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The Effect of Oil Production on Various Macroeconomic Factors: The Case Study of the Economy of Kazakhstan

DOI: 10.26399/meip.4B(79).2023.39/a.rakhimanova

Introduction

The issue of how to stabilise the economy and finance economic transformation has been raised for all former Soviet Union countries after its collapse. Particularly, the problem became more crucial for the Central Asian region, which initially was less developed than the rest of the former republics. Due to this fact, this region was exposed to high sensitivity to political and economic instability. After gaining independence, Kazakhstan, which was quite rich in natural resources, focused on the petrochemical industry. In the period of the tendency of oil price increase, as in other oil-dependent countries, economic growth in Kazakhstan was very substantial in comparison with other non-energy countries. On the contrary, the oil price drop in the years 2014–2015 impacted the economy to a great extent. Since the rapid decrease in oil revenues, the economy of Kazakhstan implemented a flexible foreign exchange rate. These events show to what extent the country is sensitive to oil price fluctuations. Hence, the evaluation of the main determinants connected with oil prices is considered to be important. Since the establishment of sovereignty, the performance of the economy of Kazakhstan looks good in all fields. Therefore, the analysis of Kazakhstan's economy is a fascinating area for discussion. The main advantage of the economy of Kazakhstan is mainly natural resources, since the subsoil contains a significant amount of them. In this thesis, we will concentrate on one of the important resources nowadays: oil. According to Kazenergy (2023), most of the oil reserves are concentrated in the western and northern parts of

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the Precaspian Basin. To be more precise, the oil production of Kazakhstan is considered the largest in Central Asia, as it exports nearly 80% of the crude oil produced. Moreover, the oil sector occupies 15% of GDP and oil exports account for 63% of total exports. Generally, export volumes of oil in 1995 were approximately 10 million tonnes; nowadays, it has increased substantially to 64.8 million tonnes based on 2022 data (International Energy Agency, 2022).

Oil is considered an extremely significant natural resource, as its usage is widespread across many industries. Since there is a global dependency on oil, the relationship between oil and the main economic determinants has become an interesting topic for research. As Kazakhstan is prominent in oil production, its reliance on oil revenues increases the sensitivity of the economy to external factors. Hence, the aim of the thesis is to examine to what extent oil price changes can predict changes in other economic determinants. Therefore, for the econometric analysis, the VAR framework for the period of 2000 Q1–2022 Q4 is going to be applied. In this regard, the IRFs, VD, and Granger Cause procedure will be used.

The first chapter discusses and summarises the papers about the interrelationship of oil prices with inflation, the exchange rate, and GDP. Later, we proceed with the analysis of papers focused particularly on the economy of Kazakhstan. The second chapter discusses the dataset and the theoretical approach of the VAR model. Moreover, the procedure of Granger causality and diagnostic tests is analysed. The third chapter provides the outcome of estimations; therefore, the results obtained through the econometric approach are discussed. The fourth chapter summarises the results of the paper, and conclusions based on these results are made.

Literature review

The first chapter of this research summarises the available studies and scientific papers regarding the interrelationship between petroleum and economic growth, the rate of exchange, and inflation.

Oil is recognised within the economic area as the largest internationally traded good and an indicator of a stable economy. Moreover, energy-intensive countries' dependency on the oil price level is substantial; every oil price shock affects the macroeconomic indicators in some way. There are wide-ranging responses for each country in the case of price fluctuations, based on whether the economy is an oil importer or oil exporter. Thus, some economists claim the presence of a tight interrelationship between oil and economic achievement. However, if there is indeed the existence of some relationship, it is still not clear (Adelman, 2004).

The effect of oil prices on GDP

There are many papers that analyse the oil price level and economic growth intercorrelation. The attractiveness of this topic remarkably increased after the research of Hamilton in 1983. He claims that oil price fluctuations substantially contributed to most downturns in the case of the USA. Moreover, his research revealed the existence of a harmful influence of oil prices on economic development (Hamilton, 1983). His research, which was one of the earliest in this area, was supported by other colleagues. Later, Mork (1989) supports his conclusion with a paper which concentrates on asymmetric effects based on the type of oil price shock. Therefore, he concludes that the oil price downturn is not as significantly harmful as the oil price rise (Mork, 1989). Through his work, he encouraged a number of economists, who in turn indeed found asymmetrical effects and claimed that the negative oil price shock is insignificant in the case of the USA. Jimenez-Rodriguez and Sanchez (2004) examine the non-linear influence of oil prices on GDP within the panel data of oil-producing and oil-consuming countries based on a Multivariate VAR framework. They argue that the oil price increase contributed to changes in GDP growth, while the oil price drop did not have a significant effect on the economy. Moreover, they conclude that there is a negative interrelation between oil prices and GDP for oil-importing countries and a positive one for oil-exporting countries. In his research, Jin (2008) compares panel data consisting of three countries – Japan, China, and Russia. He concludes that there is a positive outcome of an increase in the oil price level for Russia. Conversely, for oil-importing China and Japan, the result shows the existence of a negative interrelationship. Akinci, Akturk and Yilmaz (2012) analysed the panel data for OPEC countries, and they found that a 10 percent oil price increase is associated with an increase of GDP by 0.14 percentage points for OPEC countries, while for oil-importing countries, it caused a drop in GDP by 0.01 percent. Korhonen and Ledyaeva (2008) analyse and compare the different responses to oil price increases based on a set of oil-importing/exporting countries. The research was focused on the VAR system, and the achieved results were as follows: Canada and Russia, as oil exporters, would benefit from increases in oil prices (positive relationship), while the USA, Japan, China, Germany, and the UK, as oil-importing countries, would lose from the increase in petroleum prices (negative relationship). Rautava (2002) analyses the time series data of Russia based on quarterly data from 1995 Q1 to 2001 Q3. Based on the cointegration technique, the Johansen cointegration test, he applies the restricted form of the VAR model, VECM. He claims that a permanent increase (decrease) in oil prices by 1 percentage point is accompanied by a 0.22 percent increase (decrease) in GDP in the short run and 0.46 percentage points in the long run. Summarising all the literature above, we can conclude that the effect of an oil price shock on the GDP of Kazakhstan is expected to have a positive relationship, as in our case the analysed country is an oil exporter.

The effect of oil prices on the exchange rate

The research area on the interrelationship between the exchange rate and international oil prices is extensive. The first studies about the influence of oil prices on exchange rate movements were examined in the 1980s by a number of economists. While in his study, Golub (1983) mainly explains the strong relationship by the channels for wealth transferring, in the studies of Krugman (1983a, 1983b), he claims that the changes in the rate of exchange are mostly based on the preferences of import countries and oil-producing countries' investment decisions regarding oil price increases. Later, using several types of decomposition techniques, Huizinga (1987) and Baxter (1994) found that even though exchange rates might not abide by the random walk, the changes were mostly caused by the permanent components. Clarida and Gali (1994), who use quarterly data from 1974 to 1992 for US-Canada, US-Germany, and US-UK, estimate to what extent oil prices impact movements in the exchange rate. In their studies, they implement the Blanchard–Quah identification strategy and state that 50% of the variation in the estimated exchange rate can be mainly explained by changes in the oil price level. Chaudhuri and Daniel (1998) examine 16 OECD countries based on quarterly data from 1972 Q1 to 1996 Q4. Using the cointegration procedure, they state that there is cointegration between US exchange rates and oil prices, which both in turn follow a non-stationary path. Based on the results, they conclude that there is causality directing from oil prices to US exchange rates. Amano and Norden (1998a, 1998b) support their research with similar results based on monthly data from 1973 M1 to 1993 M12. They use data for Germany, Japan, and the US to examine whether oil prices and the exchange rate have a permanent relationship. They state that sudden oil supply-side shocks would likely result in a new equilibrium point for real exchange rates in the long run. They also state the existence of causality directing from oil prices to exchange rates, while for inverse causality, they do not find enough evidence. In later studies, Chen and Chen (2007) analyse the relationship between the exchange rate and oil prices for G7 countries. Using the panel predictive regression model, they state that oil prices indeed have substantial forecasting power for the exchange rate. Koranchelian (2005) analyses the relationship between oil prices and the exchange rate by applying VECM over the 1970–2003 period. It has been stated that there is a statistically positive interrelationship between the mentioned variables in the case of Algeria as an oil producer. Habib and Kamalova (2007) examine the impact of oil prices on the exchange rate for a panel data set consisting of Russia, Saudi Arabia, and Norway. They argue that there is no significant link between oil prices and the exchange rate in the case of Saudi Arabia and Norway. However, in the case of Russia, they found that the relationship between the estimated variables is statistically significant in the long run. These results can be explained by different policy responses and/or specific structural features. Korhonen and Juurikkala's (2009) study examines the factors that affect the exchange rates for countries belonging to OPEC. The authors use PMG and MG estimators to identify the relationship between the exchange rate and a number of potential determinants. It has been concluded that the price of oil has a significantly positive forecasting power in determining the rate of exchange. From the estimated elasticity, it has been indicated that a 1 percent increase in the oil price level leads to a 0.4–0.5 percent increase in the real exchange rate. Hasanov (2010) analyses quarterly data from 2000–2007 using Johansen and ARDL cointegration techniques. He concludes that an oil price increase of 1 percent will eventually increase the exchange rate by 0.7 percent in the long-term perspective for the Azerbaijani economy. Moreover, the ECM showed that the short-term deviation is corrected by almost 15–20 percent in the long run. Bergvall (2004) analyses a few countries of the Scandinavian region, which included Denmark, Finland, and Norway for the period of 1975–2001. He concludes that for Denmark and Finland, the rise in oil prices is supplemented by a rise in the exchange rate. However, in the case of Norway, which is the only oil-exporter country in this set, he concludes that an increase in oil prices leads to a drop in the exchange rate of the Norwegian krone. The results of Bergvall (2004) match the findings of Akram (2004), who examines the asymmetric interrelationship between oil prices and the exchange rate for Norway. He states that changes in oil prices affect the exchange rate in the short run, especially when prices drop to the point of 14 USD or lower. To sum up this part of the literature review, it can be assumed that in the case of Kazakhstan, the relationship between oil prices and the exchange rate will be negative. To be more precise, a decrease (increase) in oil prices should lead to a rise (fall) in the exchange rate and, therefore, the Kazakhstani tenge depreciates (appreciates).

The effect of oil prices on inflation

The responses of inflation to oil price fluctuations differ from country to country. The reaction depends on whether the analysed country is oil-exporting or oil-importing, developing or advanced, and, especially, on the extent to which the country is oil--intensive. This part of the literature is divided into two sections, making it clearer which outcome is more probable for Kazakhstan. Even though most literature has analysed the influence of oil prices on inflation, the results are relatively varied. Based on the work of Hooker (1996, 2002) and the studies of Blanchard and Gali (2007), Gomez-Loscos, Gadea and Montanes (2012), and Valcarcel and Wohar (2013), it is revealed that the role of oil prices in inflation significantly declined for advanced economies after the oil price shock of the 1970s. The main factors in reducing the power of oil prices were effective improvements in monetary policy, more flexible markets and lower energy intensity in production. Also, based on the non-linear pattern of oil price changes, Lown and Rich (1997) concluded that an increase in oil prices does not affect inflation significantly; however, in the case of a drop in oil prices, the effect is much more tangible. Similar research by Cologni and Manera (2008) found that inflation is affected by oil prices, which in turn pushed up interest rates and reduced GDP. Wu and Ni (2011) support these findings for the USA over 1995–2005, showing that inflation is indeed Granger-caused by oil price fluctuations. LeBlanc and Chinn (2004) analyse quarterly data for 1980–2001 for France, Germany, the United States, the United Kingdom and Japan. They find that a 1 percent increase in oil prices leads to a 0.01–0.08 percent rise in inflation. Chen (2009) extends this to 19 advanced countries and finds that a 10 percent increase in oil prices results in 0.05 percent inflation growth after one quarter; however, this effect vanishes over time, which the author attributes to improved monetary policy and greater trade openness. Cavalcanti and Jalles (2013) analyse data for Brazil and the United States based on different levels of oil import dependence. Since oil dependence in the USA is higher than in Brazil, oil price shocks did not significantly impact Brazil's economic growth or inflation rate; however, they note that US growth is influenced by oil prices. Applying a recursive VAR model, Chen (2015) finds that dependency on oil prices is significantly high in China, making it vulnerable to oil price fluctuations. In a similar study of Turkey for 1990–2011, Ozturk (2015) uses quarterly data and reveals a positive relationship between oil price shocks and inflation in Turkey. This was supported by the research of Rasasi and Yilmaz (2016), who came to the same conclusion and stated that inflation growth is observable not immediately, but after a few quarters. Lu, Lii and Tseng (2010) analyse the oil prices' non-symmetrical effect on inflation in Taiwan by using bivariate GARCH and Granger causality methods. They found a severe nonlinear response directing from oil prices to inflation. Köse and Ünal (2021) evaluate oil price influence on inflation growth using the SVAR model for time-series data from 1988 to 2019. The result shows that the variation in inflation is mostly dominated, especially in the first few periods, by variation in oil prices and the exchange rate. This aspect should be taken into consideration when applying monetary and fiscal policies. Tang, Wu, and Zhang (2010) analyse the period of 1998–2008 for China using the Structured Vector Autoregression Model (SVAR) framework. They conclude that increased oil prices diminish output and investment and, at the same time, drive inflation and interest rates in the short run. Nevertheless, this effect is almost negligible in the long run due to tight monetary and fiscal policies. Similar studies conducted by Chen, Chen, and Härdle (2015) and Qianqian (2011) support the idea that rising oil prices lead to a higher CPI for China. Nevertheless, Katircioglu *et al.* (2015) conclude that oil prices impact inflation negatively for OECD countries. Mehrara and Oskoui (2006) analyse a set of the biggest oil-producing countries using the SVAR model. The authors conclude that the economies of Iran and Saudi Arabia are affected by oil price variation to a great extent; at the same time, with the help of industry diversification, Kuwait and Indonesia are able to mitigate the fluctuations occurring in the economy. Nigeria, as the main oil exporter in Africa, is highly sensitive to oil price fluctuations. In the study of Adenuga, Hilili and Evbuomwan (2012), the ARDL model was used, and the researchers conclude that a 10 percent rise in oil prices eventually led to a 0.4 percent increase in CPI in the short run and 0.6 percent in the long run. In his studies, Ito (2008, 2010) analyses quarterly data for Russia in the period of 1995–2007 using the VAR framework. The author states that GDP and inflation are affected positively by higher oil prices. In his later studies over the same period, using the VEC model, the previous study was supported by the same results: a 10 percent rise in the price of oil led to GDP and inflation growth of 2.5 and 3.6 percent respectively over the next 12 quarters, with a stabilising effect. Abounoori, Nazarian and Amiri (2014) analyse the data for Iran and state the presence of short- and long-run effects between positively correlated oil prices and inflation. However, in another study by Davari and Kamalian (2018), using a non-linear ARDL framework, the absence of any relationship between the aforementioned variables is concluded. In their research study, De Gregorio, Neilson and Landerretche (2007) present evidence of reduced influence of oil prices on inflation in developed and developing economies. They state that the reduction in influence is more relevant in developed economies due to a decrease in oil intensity in industry and the Central Bank's (CB) monetary policy. In their recent study, Gelos and Ustyugova (2017) analyse the phenomenon for various developed and developing economies for the period of 2000–2010 using the Augmented Phillips Curve framework. They introduced the idea that high petroleum intensity and prior rudiments of inflation are the only significant factors contributing to inflation. After analysing the literature about the relationship between oil prices and inflation, it can be assumed that there should be a positive relationship due to Kazakhstan's oil intensity. In fact, Kazakhstan is included in the top ten oil exporters' list; however, the diversification of Kazakhstan's industry is still questionable, even after EXPO-2017, which aimed to develop the idea of implementing renewable energy policy (Del Sordi, 2017).

The effect of oil prices on various economic indicators for Kazakhstan

After the analysis focused on international literature, some scientific papers about the interrelationship between oil prices and estimated economic indicators for

Kazakhstan are going to be considered. Surprisingly, there are few studies so far focused on the position of oil production. Korhonen and Mehrotra (2009) examine the connection between oil prices and GDP in four large oil producers: Russia, Kazakhstan, Iran, and Venezuela. Based on the analysis using the Structural VAR model, the authors claim that GDP is affected by higher oil prices in a positive way, except for Iran. Moreover, their study includes the aspect of exchange rates and how they are impacted by oil price shocks. The authors argue that higher fuel prices are accompanied by the depreciation of the local currency in Venezuela and Iran; however, in the case of Russia and Kazakhstan, the influence is insignificant. The study of Gurvich, Vakulenko, and Krivenko (2009) includes the following five oil-producing countries: Venezuela, Norway, Iran, Russia, and Kazakhstan. They conclude that there is a correlation between oil prices and economic aggregates for Venezuela, Norway, Iran, and Russia; however, there is no such result for Kazakhstan. The results show that only 4% of variation in GDP for Kazakhstan can be explained by the changes in fuel price. Later, the study of Pushkarev (2013), which was based on VECM over the period from 2000 Q1 to 2010 Q4, supports the conclusion of Gurvich, Vakulenko, and Krivenko (2009). Even though oil price shocks have a positive effect on GDP, the impact was insignificant for Kazakhstan. Another study conducted by Gronwald, Mayr and Orazbayev (2009) applied the VAR model in order to estimate the interrelationship between oil production, GDP, exchange rate, and inflation. The results show that oil prices are impacted by a large number of factors, which caused a relatively high level of volatility, and moreover, all observed variables experience a significant decline caused by a drop in oil prices. Also, the paper proves that for the economy of Kazakhstan, the standard linear VAR model is considered most appropriate. Kretzschmar and Nurmakhanova (2010) use the Multivariate VAR model and Granger Causality based on the data available for the period from 2000 Q1 to 2010 Q1. They state that all estimated variables have a symmetric and non-symmetric relationship with each other. Furthermore, they argue that the key effect of oil price level on GDP is mostly related to the exchange rate. Kutan and Wyzan (2005) analyse whether Kazakhstan has been affected by the Dutch disease, which is mostly identified as a drop in a country's output after the discovery of a new natural resource such as oil. For the analysis, monthly data from 1996 to 2003 were used, and the result of a positive interrelationship connecting the oil prices and exchange rate was obtained. Using the VAR model, Köse and Baimaganbetov (2015) reveal that both types of oil price shocks and GDP have a positive interrelationship, while the exchange rate is affected only by negative shocks. In the case of inflation, they found that oil price shocks, both positive and negative, did not affect inflation.

Methodology

Hypothesis

H1: There is a positive effect of oil prices on inflation in Kazakhstan.
H2: There is a positive effect of oil prices on GDP in Kazakhstan.
H3: There is a negative effect of oil prices on the exchange rate in Kazakhstan.

Dataset

The dataset contains four variables: GDP, oil prices (OP), inflation (INF), and the exchange rate (EXR). The quarterly frequency from the first quarter of 2000 to the fourth quarter of 2022 was selected, as it was assumed that quarterly frequency would be more convenient for the research. The data on GDP, inflation, and the exchange rate were provided by the National Bank of Kazakhstan website (NBK 2022), while the oil price data were taken from the Federal Reserve Economic Data (FRED 2022). In the dataset, Brent oil prices, which are measured in USD per barrel, are used. Inflation is measured as the CPI response to the annual percentage change in the cost of the basket. The GDP for Kazakhstan is measured in millions of US dollars. The exchange rate is measured as the value of the local currency against the USD (Kazakhstan's tenge relative to the United States dollar). Based on the literature, where most researchers have suggested and analysed the standard linear VAR model, this framework will be used for our analysis.

Vector Autoregressive Model

The Vector Autoregression model (VAR) is a time-series econometric model defined as a system of several equations in which each variable is explained by its own lags. The model was popularised by Sims (1980), who constructed it to solve the problem that occurred in traditional single-equation models. According to Sims, systems of variables are treated equally; therefore, there is no differentiation between endogenous and exogenous variables, as all of them are assumed to have an interrelationship within a model. He concludes that the VAR framework is an efficient instrument for the economic behaviour analysis of time series, for forecasting economic indicators and, moreover, for implementing policy analysis. He claims that VAR provided more accurate economic forecasts than any other framework for economic prediction. Hence, this method is prioritised in order to estimate the dynamic interrelationship between multiple macroeconomic variables.

The proposed VAR of order p by Sims (1980) can be constructed in the following way:

$$\gamma_t = \sigma + \sum_{i=1}^{p} \delta_i \gamma_{t-i} + \varepsilon_t \tag{1.0}$$

where:
$\gamma - (n \times 1)$ vector of variables;
$\sigma = (\sigma_1, \ldots, \sigma_{4n}) - (4n \times 1)$ intercept of VAR model;
δ_i – the i-th (4n×4n) autoregressive coefficients;
p – lags number;
$\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \ldots, \varepsilon_{n4t}) - (4n \times 1)$ generalisation of white noise.

In our case, the VAR model will be used to analyse the relationship between oil prices, GDP, inflation, and the exchange rate for Kazakhstan. As there are four aforementioned variables, it will be a system of four equations:

$$\mathrm{OP}_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\mathrm{OP}_{t-i} + \sum_{i=1}^{p} \alpha_{1i}\mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \alpha_{1i}\mathrm{INF}_{t-i} + \sum_{i=1}^{p} \alpha_{1i}\mathrm{EXR}_{t-1} + \varepsilon_t \tag{1.1}$$

$$\mathrm{GDP}_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i}\mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \beta_{2i}\mathrm{OP}_{t-i} + \sum_{i=1}^{p} \beta_{3i}\mathrm{INF}_{t-i} + \sum_{i=1}^{p} \beta_{4i}\mathrm{EXR}_{t-1} \tag{1.2}$$

$$\mathrm{INF}_t = \gamma_0 + \sum_{i=1}^{p} \gamma_{1i}\mathrm{INF}_{t-i} + \sum_{i=1}^{p} \gamma_{2i}\mathrm{OP}_{t-i} + \sum_{i=1}^{p} \gamma_{3i}\mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \gamma_{4i}\mathrm{EXR}_{t-1} + \varepsilon_t \tag{1.3}$$

$$\mathrm{EXR}_t = \delta_0 + \sum_{i=1}^{p} \delta_{1i}\mathrm{EXR}_{t-i} + \sum_{i=1}^{p} \delta_{2i}\mathrm{OP}_{t-i} + \sum_{i=1}^{p} \delta_{3i}\mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \delta_{4i}\mathrm{INF}_{t-1} + \varepsilon_t \tag{1.4}$$

where:
OP_t – variable stands for the Brent oil price in USD per barrel;
GDP_t – variable stands for the Gross Domestic Product measured in USD;
INF_t – variable measured as the Consumer Price Index reflection to the annual % change in the cost of goods and services basket;
EXR_t – official exchange rate, Kazakhstan tenge relative of the United States dollar;
p – optimum number of lags;
$\alpha_0, \beta_0, \gamma_0, \delta_0$ – intercepts;
$\alpha_i, \beta_i, \gamma_i, \delta_i$ – coefficients.

There are two criteria that need to be satisfied to proceed with the VAR model: an optimum number of lags needs to be selected, and variables need to be stationary.

The optimum lag length

To decide on the optimum number of lags, there are four types of information criteria that can be used: Akaike, Hannan-Quinn, Schwarz, and Final Prediction Error information criteria. These information criteria need to minimise the value of information criteria; in other words, a lag length with the minimum value of information criteria needs to be chosen. Once the optimum lag length is chosen, we can move to the unit root test and check whether the variables are stationary or not.

ADF test

Proceeding with the model following a non-stationary path can lead to non-valid results, which will not make any economic sense. Therefore, to ensure that our variables exhibit stationarity, we need to run the ADF unit root test (Dickey and Fuller 1981, ADF).

The ADF test has the following form:

$$\Delta_{yt} = \alpha_0 + \alpha_1 \mathrm{trend} + \delta_1 y_{t-1} + \alpha_i \sum_{n}{}^{m} \Delta_{y\ t-1} + \varepsilon_t \tag{2.0}$$

The hypothesis can be presented in the following way:
$H_0 : \delta = 0$; the variable is non-stationary;
$H_1 : \delta \neq 0$; the variable is stationary.

There are three equations in the ADF model, which represent different types of random walk: without drift and trend, with drift, and with drift and trend.

Without drift and trend:

$$\Delta_{\gamma_t} = \lambda \gamma_{t-1} + \beta_i \sum_{i=1}^{m} \Delta_{\gamma_{t-1}} + \varepsilon_t \tag{2.1}$$

With drift:

$$\Delta_{\gamma_t} = \alpha_1 + \lambda\gamma_{t-1} + \beta_i \sum_{i=1}^{m} \Delta_{\gamma_{t-1}} + \varepsilon_t \tag{2.2}$$

With drift and trend:

$$\Delta_{\gamma_t} = \alpha_1 + \alpha_2 t + \lambda\gamma_{t-1} + \beta_i \sum_{i=1}^{m} \Delta_{\gamma_{t-1}} + \varepsilon_t \tag{2.3}$$

where:
α_1 – drift trend;
α_2 – parameter of a time trend.

If the ADF test shows that the variables are stationary in levels, the unrestricted VAR (in levels) will be conducted. However, if there is a result of non-stationarity in levels, we will need to apply the first differences to make the variables stationary. Hence, the following VAR model in first differences of order *p* will be applied:

$$\Delta_{\gamma_t} = \sum_{i=1}^{p} \delta_i \, \Delta_{\gamma_{t-1}} + \varepsilon_t \tag{3.0}$$

where:
γ – (4×1) matrix vector of variables;
δ_i – the i-th (4×4) autoregressive coefficients;
p – lag number;
$\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t})$ – (4×1) generalisation of white noise;
Δ – difference operator.

In a more functional way, it will be constructed as follows:

$$\Delta \mathrm{OP}_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \, \Delta \, \mathrm{OP}_{t-i} + \sum_{i=1}^{p} \alpha_{1i} \, \Delta \, \mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \alpha_{1i} \, \Delta \, \mathrm{INF}_{t-i} + \sum_{i=1}^{p} \alpha_{1i} \, \Delta \, \mathrm{EXR}_{t-1} + \varepsilon_t \tag{3.1}$$

$$\Delta \mathrm{GDP}_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \, \Delta \, \mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \beta_{2i} \, \Delta \, \mathrm{OP}_{t-i} + \sum_{i=1}^{p} \beta_{3i} \, \Delta \, \mathrm{INF}_{t-i} + \sum_{i=1}^{p} \beta_{4i} \, \Delta \, \mathrm{EXR}_{t-1} + \varepsilon_t \tag{3.2}$$

$$\Delta \mathrm{INF}_t = \gamma_0 + \sum_{i=1}^{p} \gamma_{1i} \, \Delta \, \mathrm{INF}_{t-i} + \sum_{i=1}^{p} \gamma_{2i} \, \Delta \, \mathrm{OP}_{t-i} + \sum_{i=1}^{p} \gamma_{3i} \, \Delta \, \mathrm{GDP}_{t-i} + \sum_{i=1}^{p} \gamma_{4i} \, \Delta \, \mathrm{EXR}_{t-1} + \varepsilon_t \tag{3.3}$$

$$\Delta \text{EXR}_t = \delta_0 + \sum_{i=1}^{p} \delta_{1i}\, \Delta\, \text{EXR}_{t-i} + \sum_{i=1}^{p} \delta_{2i}\, \Delta\, \text{OP}_{t-i} + \sum_{i=1}^{p} \delta_{3i}\, \Delta\, \text{GDP}_{t-i} + \sum_{i=1}^{p} \delta_{4i}\, \Delta\, \text{INF}_{t-1} + \varepsilon_t \quad (3.4)$$

where:
Δ – difference operator.

If the variables become stationary in first differences and the variables are not cointegrated, the unrestricted VAR model will be applied. However, if the incidence of cointegration is proven, then the Vector Error Correction Model (VECM) needs to be applied. Once we have chosen the number of lags and checked the variables for stationarity, we move to the estimation of the VAR(*p*) model and verify whether this model is applicable to our data.

Diagnostic tests

The next stage is to proceed with the following diagnostic tests: autocorrelation, normal distribution, and stability.

To examine the residuals for autocorrelation, the BG-LM test and Portmanteau test will be used. The null hypothesis rejects the existence of autocorrelation within the residuals, while the alternative hypothesis supports its presence.

H_0: No autocorrelation;
H_1: Autocorrelation is present.

For a normality check, the Jarque-Bera (JB) test will be used. The null hypothesis assumes a normal distribution of residuals, while the alternative posits that they are abnormally distributed.

H_0: There is a normal distribution;
H_1: There is an abnormal distribution.

For the stability check, the cumulative sum of error terms (OLS-CUSUM charts) will be used; therefore, we can assess from the obtained graphs whether our variables are stable or not.

Ordering

To analyse the relationship between the variables used in the VAR model from an economic perspective, we need to decide on the ordering of the variables. Then, the procedures of Granger causality, IRF, and VD will be conducted.

Based on the papers mentioned in the literature review – such as Wu and Ni (2011), Gounder and Barleet (2007), Jimenez-Rodriguez and Sanchez (2004), Gronwald, Mayr and Orazbayev (2009), Nurmakhanova and Kretzschmar (2010), Chen (2015), Lu, Lii and Tseng (2010), and Zalduendo (2006) – the following orderings of the variables can be constructed for representative analysis:

OP→GDP→EXR→INF
OP→GDP→INF→EXR
OP→EXR→INF→GDP

Granger Cause test

Once the order has been chosen, we can move to Granger causality analysis. This method is useful for establishing the relationship between the variables within the model. The null hypothesis assumes that there is no Granger causality, while the alternative hypothesis supports the existence of Granger causality between the variables.

H_0: Variable 'x' does not cause variable 'y';
H_1: Variable 'x' does cause variable 'y'.

This method can show to what extent the lag in one variable can predict the behaviour of another variable.

Impulse response functions and variance decomposition

The next step is to examine the impulse response functions. Since interpreting coefficients in the VAR model is difficult, IRF analysis will be used. This procedure helps identify the relationship between the variables in a simpler way and shows how long it takes for the effect to vanish. The final step is to study variance decomposition, which is mainly used as a technique to understand the contribution of each variable to the variation in the system, as well as the influence of each lag on the variation of each variable.

Econometric analysis

ADF test

According to the methodology, the first phase is the unit root test procedure to ensure the stationarity of the data and to exclude the possibility of spurious results. If the p-value is higher than the 10% level, we can conclude that the variable is non-stationary. However, if the p-values are lower than the 1%, 5%, or 10% levels, a conclusion of stationarity can be made based on the level of significance.

Table 1.
ADF test

Variables	None	With intercept	With intercept and trend
OP	0.7887	0.2034	0.4132
GDP	0.9987	0.1024	0.8868
INF	1.0000	0.7820	0.8550
EXR	0.9808	0.9784	0.7653
ΔOP	0.0000***	0.0000***	0.0000***
ΔGDP	0.0000***	0.0000***	0.0000***
ΔINF	0.1470	0.0000***	0.0000***
ΔEXR	0.0000***	0.0000***	0.0000***

Source: Author's own calculations.

From Table 1, it is clearly seen that the probabilities for the estimated variables in levels are higher than the 10% significance level. The results indicate the presence of a unit root within the estimated variables, and therefore, the variables follow a non--stationary path. According to the obtained p-values, it can be concluded that the alternative hypothesis cannot be rejected. If the problem of non-stationarity is not addressed, it can lead to insignificant outcomes. One way to solve the issue of non--stationarity is by transforming the variables to first differences. Hence, first differences were applied to the variables. The results show significance at the 1% level for almost all the examined variables. Therefore, we can conclude that there is no unit root within the differenced variables. Thus, the results indicate that all the variables are integrated of order one. Overall, we can conclude that the variables are non-stationary in levels;

however, after applying first differences, they become stationary. We can now proceed with the variables in first differences for further analysis.

Optimum lag length

Following the methodology discussed in the previous chapter, the next step is to determine the lag length based on the aforementioned information criteria such as AIC, FPE, HQC, and SC. Additionally, the software suggested the LR information criterion. If the mentioned criteria indicate the same number of lags, the selection is clear. However, in the case of conflicting results, Ivanov and Kilian (2005) state that the AIC criterion showed the best performance in a relatively small sample size for quarterly reported data. According to Table 2, almost all the information criteria suggested a lag number of 2, except SC. Therefore, the optimum number of lags is 2.

Table 2.
Information criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	319.5232	NA	9.03e-09	-7.170982	-7.058376	-7.125616
1	844.6110	990.5065	8.53e-14	-18.74116	-18.17813*	-18.51433
2	875.1342	54.80312*	6.15e-14*	-19.07123*	-18.05778	-18.66294*
3	887.8742	21.71586	6.66e-14	-18.99714	-17.53326	-18.40738
4	897.7958	16.00978	7.73e-14	-18.85899	-16.94469	-18.08777

Source: Author's own calculations.

Estimation of VAR (2)

The VAR(2) model is to be established and analysed; the outcome of the model is presented below in Table 3. The value of the log likelihood is 196.3548, which is relatively high, and the AIC value is comparatively small, which indicates the superior explanatory power of the estimated model. Moreover, the R^2 is equal to 0.993307, which is good, as it indicates that 99.3307% of the variation can be explained by the estimated model.

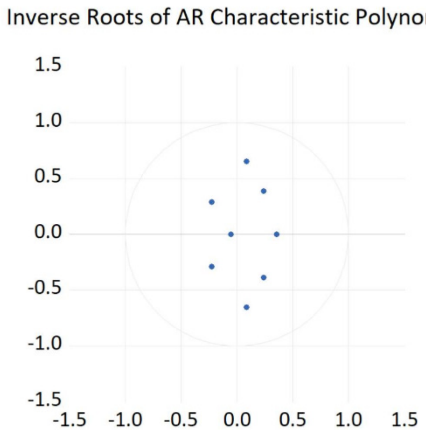
Table 3.
VAR (2)

	LGDP	LOP	LINF	LEXR
LGDP(-1)	0.491828	-0.018907	0.022743	0.016745
	(0.11520)	(0.26730)	(0.02741)	(0.07867)
	[4.26952]	[-0.07073]	[0.82979]	[0.21285]
LGDP(-2)	0.353316	-0.041746	0.043684	-0.036613
	(0.11505)	(0.26696)	(0.02737)	(0.07857)
	[3.07101]	[-0.15638]	[1.59583]	[-0.46599]
LOP(-1)	0.287366	1.043021	0.016916	-0.066510
	(0.05194)	(0.12052)	(0.01236)	(0.03547)
	[5.53248]	[8.65401]	[1.36878]	[-1.87496]
LOP(-2)	-0.230755	-0.318846	-0.012220	0.020902
	(0.05352)	(0.12419)	(0.01273)	(0.03655)
	[-4.31159]	[-2.56748]	[-0.95961]	[0.57186]
LINF(-1)	0.772202	1.508621	1.142121	-0.137127
	(0.45172)	(1.04817)	(0.10748)	(0.30850)
	[1.70946]	[1.43929]	[10.6264]	[-0.44450]
LINF(-2)	-0.560908	-1.055053	-0.294376	0.271994
	(0.42658)	(0.98984)	(0.10150)	(0.29133)
	[-1.31489]	[-1.06589]	[-2.90031]	[0.93363]
LEXR(-1)	-0.892715	-0.584222	0.110652	1.283468
	(0.18869)	(0.43784)	(0.04490)	(0.12887)
	[-4.73104]	[-1.33433]	[2.46461]	[9.95972]
LEXR(-2)	0.781995	0.216000	-0.018702	-0.396503
	(0.18714)	(0.43423)	(0.04453)	(0.12780)
	[4.17871]	[0.49743]	[-0.42001]	[-3.10244]
C	0.312830	0.439201	-0.117196	0.089301
	(0.17457)	(0.40508)	(0.04154)	(0.11922)
	[1.79196]	[1.08423]	[-2.82147]	[0.74902]
R-squared	0.993307	0.906371	0.999266	0.991546
Adj. R-squared	0.992646	0.897124	0.999194	0.990711
Sum sq. resids	0.067104	0.361302	0.003799	0.031298
S.E. equation	0.028783	0.066787	0.006848	0.019657
F-statistic	1502.569	98.01442	13784.55	1187.576
Log likelihood	196.3548	120.5988	325.5737	230.6764
Akaike AIC	-4.163441	-2.479974	-7.034971	-4.926142

Source: Author's own calculations.

Additionally, the AR roots graph was created. According to Lütkepohl (1991), the estimated VAR model is stable if all the roots have an absolute value less than one (>|1|) and lie within a unit circle. As can be seen from Figure 1, the estimated roots lie inside the unit circle and are significantly below the value of one; hence, the VAR(2) model is stable.

Figure 1.
AR roots graph



Source: Author's own calculations.

Cointegration test

The next step is to apply cointegration techniques to check whether the variables are cointegrated. If they are, we will follow the specific case of the VAR model to identify the long-term relationship. If not, the unrestricted VAR (VAR in first differences) model will be used. There are a number of techniques for cointegration testing; in this paper, the Johansen cointegration test is applied. The main purpose of this test is to analyse whether a long-run relationship between the presented variables exists. The test is considered superior for cointegration checks and is based on the maximum eigenvalue and trace statistic. The r indicates the number of cointegrated vectors under H_0. If the trace statistic or the maximum eigenvalue exceeds the 5% critical value, we can state the presence of cointegrating vectors in the given system. Table 4, presented below, shows the outcome of the test applied to our dataset in levels.

Table 4.
Johansen cointegration test

Number of cointegrated vectors	Trace Statistic	5% critical value	Maximum Eigenvalue Statistic	5% critical value
r = 0	46.06088	47.85613	25.41712	27.58434
r ≤ 1	20.64376	29.79707	11.39936	21.13162
r ≤ 2	9.244405	15.49471	6.460794	14.26460
r ≤ 3	2.783612	3.841465	2.783612	3.841465

Source: Author's own calculations.

In our case, the estimated values of the trace statistic and the maximum eigenvalue do not exceed the 5% critical value. Therefore, the null hypothesis H_0 cannot be rejected. Based on our results, we can conclude that in the case of Kazakhstan, oil price, GDP, inflation, and the exchange rate do not have a long-term relationship. Therefore, we will proceed with the unrestricted VAR model in first differences.

Construction of VAR (2) model in the first differences

Based on the procedure discussed above, the following analysis continues with the variables in first differences and a lag length of 2. Based on these criteria, the following system was constructed:

$$\Delta \mathrm{OP}_t = \beta_0 + \beta_1 \Delta \mathrm{OP}_{t-1} + \beta_2 \Delta \mathrm{OP}_{t-2} + \beta_3 \Delta \mathrm{GDP}_{t-1} + \beta_4 \Delta \mathrm{GDP}_{t-2} + \beta_5 \Delta \mathrm{INF}_{t-1} + \beta_6 \Delta \mathrm{INF}_{t-2} + \beta_7 \Delta \mathrm{EXR}_{t-1} + \beta_8 \Delta \mathrm{EXR}_{t-2} \quad (4.0)$$

$$\Delta \mathrm{GDP}_t = \theta_0 + \theta_1 \Delta \mathrm{GDP}_{t-1} + \theta_2 \Delta \mathrm{GDP}_{t-2} + \theta_3 \Delta \mathrm{OP}_{t-1} + \theta_4 \Delta \mathrm{OP}_{t-2} + \theta_5 \Delta \mathrm{INF}_{t-1} + \theta_6 \Delta \mathrm{INF}_{t-2} + \theta_7 \Delta \mathrm{EXR}_{t-1} + \theta_8 \Delta \mathrm{EXR}_{t-2} \quad (4.1)$$

$$\Delta \mathrm{INF}_t = \mu_0 + \mu_1 \Delta \mathrm{INF}_{t-1} + \mu_2 \Delta \mathrm{INF}_{t-2} + \mu_3 \Delta \mathrm{OP}_{t-1} + \mu_4 \Delta \mathrm{OP}_{t-2} + \mu_5 \Delta \mathrm{GDP}_{t-1} + \mu_6 \Delta \mathrm{GDP}_{t-2} + \mu_7 \Delta \mathrm{EXR}_{t-1} + \mu_8 \Delta \mathrm{EXR}_{t-2} \quad (4.2)$$

$$\Delta \mathrm{EXR}_t = \sigma_0 + \sigma_1 \Delta \mathrm{EXR}_{t-1} + \sigma_2 \Delta \mathrm{EXR}_{t-2} + \sigma_3 \Delta \mathrm{OP}_{t-1} + \sigma_4 \Delta \mathrm{OP}_{t-2} + \sigma_5 \Delta \mathrm{GDP}_{t-1} + \sigma_6 \Delta \mathrm{GDP}_{t-2} + \sigma_7 \Delta \mathrm{INF}_{t-1} + \sigma_8 \Delta \mathrm{INF}_{t-2} \quad (4.3)$$

After forming the variables, we can verify whether the VAR model is statistically significant and whether it is valid for our data. After estimating the equations, the following results were obtained, as presented in Table 5.

Table 5.
VAR (2) in first differences

	D(LGDP)	D(LOP)	D(LINF)	D(LEXR)
D(LGDP(-1))	-0.436283	-0.172457	-0.014977	-0.063218
	(0.13126)	(0.30179)	(0.02992)	(0.08758)
	[-3.32385]	[-0.57145]	[-0.50055]	[-0.72184]
D(LGDP(-2))	-0.119690	-0.264912	0.022166	-0.080124
	(0.11893)	(0.27345)	(0.02711)	(0.07935)
	[-1.00638]	[-0.96879]	[0.81759]	[-1.00970]
D(LOP(-1))	0.264436	0.196068	0.010277	-0.036981
	(0.05062)	(0.11637)	(0.01154)	(0.03377)
	[5.22446]	[1.68482]	[0.89070]	[-1.09505]
D(LOP(-2))	0.041934	-0.126443	0.026162	-0.003620
	(0.05944)	(0.13667)	(0.01355)	(0.03966)
	[0.70544]	[-0.92516]	[1.93066]	[-0.09127]
D(LINF(-1))	0.652137	0.475988	0.333364	-0.251313
	(0.46249)	(1.06335)	(0.10543)	(0.30858)
	[1.41006]	[0.44763]	[3.16199]	[-0.81441]
D(LINF(-2))	0.338326	1.508160	-0.220601	0.044627
	(0.47217)	(1.08561)	(0.10764)	(0.31504)
	[0.71653]	[1.38923]	[-2.04952]	[0.14165]
D(LEXR(-1))	-0.985598	-0.307669	0.069272	0.409538
	(0.19281)	(0.44330)	(0.04395)	(0.12865)
	[-5.11180]	[-0.69404]	[1.57608]	[3.18347]
D(LEXR(-2))	-0.044388	-0.407224	-0.001835	-0.271940
	(0.21476)	(0.49377)	(0.04896)	(0.14329)
	[-0.20669]	[-0.82472]	[-0.03749]	[-1.89781]
C	0.014131	-0.003440	0.007381	0.008819
	(0.00656)	(0.01508)	(0.00149)	(0.00438)
	[2.15483]	[-0.22815]	[4.93789]	[2.01557]

Source: Author's own calculations.

Based on the probability values and t-statistics, it has been observed that several of the estimated variables are statistically insignificant.

Considering statistical significance, in equation 5.0 there is a negative relationship with GDP in the previous period, and a positive relationship with oil prices in the previous period and the exchange rate in the previous period. In equation 5.1, where the dependent variable is oil prices, it has been observed that all the coefficients are statistically insignificant. Based on equation 5.2, it has been concluded that the coefficients for inflation with lag lengths of one and two are statistically significant, with a positive and negative relationship, respectively. Moreover, the oil price variable at lag 2 is statistically significant and has a positive relationship, while the coefficients of the remaining variables remain statistically insignificant. In equation 5.3, where the dependent variable is the exchange rate, the coefficient of the inflation variable at lag one is statistically significant and has a positive relationship, while inflation at lag two is statistically significant and has a negative relationship.

$$\Delta \mathrm{GDP}_t = \theta_0^{***} + \theta_1^{***}\,\Delta\,\mathrm{GDP}_{t-1} + \theta_2\,\Delta\,\mathrm{GDP}_{t-2} + \theta_3^{***}\,\Delta\,\mathrm{OP}_{t-1} + \theta_4\,\Delta\,\mathrm{OP}_{t-2} + \theta_5\,\Delta\,\mathrm{INF}_{t-1} + \theta_6\,\Delta\,\mathrm{INF}_{t-2} + \theta_7^{***}\,\Delta\,\mathrm{EXR}_{t-1} + \theta_8\,\Delta\,\mathrm{EXR}_{t-2} \quad (5.0)$$

$$\Delta \mathrm{OP}_t = \beta_0 + \beta_1\,\Delta\,\mathrm{OP}_{t-1} + \beta_2\,\Delta\,\mathrm{OP}_{t-2} + \beta_3\,\Delta\,\mathrm{GDP}_{t-1} + \beta_4\,\Delta\,\mathrm{GDP}_{t-2} + \beta_5\,\Delta\,\mathrm{INF}_{t-1} + \beta_6\,\Delta\,\mathrm{INF}_{t-2} + \beta_7\,\Delta\,\mathrm{EXR}_{t-1} + \beta_8\,\Delta\,\mathrm{EXR}_{t-2} \quad (5.1)$$

$$\Delta \mathrm{INF}_t = \mu_0{}^{***} + \mu_1{}^{***}\,\Delta\,\mathrm{INF}_{t-1} + \mu_2{}^{***}\,\Delta\,\mathrm{INF}_{t-2} + \mu_3\,\Delta\,\mathrm{OP}_{t-1} + \mu_4{}^{***}\,\Delta\,\mathrm{OP}_{t-2} + \mu_5\,\Delta\,\mathrm{GDP}_{t-1} + \mu_6\,\Delta\,\mathrm{GDP}_{t-2} + \mu_7\,\Delta\,\mathrm{EXR}_{t-1} + \mu_8\,\Delta\,\mathrm{EXR}_{t-2} \quad (5.2)$$

$$\Delta \mathrm{EXR}_t = \sigma_0^{***} + \sigma_1^{***}\,\Delta\,\mathrm{EXR}_{t-1} + \sigma_2^{***}\,\Delta\,\mathrm{EXR}_{t-2} + \sigma_3\,\Delta\,\mathrm{OP}_{t-1} + \sigma_4\,\Delta\,\mathrm{OP}_{t-2} + \sigma_5\,\Delta\,\mathrm{GDP}_{t-1} + \sigma_6\,\Delta\,\mathrm{GDP}_{t-2} + \sigma_7\,\Delta\,\mathrm{INF}_{t-1} + \sigma_8\,\Delta\,\mathrm{INF}_{t-2} \quad (5.3)$$

*** – indicates statistical significance at the 5% level.

To confirm statistical significance/insignificance, we examine the Wald Test, which provides the p-values for the joint significance of the aforementioned equations. The null hypothesis of the Wald Test is that the coefficients of the variables are statistically insignificant, while the alternative states that they are statistically significant.

H_0: The coefficients simultaneously equal to zero;
H_1: The coefficients are not simultaneously equal to zero.

Table 6.
Wald coefficient test

Dependent variable	Chi-square	Probability	Result
ΔLGDP	62.41025	0.0000	Statistically significant
ΔLOP	8.913875	0.3496	Statistically insignificant
ΔLINF	21.46293	0.0060	Statistically significant
ΔLEXR	28.41511	0.0004	Statistically significant

Source: Author's own calculations.

Based on the outcome presented in Table 6, it can be concluded that there is joint statistical significance in the equations for GDP, oil prices, and the exchange rate. Therefore, the estimated coefficients for these variables are not simultaneously equal to zero. However, there is an opposite result for oil prices.

After obtaining the results regarding the significance of the coefficients, we proceed with the following diagnostic test to identify the reason for the statistical insignificance of the coefficients in some equations. To support our conjecture, we analyse the result of the Jarque-Bera test, which is used to check for normality. Most likely, this is the reason for the joint statistical insignificance. The null hypothesis assumes a normal distribution of residuals, while the alternative states the opposite. A probability higher than 10% at the critical level signals normal distribution in the residuals for the given variable. However, if the probability is lower than 1%, 5% or 10% at the significance level, the residuals are abnormally distributed.

Table 7.
JB test

Variable	**Jarque-Bera**	**Probability**
ΔLGDP	0.761089	0.6835
ΔLOP	58.83551	0.0000
ΔLINF	269.6157	0.0000
ΔLEXR	47.03128	0.0000

Source: Author's own calculations.

According to Table 7, the estimated probability for GDP is 0.6825, which is higher than the 5% level; therefore, the error terms for GDP are normally distributed. This is an expected result since the coefficients in most cases are statistically significant. The probabilities for oil prices, inflation, and the exchange rate are equal to zero; hence, we can conclude that the residuals for these three components are not normally distributed. This may be explained by the fact that, in the case of oil prices, all the coefficients are statistically insignificant, while the abnormal distribution in inflation and the exchange rate can be attributed to the variation in the dependent variables being explained mostly by their own lags, which can cause such an issue.

The next step is to examine whether the residuals suffer from autocorrelation. Hence, the BG-LM test and Portmanteau test are going to be used. The null hypothesis rejects the existence of autocorrelation within the residuals, while the alternative hypothesis indicates its presence.

H_0: No autocorrelation.
H_1: Autocorrelation is present.

Table 8.
Breusch-Godfrey Lagrange Multiplier test and Portmanteau test

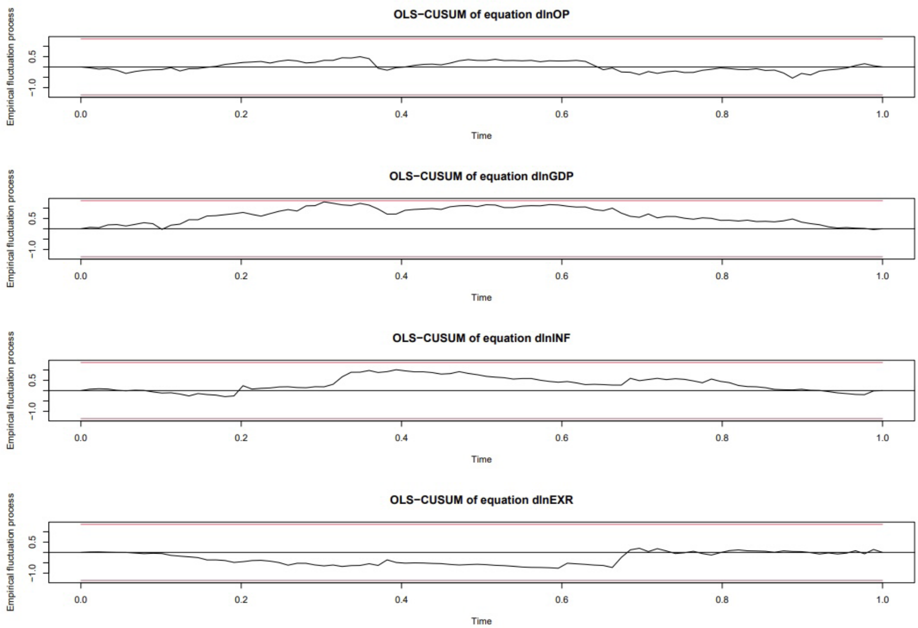
Lag	Portmanteau test	Result	BG-LM test	Result
1	-	-	0.8762	No autocorrelation
2	-	-	0.1909	No autocorrelation
3	0.3494	No autocorrelation	0.4088	No autocorrelation
4	0.2085	No autocorrelation	0.1731	No autocorrelation

Source: Author's own calculations.

Based on the results of the BG-LM test and Portmanteau test presented in Table 8, it can be concluded that there is no autocorrelation, since all the estimated p-values are higher than the 10% significance level.

For the stability check, the cumulative sum of error terms (OLS-CUSUM charts) is going to be used; therefore, we can determine from the resulting graphs whether our variables are stable or not.

Figure 2.
Charts of OLS-CUSUM



Source: Author's own calculations.

After analysing Figure 2, it can be concluded that the variables are stable, since they lie within the red boundaries.

Granger Causality test

The next step of the analysis is to conduct the Granger Causality test, which will confirm or reject the causality existing between the variables. A probability higher than the 10% level will indicate the absence of Granger causality; however, if the estimated probability is lower than the 1%, 5%, or 10% significance level, it will indicate the presence of Granger causality at the corresponding significance level.

Table 9.
Granger Causality

Null hypothesis	Probability	Result
OP does not Granger Cause GDP	6.E-07	The lag in OP significantly improves the prediction of GDP
GDP does not Granger Cause OP	0.3269	The lag in GDP does not significantly improve the prediction of OP
OP does not Granger Cause INF	0.7613	The lag in OP does not significantly improve the prediction of INF
INF does not Granger Cause OP	0.4524	The lag in INF does not significantly improve the prediction of OP
OP does not Granger Cause EXR	0.0916	The lag in OP significantly improves the prediction of EXR
EXR does not Granger Cause OP	0.9362	The lag in EXR does not significantly improve the prediction of OP
GDP does not Granger Cause INF	0.5065	The lag in GDP does not significantly improve the prediction of INF
INF does not Granger Cause GDP	0.5617	The lag in INF does not significantly improve the prediction of GDP
GDP does not Granger Cause EXR	0.0004	The lag in GDP significantly improves the prediction of EXR
EXR does not Granger Cause GDP	0.1492	The lag in EXR does not significantly improve the prediction of GDP
INF does not Granger Cause EXR	0.0643	The lag in INF significantly improves the prediction of EXR
EXR does not Granger Cause INF	0.3161	The lag in EXR does not significantly improve the prediction of INF

Source: Author's own calculations.

According to the results presented in Table 9, it can be observed that most of the variables are not subject to Granger causality, since the p-values are significantly higher than the 10% level. Therefore, the null hypothesis of no Granger causality cannot be rejected. However, there is a significant result for the causality running from GDP to EXR and from INF to EXR, which is statistically significant at the 1% and 10% levels, respectively. Hence, the alternative hypothesis of Granger causality is accepted at the 1% and 10% significance levels, respectively. Interestingly, the result of the existence of Granger causality running from OP to GDP and EXR is statistically significant at the 1% and 10% levels, respectively. Therefore, the alternative hypothesis of Granger causality is accepted at the 1% significance level for GDP and at the 10% level for the exchange rate. Based on the aforementioned results, we can state that oil prices Granger cause the exchange rate and GDP in the case of Kazakhstan.

Impulse Response Functions

Before constructing the IRFs, the appropriate ordering needs to be established. Therefore, based on the methodology and literature review, the orderings are as follows:

OP→GDP→EXR→INF

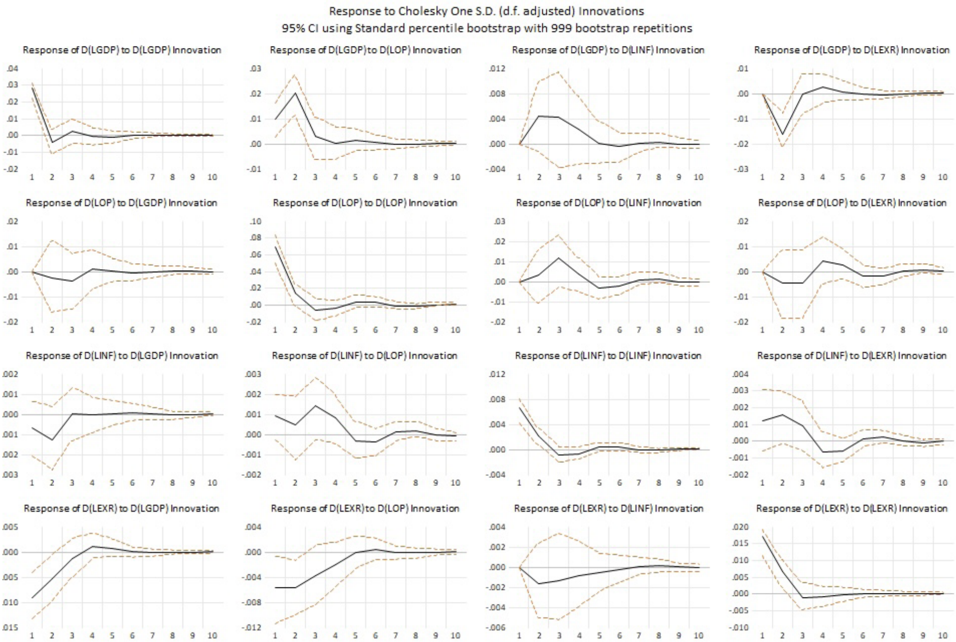
OP→GDP→INF→EXR

OP→EXR→INF→GDP

The first ordering is written as follows: OP→GDP→EXR→INF (Figure 3). The shock that occurs to OP leads to fluctuations in GDP, and then fluctuations in GDP affect EXR, and therefore, EXR impacts INF. Thus, OP has a direct effect on GDP and an indirect effect on the exchange rate and inflation.

According to Figure 3, the positive shock that occurred in the prior period of GDP has a positive effect on GDP in the first period, with the effect converging to equilibrium by the sixth period. The positive shock that occurred in the previous period of GDP has a negative effect on both OP and INF; however, in the case of OP, there is a converging effect returning to equilibrium by the fifth quarter, while for INF, there is a significant effect for the first three quarters, which then converges to equilibrium. The shock in the prior period of GDP negatively affects EXR in the first quarter. In the fourth quarter, EXR rises above equilibrium; however, it converges back by the sixth quarter. The shock that occurred in the prior period of OP has a positive effect on GDP in the first quarter; moreover, the effect is even more significant in the second quarter, and then it converges back to equilibrium. The same shock has a positive effect on both OP itself and INF, with a clear cyclical pattern. The response of OP converges to equilibrium by the seventh period, while for INF, it takes two additional quarters. The shock to OP also has a negative effect on EXR in the first quarter; however, the increasing trend converges back to equilibrium by the seventh quarter. The shock that occurred in the prior period of INF has a positive effect on GDP, OP, and INF itself in the first quarter; moreover, there is a clear cyclical pattern converging back to equilibrium by the ninth quarter for all mentioned variables. However, in the case of EXR, there is a negative effect that persists until the seventh quarter, although it converges to equilibrium by the eighth or ninth period. The shock that occurred in the previous period of EXR has a negative effect on GDP and OP, and a positive effect on INF. All three responses exhibit a strongly marked cyclical pattern converging to equilibrium by the sixth quarter for GDP and the eighth quarter for OP and INF. The same conclusion applies to EXR; however, there is no cyclical pattern, and it converges back by the fifth quarter.

Figure 3.
IRFs for ordering OP→GDP→EXR→INF



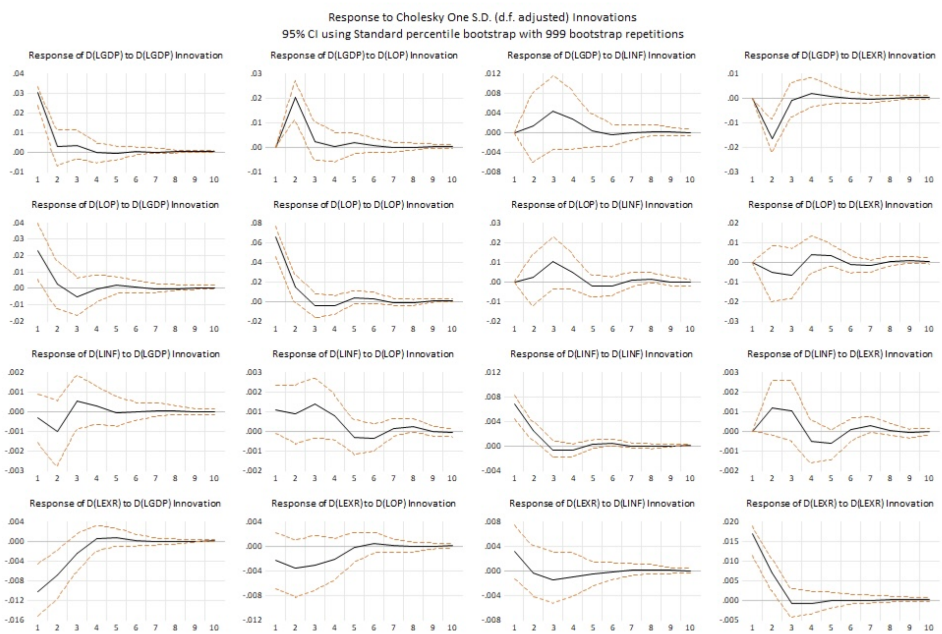
Source: Author's own calculations.

The second ordering is written as follows: OP→GDP→INF→EXR (Figure 4). The shock that happens to OP leads to variation in GDP, which then affects INF; therefore, INF impacts EXR. Hence, GDP is directly affected, while inflation and the exchange rate are indirectly affected by OP.

According to Figure 4, the positive shock that occurred in the prior period of GDP has a substantially positive effect on GDP and OP in the first period, with the effect converging to equilibrium. The same shock has a negative effect on both EXR and INF; in the case of EXR, the effect converges back to equilibrium by the sixth quarter. In the case of INF, there is a significant effect for the first four quarters, and then it converges. Both EXR and INF show a cyclical pattern. The shock that occurred in the previous period of OP has a positive effect on GDP in the first quarter. Moreover, the effect is even more significant in the second quarter; however, it then converges to equilibrium. The shock to OP also has a positive effect on both OP itself and INF, with a clear cyclical pattern. OP converges to equilibrium in the sixth period, while INF takes one additional quarter. The same shock has a negative effect on EXR in the first quarter, but the increasing trend converges to equilibrium by the seventh quarter. The shock that occurred in the prior period of INF has a positive effect on GDP and

OP in the first quarter; moreover, there is a clear cyclical pattern converging back to equilibrium in the sixth quarter for GDP and the ninth quarter for OP. In the case of INF and EXR, there is a positive effect that converges by the seventh quarter. The shock that occurred in the prior period of EXR has a negative effect on GDP and OP, and a positive effect on INF. All three responses have a strongly indicated cyclical pattern, converging back to equilibrium in the fifth quarter for GDP and the eighth quarter for OP and INF.

Figure 4.
IRFs for ordering OP→GDP→INF→EXR

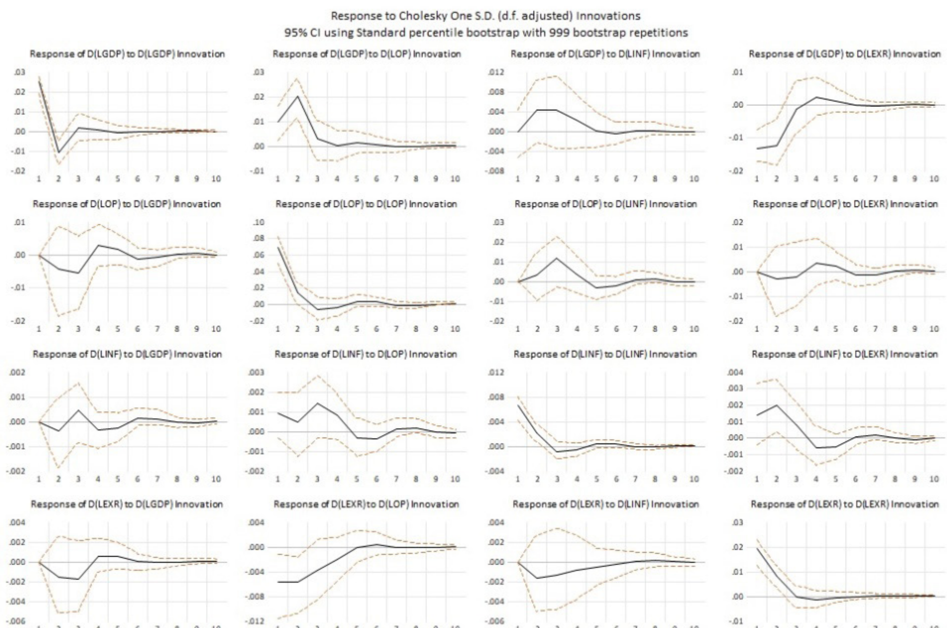


Source: Author's own calculations.

The third ordering is written as follows: OP→EXR→INF→GDP (Figure 5). The shock that happens to OP leads to a change in EXR, which then affects INF, and therefore INF impacts GDP. Thus, OP has a direct effect on EXR and an indirect effect on inflation and GDP.

According to Figure 5, the positive shock that occurred in the prior period of GDP has a positive effect on GDP in the first period, with the effect converging to equilibrium by the fifth quarter. The same shock has a negative effect on OP, EXR, and INF, with convergence back to equilibrium by the eighth quarter for OP and EXR, and the sixth quarter for INF. The shock to OP in the previous quarter has a positive effect on GDP in the first quarter; moreover, the effect is more significant in the second quarter, but then slowly converges to equilibrium. The same shock has a positive effect on OP, with a clear cyclical pattern converging to equilibrium in the seventh period. It also positively affects INF in the first quarter, with a more significant effect in the third quarter, followed by a converging pattern. In the case of EXR, there is a negative effect followed by an increasing trend returning to equilibrium by the seventh quarter. The shock that occurred in the previous period of INF has a positive effect on GDP and OP in the first quarter; moreover, the effect is more significant in the third quarter. A clear cyclical pattern follows, converging to equilibrium in the sixth quarter for GDP and the ninth quarter for OP. In the case of INF, the trend is downward sloping, with a diminishing effect. For EXR, there is a negative effect followed by an increasing trend converging to equilibrium in the seventh quarter. The shock to EXR in the previous period has a negative effect on GDP and OP and a positive effect on INF and EXR. All three responses, except for EXR, have a strongly marked cyclical pattern converging to equilibrium in the sixth quarter for GDP and the eighth quarter for OP and INF. In the case of EXR, there is a positive effect in the first quarter followed by a decreasing trend converging to equilibrium in the seventh quarter.

Figure 5.
IRFs for ordering OP→EXR→INF→GDP



Source: Author's own calculations.

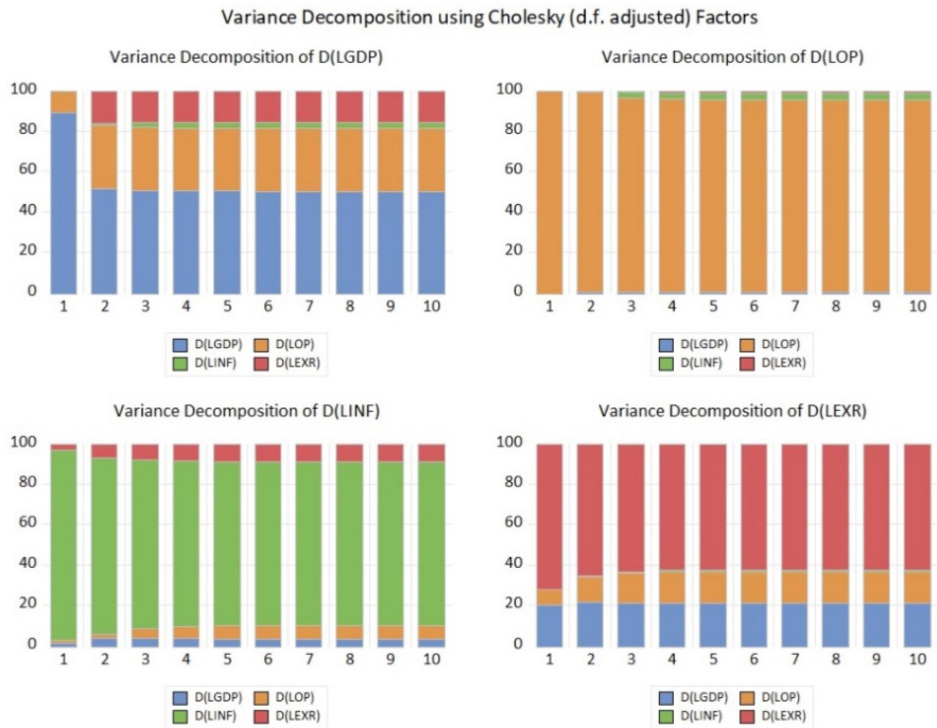
Variance Decomposition

In the next part of the analysis, the Variance Decomposition results are going to be presented and discussed.

- First ordering: OP→GDP→EXR→INF (Figure 6)

As can be observed in Figure 6 below, when a shock occurs to GDP, the changes in GDP for the first period are mostly caused by GDP itself; however, from the second quarter, this drops and stagnates at the level of 50%. The input of oil prices in the first quarter constitutes about 15% of the variation in GDP; however, from the second quarter, it reaches the level of 30–35% and stagnates. The fluctuations in GDP can also be clarified by the variation in the exchange rate; however, the effect is significant only from the second quarter, with a dying-out effect. The contribution of inflation is also significant from the second quarter; however, the proportion slightly increases over time. When a shock occurs to oil prices, the variation in oil prices can mostly be described by oil prices themselves. The contribution of the other variables is almost negligible, except for the contribution of inflation, which gains influence from the third period with a slightly increasing effect to the 5% level. In terms of inflation, it can be observed that the changes in inflation can be explained by inflation itself for the first quarter; however, the influence of oil prices and the exchange rate starts increasing slightly and ends up at approximately 11–12% for the exchange rate and 6–7% for oil. The peak of the impact of GDP on changes in inflation occurs in the second–third period; however, after this increase, a dying-out effect can be noted over time. When a shock occurs to the exchange rate, approximately 70% of the changes in the exchange rate can be described mostly by the exchange rate itself, with a slightly dying-out effect over time. The role of oil prices in the variation of the exchange rate in the first period is 6–7%, with an increasing proportion to almost 16–17% at the end of the period. The role of GDP is substantial over the period; however, until the end of the period, it remains unchanged, indicating that 20% of the variation in the exchange rate can be explained by shifts in GDP.

Figure 6.
VD for ordering OP→GDP→EXR→INF



Source: Author's own calculations.

- Second ordering: OP→GDP→INF→EXR (Figure 7)

According to Figure 7 below, when a shock occurs to GDP, almost 80% of the changes in GDP for the first period are mostly caused by GDP itself; however, from the second quarter, the proportion drops and remains unchanged at the level of 50% until the end of the period. The input of oil prices in the first quarter constitutes about 10% of the variation in GDP; however, from the second quarter until the end of the estimated period, almost 31–32% of the changes in GDP can be accounted for by oil prices. The change in GDP can also be explained by the variation in inflation; however, the effect is significant only from the third quarter, with a gradually increasing trend, while the contribution of the exchange rate appears in the second quarter and accounts for 17–18% of the variation, with a gradually decreasing effect. Due to changes in oil prices in the previous period, the variation can mostly be attributed to the oil price itself. The contribution of the other variables is almost unsubstantial, except for the contribution of inflation, which gains influence from the third period, with a slightly increasing effect to the 3–4% level. In the case of inflation, it can be noted that changes in inflation can be explained by inflation itself in the first quarter, though the roles of the oil price and exchange rate start to increase slightly and end up at approximately 8–9% for the exchange rate and 5–6% for the oil price. The peak of the influence of GDP on changes in inflation occurs within the second–fourth period; however, after this increase, a dying-out effect can be noted over time. When there is a shock to the exchange rate in the previous period, approximately 65% of all changes in the exchange rate can be explained mostly by the exchange rate itself, with a faintly diminishing effect to 60%. The role of the oil price in the variation of the exchange rate in the first period is 7–8%, with an increasing proportion to almost 16–17% in the fourth quarter; however, with a stagnating trend. The role of GDP is substantial over the period; however, until the end of the period, it remains unchanged, indicating that 20% of the changes in the exchange rate can be explained by variations in GDP.

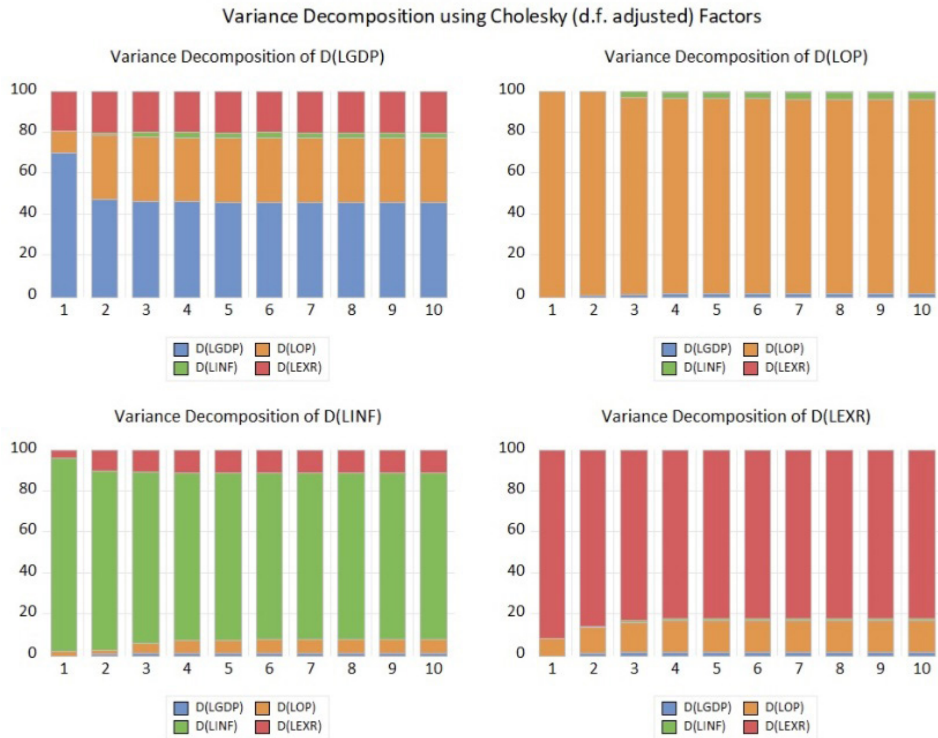
Figure 7.
VD for ordering OP→GDP→INF→EXR

Source: Author's own calculations.

- Third ordering: OP→EXR→INF→GDP (Figure 8)

According to Figure 8, when some shocks occur to GDP, approximately 70% of the changes in GDP for the first period are mostly caused by GDP itself; however, from the second quarter, this drops and remains unchanged at 45% until the end of the period. The difference in GDP can be described by the differences in oil prices, which, in numerical terms, explain 10% of the variation; however, from the second quarter until the end of the period, the proportion constitutes about 35%. The change in GDP can also be explained by the variation of inflation; however, the effect is significant only from the third quarter, with a steadily increasing trend, while 20% of the variation in GDP can be explained by variation in the exchange rate, which remains unchanged until the end of the period. Changes in oil prices in the prior period can be mostly described by changes in oil prices themselves in the present period. The contribution of the other variables is almost unsubstantial; however, from the third period, changes in oil prices can be explained by changes in inflation, though the effect is not noticeable. Changes in inflation can be explained by inflation itself in the first quarter; however, the contributions of oil prices and the exchange rate begin to dominate, while the effect of GDP is almost unnoticeable. In the case of the exchange rate, approximately 95% of its changes can be described by the exchange rate itself, with a declining effect to 80–82 percent. The role of oil prices in the fluctuations of the exchange rate in the first period is 7–8 percent, with an increasing proportion to almost 17–18 percent in the fourth quarter, albeit with a stagnating trend, while the effects of GDP and inflation are not significant.

Figure 8.
VD for ordering OP→EXR→INF→GDP



Source: Author's own calculations.

Conclusion

To conclude, this thesis analyses the interrelationship between the main economic indicators and oil prices in the case of Kazakhstan for the period 2000 Q1 – 2022 Q4. Firstly, the background of Kazakhstan's oil industry and all essential literature on the relationship between the variables have been analysed. Moreover, some of the papers with a focus on the case of Kazakhstan have been presented and discussed. Next, the methodology, which consists of the VAR framework, the criteria for applying this type of model, a brief discussion of diagnostic tests, Granger causality, IRFs, and Variance Decomposition, has been presented. In the econometric analysis, the appropriate lag length has been chosen and variables have been transformed to the first differences;

therefore, the unrestricted VAR model has been constructed and analysed. From the model, it has been concluded that most of the variables are statistically insignificant; however, the analysis has established a valid relationship between GDP, oil prices, and the exchange rate, which is positive between GDP and oil prices and negative between oil prices and the exchange rate. Moreover, a positively substantial relationship between oil prices and inflation has been found. During the Granger causality analysis, causality running from oil prices to GDP, the exchange rate, and inflation has been found. Using the variance decomposition analysis, it can be summarised that shocks to oil prices substantially contribute to fluctuations in GDP. Additionally, there is a contribution of oil prices to the exchange rate and inflation, though to a smaller extent. The analysis of impulse responses shows that there is a positive relationship between GDP, inflation, and oil prices. Furthermore, the analysis shows that there is a negative relationship between oil prices and the exchange rate. Moreover, according to the Johansen test, it is possible to conclude that there is a short-run effect rather than a long-run one, as the contribution of oil prices diminishes over a short-term period. Therefore, the hypotheses outlined above regarding the relationship between oil and the main economic indicators can be accepted.

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The Effect of Oil Production on Various Macroeconomic Factors: The Case Study of the Economy of Kazakhstan

Abstract

This thesis analyses the effect of oil prices on GDP, inflation, and the exchange rate in the case of the Republic of Kazakhstan, based on quarterly data from 2000 Q1 to 2022 Q4. To estimate to what extent oil prices affect the economic aggregators of Kazakhstan, the Vector Autoregression Model (VAR) is implemented. The findings disclose the presence of statistically significant Granger Cause running from oil prices to the exchange rate, inflation, and GDP. Based on the outcome of IRFs and VD, it has been found that there is a positive impact of oil prices on inflation and GDP; conversely, the effect between oil prices and the exchange rate has been found to be negative. Additionally, we can summarise that changes in oil prices greatly contribute to the fluctuations in GDP; however, the contribution of oil prices is fainter in terms of the exchange rate and inflation.

Keywords: Oil prices, inflation, Kazakhstan, exchange rate, VAR model, SVAR model, Granger causality, oil-exporting economies

Wpływ wydobycia ropy naftowej na różne czynniki makroekonomiczne: studium przypadku gospodarki Kazachstanu

Streszczenie

W niniejszym opracowaniu przeanalizowano wpływ cen ropy naftowej na PKB, inflację i kurs walutowy w przypadku Republiki Kazachstanu na podstawie danych kwartalnych od I kwartału 2000 r. do IV kwartału 2022 r. Aby oszacować, w jakim stopniu ceny ropy naftowej wpływają na agregaty ekonomiczne Kazachstanu, zastosowano model autoregresji wektorowej (VAR). Wyniki badań wskazują na istnienie statystycznie istotnego związku Grangera między cenami ropy naftowej a kursem walutowym, inflacją i PKB. Na podstawie wyników IRF i VD stwierdzono, że ceny ropy mają pozytywny wpływ na inflację i PKB; natomiast wpływ cen ropy na kurs walutowy jest negatywny. Ponadto zmiany cen ropy w znacznym stopniu przyczyniają się do wahań PKB, jednak ich wpływ na kurs walutowy i inflację jest mniejszy.

Słowa kluczowe: ceny ropy, inflacja, Kazachstan, kurs walutowy, model VAR, model SVAR; przyczynowość w sensie Grangera, wskaźniki makroekonomiczne, gospodarki eksportujące ropę