-9.712404	0.0000
LPOIL_POS	-1.318921	0.509541	-2.588448	0.0125
LPOIL_NEG(-1)	-2.479049	1.067677	-2.321909	0.0242
G(-1)	-0.655023	0.182159	-3.595892	0.0007
ER	-0.007853	0.002476	-3.171611	0.0025
D(NGDP(-1))	0.691404	0.087789	7.875750	0.0000
D(NGDP(-2))	0.641267	0.105894	6.055758	0.0000
D(NGDP(-3))	0.633991	0.117293	5.405173	0.0000
D(LPOIL_NEG)	1.575674	2.502948	0.629527	0.5318
D(LPOIL_NEG(-1))	7.510114	2.302382	3.261889	0.0020
D(LPOIL_NEG(-2))	4.640428	2.342242	1.981190	0.0529
D(LCPI)	-24.52023	7.419738	-3.304729	0.0017
D(G)	1.002724	0.232888	4.305614	0.0001
D(G(-1))	1.652557	0.265763	6.218150	0.0000
D(G(-2))	1.568492	0.259691	6.039840	0.0000

4.2.2 Error correction model

According to the results of Table 9, the error correction coefficient is negative and significant. Therefore, in case of a shock to the model, it takes about a period (one year) to reach the long-term equilibrium again. Considering that the error correction factor is 1.07, the model adjustment speed is claimed to be high.

Table 9: Error Correction Model

	Coefficient	Probability
ECT (-1)	-1.07	0.0000

4.2.3 Symmetry test

According to Table 10, the results of short-term and long-term symmetry test indicate the acceptance of the null hypothesis and symmetry in the model.

Table 10: Symmetry Test Results

Period	χ^2 Statistic	Probability	Condition
Short-term	1.10	0.29	Asymmetry
Long-term	0.77	0.37	Asymmetry

4.2.4 Structural stability test

CUSUM and CUSUMQ were used to evaluate the model stability. As it can be seen, in both tests, the diagram has not gone beyond the critical levels of 5% and the stability of the model can be confirmed.

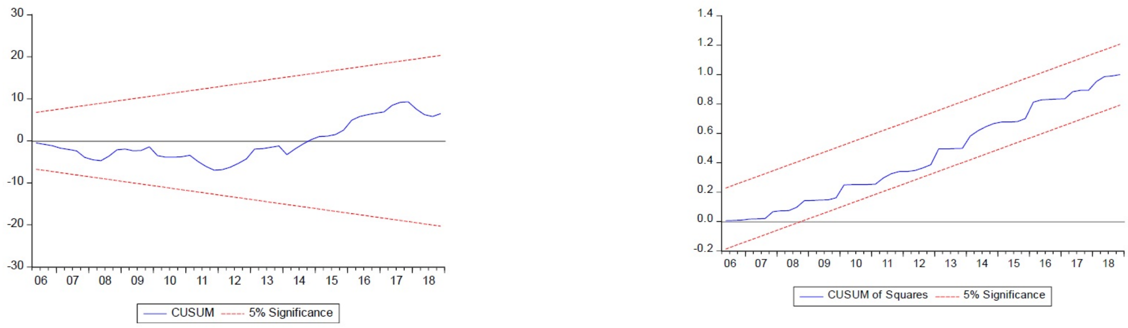

Figure 4: Stability Test

4.2.5 Diagnostic tests

The results of diagnostic tests in Table 11 show that the null hypothesis of the normality test that the residuals are normal is confirmed. Ramsey test also supports the functional form of the model. The variance heterogeneity test refers to the confirmation of homogeneity in the model, and finally the autocorrelation test provides evidence that there is no autocorrelation in the model.

Table 11: Diagnostic Test Results

Test	Normality	Ramsey	Arch heterogeneity	LM
Probability	0.93	0.28	0.40	0.42

4.3 Model 3: The impact of oil revenues on the economic growth with oil

4.3.1 Bounds test

Understanding that the variables are static at different levels, we examined whether or not the existence of co-integration between the variables is established using the bounds test proposed by Pesaran et al. [40]. As mentioned earlier, the boundary test is mainly based on the F-statistic, in which the null hypothesis confirms the absence of a co-integration relationship, and the opposite hypothesis confirms the existence of this relationship. If F-statistic is higher than the upper and lower critical values, the null hypothesis in terms of no co-accumulation is rejected [4].

In the third model, as can be seen, the F-statistic has a numerical value of 8.51, which is higher than the upper and lower limits in all significance levels. Therefore, the existence of a long-term relationship is confirmed.

Table 12: Bound Test Results

F-statistic	Probability	I(0)	I(1)
8.51	10%	2.08	3
	5%	2.39	3.38
	2.5%	2.7	3.7
	1%	3.06	4.15

Table 13 shows the results of model estimation of the effect of oil revenues on the economic growth. All variables affect economic growth in the long-term and short-term periods. In the long and short run, the positive shock of oil revenues has a negative impact on economic growth, while for the negative shock, we see a positive impact. The consumer price index also had a positive effect on the economic growth in the long run. Rising inflation immediately reduces a person's wealth and the rate of return on a person's real money balance. As a result, people save more to raise their wealth by moving assets, raising their prices, and thus lower real interest rates. More savings mean higher capital accumulation and consequently faster economic growth.

Exchange rates and economic growth have a negative impact on each other. An increase in the exchange rate reduces the demand for domestic currency and forces the central bank to adopt a restrictive monetary policy to protect the devaluation of the domestic currency, which in turn will have another detrimental effect on employment and GDP.

According to the results, government spending has a negative impact on the economic growth. Government spending can affect competition and raise prices by supporting inefficient firms. With rising prices, the demand for products decreases and has a negative impact on the economic growth.

Table 13: Model Estimation Results

Variables	Coefficient	Standard deviation	t-Statistic	Probability
		Long-term model (5,5,5,5,5,2)		
LROIL_POS	-76.17882	25.87941	-2.943608	0.0056
LROIL_NEG	50.65971	13.59132	3.727359	0.0006
LCPI	101.5466	21.95009	4.626247	0.0000
ER	-0.242473	0.126367	-1.918805	0.0627
G	-15.61114	3.653530	-4.272893	0.0001
C	-5.671891	63.12838	-0.089847	0.9289
		Short-term Model (5,5,5,5,5,2)		
C	-1.929695	21.51213	-0.089703	0.9290
GDP(-1)	-0.340221	0.063250	-5.378979	0.0000
LROIL_POS(-1)	-25.91762	10.47402	-2.474466	0.0181
LROIL_NEG(-1)	17.23549	5.929197	2.906884	0.0061
LCPI(-1)	34.54825	10.22945	3.377331	0.0017
ER(-1)	-0.082494	0.037298	-2.211739	0.0332
G(-1)	-5.311236	1.512148	-3.512378	0.0012
D(GDP(-1))	0.202803	0.080490	2.519601	0.0162
D(LROIL_POS)	-50.33025	21.83387	-2.305145	0.0269
D(LROIL_POS(-1))	-14.66839	16.65437	-0.880753	0.3841
D(LROIL_POS(-2))	-12.45941	17.28462	-0.720838	0.4755
D(LROIL_POS(-3))	-11.21920	17.40200	-0.644708	0.5231
D(LROIL_POS(-4))	102.3177	20.26860	5.048088	0.0000
D(LROIL_NEG)	84.59417	13.52195	6.256061	0.0000
D(LROIL_NEG(-1))	-21.19095	12.64885	-1.675327	0.1023
D(LCPI)	-31.32935	59.30150	-0.528306	0.6004
D(LCPI(-1))	-39.29214	54.31742	-0.723380	0.4740
D(LCPI(-2))	-90.40449	53.78922	-1.680718	0.1012
D(LCPI(-3))	-154.9079	56.39671	-2.746754	0.0092
D(LCPI(-4))	198.0488	68.18196	2.904709	0.0062
D(ER)	-0.410044	0.093161	-4.401444	0.0001
D(ER(-1))	0.028834	0.062759	0.459438	0.6486
D(ER(-2))	-0.051654	0.062113	-0.831617	0.4110
D(ER(-3))	-0.099686	0.063727	-1.564274	0.1263
D(ER(-4))	-0.127226	0.063904	-1.990877	0.0539
D(G)	-3.632494	1.237661	-2.934966	0.0057
D(G(-1))	2.619002	1.487095	1.761153	0.0865
D(G(-2))	2.238246	1.406906	1.590900	0.1201
D(G(-3))	1.711264	1.266852	1.350800	0.1850
D(G(-4))	-2.038332	1.412677	-1.442886	0.1575

4.3.2 Error correction model

In examining the impact of oil revenues on the economic growth, the rate of adjustment toward the long-run equilibrium, as shown in Table 14, is 0.34. In other words, about 34% of the imbalance error will be eliminated in each period.

Table 14: Error Correction Model

	Coefficient	Probability
ECT (-1)	-0.34	0.0000

4.3.3 Symmetry test

In Wald Test, to evaluate the symmetry and asymmetry of oil revenues in the model, $\pi_i^+ = \pi_i^-$ is taken into account in the short term and $\sum_{i=0}^{q} \pi_i^+ = \sum_{i=0}^{q} \pi_i^-$ in the long term. According to the results, in the short and long terms, there is an asymmetry between the positive and negative components of oil revenues.

4.3.4 Structural stability test

Checking the stability of the parameters is necessary to check the robustness of statistical analysis. Brown et al. [7], Persaran and Persaran [39] proposed CUSUM and CUSUMQ. As mentioned earlier, the stability of the model

Table 15: Symmetry Test Results

Period	χ^2 Statistic	Probability	Condition
Short-term	22.48	0.0000	Asymmetry
Long-term	9.71	0.0018	Asymmetry

is confirmed if the relevant diagrams do not cross the lines related to the critical levels. As shown in Graph 5, the stability of the model is confirmed.

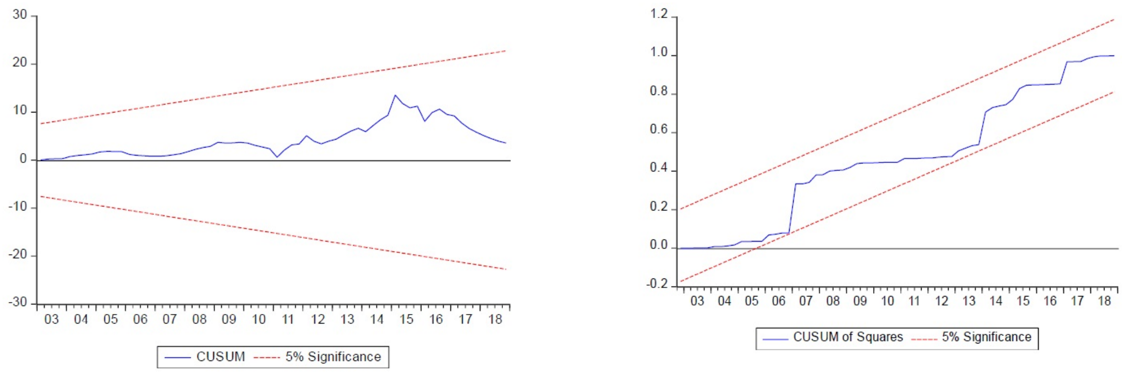

Figure 5: Stability Test

4.3.5 Diagnostic tests

Table 16 shows the results of diagnostic tests. In the normality test, the null hypothesis is normal model residuals, which are confirmed. Also, the correctness of the functional form was accepted by Ramsey test, the homogeneity of variances by the Arch test and the absence of autocorrelation by the LM test.

Table 16: Diagnostic Test Results

Test	Normality	Ramsey	Arch heterogeneity	LM
Probability	0.87	0.54	0.61	0.35

4.4 Model 4: The impact of oil revenues on oil-free economic growth

4.4.1 Bounds test

Pesaran et al. [40] proposed bounds test which does not require a fixed pre-test in order to analyze the long-term relationship of a set of variables. This can be used regardless of whether the variables are I (0) or I (1) (but not I (2)). F-statistic of bounds test is 8.16. It is significant and greater than upper and lower limits, indicating a long-term relationship.

Table 17: Bound Test Results

F-statistic	Probability	I(0)	I(1)
8.16	10%	2.08	3
	5%	2.39	3.38
	2.5%	2.7	3.7
	1%	3.06	4.15

Table 18 shows the results of the model estimation of the effect of oil revenues on the economic growth without oil. According to the results, government spending in the long run and short-term and the exchange rate in the short run have no effects on the economic growth. In the long run, negative and positive shocks to oil revenues have a significant, negative effect on the economic growth. Inflation has also had a negative effect in the short and long terms. High inflation is always associated with increased price variability, which can lead to the uncertainty about the future profitability of investment projects. This will result in more conservative decisions and ultimately lead to lower levels of investment and economic growth. The findings also show that the real exchange rate has a negative impact on the economic growth. The real exchange rate has the potential to reduce capital accumulation and productivity growth, thereby weakening the channels through which economic development strengthens the economic growth. Rising exchange rates have also reduced the current income of firms, reduced their ability to borrow to survive, and reduced long-term investment in the country, which ultimately has a devastating effect on the economic growth.

Table 18: Model Estimation Results

Variables	**Coefficient**	**Standard deviation**	**t-Statistic**	**Probability**
		Long-term model (0,4,0,0,0,5)		
LROIL_POS	-2.257545	1.130167	-1.997531	0.0506
LROIL_NEG	-1.956698	1.115084	-1.754754	0.0848
LCPI	-3.824198	1.305291	-2.929766	0.0049
G	-0.123160	0.191899	-0.641792	0.5236
ER	-0.004269	0.002206	-1.935120	0.0580
C	25.46438	5.981200	4.257404	0.0001
		Short-term Model (0,4,0,0,0,5)		
C	19.44871	3.834460	5.072085	0.0000
NGDP(-1)	-0.763761	0.113475	-6.730680	0.0000
LROIL_POS	-1.724225	1.022741	-1.685886	0.0974
LROIL_NEG	-1.494451	0.672809	-2.221211	0.0304
LCPI	-2.920774	1.024565	-2.850745	0.0061
G(-1)	-0.094065	0.102691	-0.915995	0.3636
ER	-0.003260	0.002676	-1.218188	0.2283
D(NGDP(-1))	0.521750	0.084894	6.145904	0.0000
D(NGDP(-2))	0.495436	0.099083	5.000212	0.0000
D(NGDP(-3))	0.540128	0.108232	4.990448	0.0000
D(NGDP(-4))	-0.359232	0.116301	-3.088797	0.0031
D(G)	1.380311	0.223724	6.1697048	0.0000
D(G(-1))	1.155804	0.226873	5.094502	0.0000
D(G(-2))	1.097978	0.229247	4.789501	0.0000
D(G(-3))	0.921866	0.224212	4.111586	0.0001
C	19.44871	3.834460	5.072085	0.0000

4.4.2 Error correction model

The error correction coefficient of the effect of oil revenues on the economic growth also shows an adjustment speed of 0.76, which means that in each period 76% of the imbalances will disappear and we will move towards a long-term equilibrium.

Table 19: Error Correction Model

	Coefficient	Probability
ECT (-1)	-0.76	0.0000

4.4.3 Symmetry test

The symmetry test examines whether or not the effect of oil revenues on economic growth has been symmetrical in the long and short terms. The results of Wald test, which shows the null hypothesis of asymmetry and the alternative of asymmetry, indicate the symmetry of the positive and negative analysis of oil revenues in the long and short term.

Table 20: Symmetry Test Results

Period	χ^2 **Statistic**	**Probability**	**Condition**
Short-term	0.49	0.48	Asymmetry
Long-term	0.03	0.84	Asymmetry

4.4.4 Structural stability test

The CUSUM and CUSUMSQ tests for parameter stability were first introduced in the statistical and econometric literature by Brown et al. [7]. These experiments are based on scalable residual analysis and have a significant advantage over the Chou test, which requires prior knowledge of the point at which the structural hypothesis exists. Graph (4) shows that there is stability in the model under study.

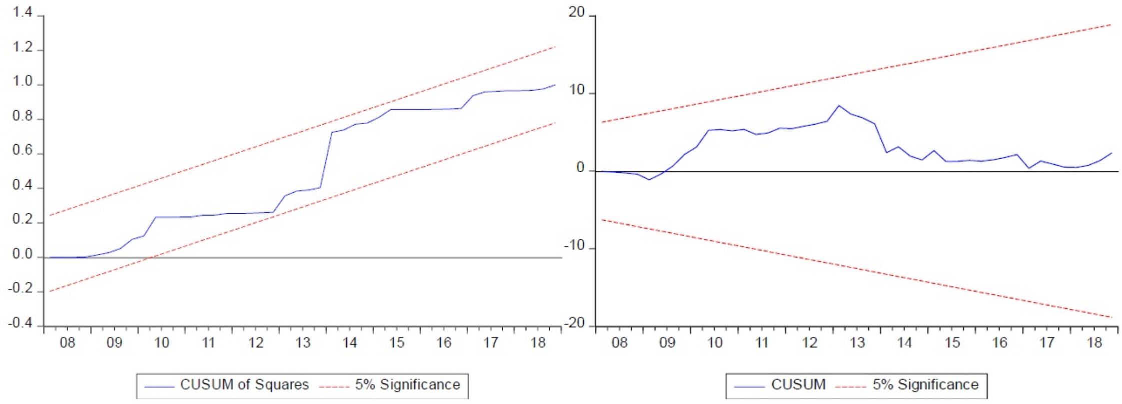

Figure 6: Stability Test

4.4.5 Diagnostic tests

Table 21 shows the results of the diagnostic test of fourth model. According to the results, there is no correlation, inhomogeneity and abnormality. The model has correctly been chosen.

Table 21: Diagnostic Test Results

Test	**Normality**	**Ramsey**	**Arch heterogeneity**	**LM**
Probability	0.19	0.62	0.79	0.34

5 Summary and conclusion

All countries in the world need crude oil as a primary source for their industries. This need has increased the demand for crude oil worldwide. From 2006 to 20019, global demand for crude oil increased from 85.3 to 100.3 million barrels per day. In fact, this growth is still increasing and is projected to increase to 101.6 million barrels per day [16]. Given the importance of crude oil in the global economy, the effect of oil price volatility on the economic activity has received special attention in the literature. This attention is justified because oil is not only the largest commodity trade in the world, but also the world's largest source of energy, accounting for 33% of the world's primary energy consumption [47]. This dominance in the transportation sector, where it represents 94% of the energy consumed, is significant. Oil prices, like many other commodity prices, are volatile and characterized by uncertainty [30]. In the present study, the effect of oil revenues and oil prices on oil and non-oil economic growth has been studied in the form of four models. Based on the results, oil prices and oil revenues have an asymmetry on oil economic growth. Therefore, the following suggestions can be made:

- According to the findings, the economic activity responds symmetrically to changes in oil prices and revenues due to government subsidies on petroleum products in Iran, which can compensate some of the adverse effects on the economic activity. Subsidized fuel prices can disrupt local oil markets, increase government spending, and thus widen financial deficits. Therefore, the price of oil must be set in the market in order to reduce market distortions and reduce the financial deficit.
- Iran needs to reduce its dependence on oil through the use of energy-efficient vehicles, replace imported gasoline with renewable energy sources, and develop indigenous energy sources such as gaseous hydrates, crustal gas, wind, solar and nuclear energy.
- The asymmetry in the results also shows that although Iran provides large oil subsidies to protect the domestic oil market from global oil shocks, the oil markets in these economies are in a competitive position where oil companies are pricing fuel products. Therefore, there should be more deregulation in oil markets and the encouragement of competition between oil marketing companies to establish a transparent mechanism for pricing all fuel products.
- It is also necessary to raise awareness among customers and regulatory bodies so that oil marketing companies pursue a fair and transparent pricing policy.

- It is necessary to apply more accurate investment metrics and allocate more resources to production costs, such as infrastructure in the event of a positive oil shock.
- Reducing financial dependence on oil and strengthening the non-oil tax base are advisable.
- Oil revenues should be invested in other sectors of the economy so that the government can pursue a policy of diversification and support employment in sectors other than the oil.
- The government should encourage domestic production and consumption of domestic goods and services in order to limit the effects of exchange rate fluctuations on other macroeconomic variables.

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