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Impact of Oil Price Shocks on Russian Macroeconomic Performance

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Abstract

This study examines the significant influence of oil price fluctuations on the economies of oil--exporting countries. While elevated oil prices can result in foreign currency inflows and advantages for oil-exporting countries, they can also trigger adverse effects, including a reduction in manufacturing sectors and a loss of price competitiveness due to currency appreciation. This research focuses on the period from 2004Q1 to 2021Q4, examining the influence of oil price fluctuations on key macroeconomic indicators in Russia, including industrial production, exchange rates, inflation and interest rates. The structural VAR model findings confirm that the monetary channel demonstrates a higher degree of responsiveness to oil price shocks compared to the fiscal channel. Specifically, the study observes that industrial production exhibits a pronounced procyclical response to oil price shocks through the fiscal channel. Conversely, the monetary channel reveals that increased oil price volatility exerts pressure on the Russian rouble, resulting in a counter-cyclical behaviour in inflation and interest rates.

Keywords: Oil price shocks, macroeconomic trends, Russian economy

JEL Classification: C32, C53, O11, Q32

1. Introduction

The significance of oil income in resource-rich countries has been the subject of extensive research in the existing literature. Fluctuations in global oil prices have direct implications for the economies of both oil-exporting and oil-importing countries. The year 2022 marked a period of substantial turbulence on the oil market, leading to wide-ranging repercussions on the global economy. Scholars have observed a strong correlation between oil price volatility and macroeconomic trends since the 1973 oil price shock (Hamilton, 1983). Various factors, including oil demand and

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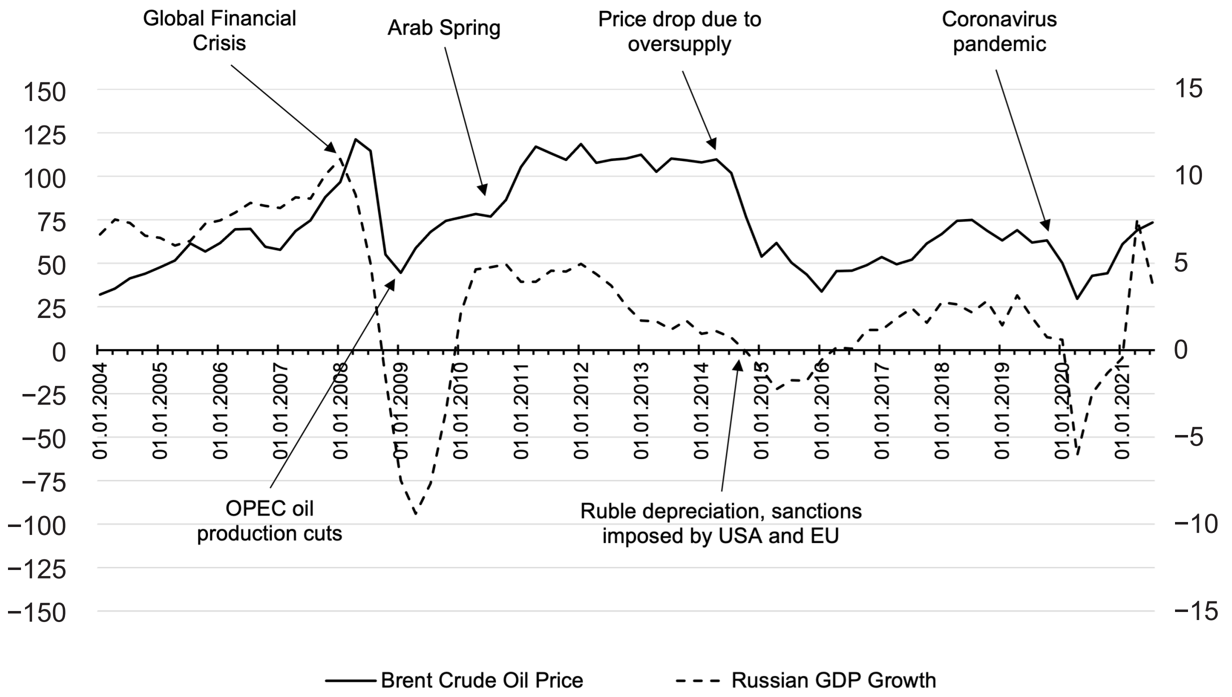
supply equilibrium (Hamilton, 2009; Kim, 2018; Baek and Yoon, 2022), precautionary demand (Anzuini *et al*., 2015), speculative activities (Kilian and Murphy, 2014), political uncertainties (Kang and Ratti, 2013; Ozdemir *et al*., 2013), investor sentiment (Qadan and Nama, 2018), market-specific factors and financial indicators (Chatziantoniou *et al*., 2021), contribute to oil price volatility. Furthermore, higher oil price volatility negatively affects stock market returns in developed economies (Diaz *et al*., 2016) and significantly influences the sovereign credit risk of BRICS countries (Bouri *et al*., 2018). However, the connection between oil price shocks and the performance of macroeconomic indicators in oil-producing countries still necessitates further analysis. This study aims to fill this gap by examining the linkages between oil price shocks and the macroeconomic performance of oil-producing countries.

This study examines the fluctuations in oil prices between 2004 and 2021 and their repercussions on Russian macroeconomic indicators. With a particular focus on the aftermath of key events such as the 2014 sanctions, the 2020–2021 pandemic and the Saudi Arabia oil price war, this study investigates how Russian macroeconomic indicators responded to oil price shocks. Russia, renowned as one of the energy superpowers, holds the position of the world's second-largest natural gas producer (after the United States) and the third-largest oil producer (after the USA and Saudi Arabia). Oil and gas revenues accounted for 28% of the total federal budget revenues in 2021, representing 60% of the country's exports (Russian Finance Ministry, 2022). Given the significant production volume and its substantial contribution to the federal budget, the Russian economy relies heavily on the export of natural resources, particularly hydrocarbons. This dependence exposes Russia to the vulnerabilities arising from oil price volatility on the global market.

This study examines relationships between oil prices and Russian macroeconomic indicators, employing the structural vector autoregressive (SVAR) model to analyse their interconnectedness, particularly the impacts on industrial production, exchange rates, inflation rates and interest rates. The industrial production index (IPI) serves as a key indicator, shedding light on the influence of oil price fluctuations on the output of Russian industries. Despite its status as one of the world's major petroleum producers, it is assumed that Russia lacks the ability to exert control over global oil prices. By investigating the responsiveness of Russian macroeconomic indicators to oil price fluctuations in recent years, the aim is to provide insights into the extent of their dependence on such dynamics. Moreover, addressing the significant economic downturns experienced by Russia after 2014 and 2020–2021 is crucial for understanding the level of responsiveness and reliance of the Russian economy on oil revenues.

The economic growth of Russia in the period from 2004 until 2021 could be described as highly volatile, yet with clearly defined periods of progress and recession. Figure 1 exhibits the growth of the Russian GDP from 2004 to 2021. It demonstrates the three economic recession periods in the given time interval. Following a continuous increase in GDP between 2004 and 2008, the first and most significant drop in the Russian economy was in 2008, which corresponded to the global financial crisis. The second economic decline was between 2014 and 2016, caused by a sharp depreciation of the Russian rouble. The rouble's depreciation was caused by a fall in investors' confidence. The oil market was experiencing a price shock and sanctions were imposed by the United States and the European Union as a response to the Russian invasion of Ukraine and annexation of Crimea. As investors were hurriedly selling off their Russian assets, the rouble's value was distressed, as was the budget income from oil exports. Finally, the third recession period was the COVID-19 pandemic of 2020, which affected all countries worldwide.

Figure 1: Progression of Russian GDP growth and Brent oil prices (2004–2021)



Note: The left axis represents Brent oil price; the right axis represents GDP growth.

Source: Data retrieved from FRED (EIA, 2022 and OECD, 2022)

The world has seen several oil price shocks that directly affected the Russian economy in the past few years. Figure 1 also represents the Brent crude oil price and marks the most significant events that caused the trend oscillations. It is noticeable that the Russian economic recession periods correlate with the oil price distress, and the oil price growth corresponds with increases in the Russian GDP. It concluded that the two given variables are interconnected, and the world oil price trends largely influence the Russian economy.

Oil pricing is thus a forceful lever that influences the economies of oil-rich countries, especially those that primarily rely on petroleum exports. This calls for an even more meticulous analysis in the case of Russia, taking into account its oil export dependence and the recent events, including the economic sanctions of 2014 and an oil trade war in 2020. Oil price fluctuations on the market have been primarily reflected in the output of the Russian economy. Periods of increasing oil prices were also when the Russian economy experienced growth and an influx of revenues. Correspondingly, oil price drops negatively affected the development of the Russian economy, reducing its oil export revenues, which represent an essential part of the budget revenues.

The rest of the paper is organized as follows: Section 2 provides an overview of the Russian economy, its position on the world oil market, a description of recent oil price shocks and Russian monetary policy in recent years. Section 3 explains the theoretical background, listing the impact channels of oil prices on macroeconomic trends. Section 4 describes the data, methodology and models used. Section 5 presents an empirical outcome using impulse response functions of different macroeconomic indicators to the oil price shocks. The results and policy implications are provided in Section 6. Supplementary material and additional results discussed throughout the paper are available in the Appendix.

2. Russian Macroeconomic Background

Following the dissolution of the Soviet Union in 1991, Russia embarked on a transformative journey from a centrally planned economy to a market-oriented one. Undertaking responsibility for the external debts of the Soviet Union presented a formidable challenge, considering the vast differences in population and territory between the Russian Federation and its predecessor, the USSR. The Russian economy experienced significant setbacks throughout the 1990s, leading to the default on the Central Bank of Russia (CBR)'s debt due to the economic crisis of 1998 and the subsequent depreciation of the rouble. Statistics from the International Monetary Fund reveal that the inflation rate reached its peak at 1 570% in 1992, followed by another surge to 874% in 1993. These alarming figures can be attributed to the implementation of "shock therapy", which involved the abrupt elimination of Soviet price controls by the Russian government, causing a sudden and drastic policy shift.

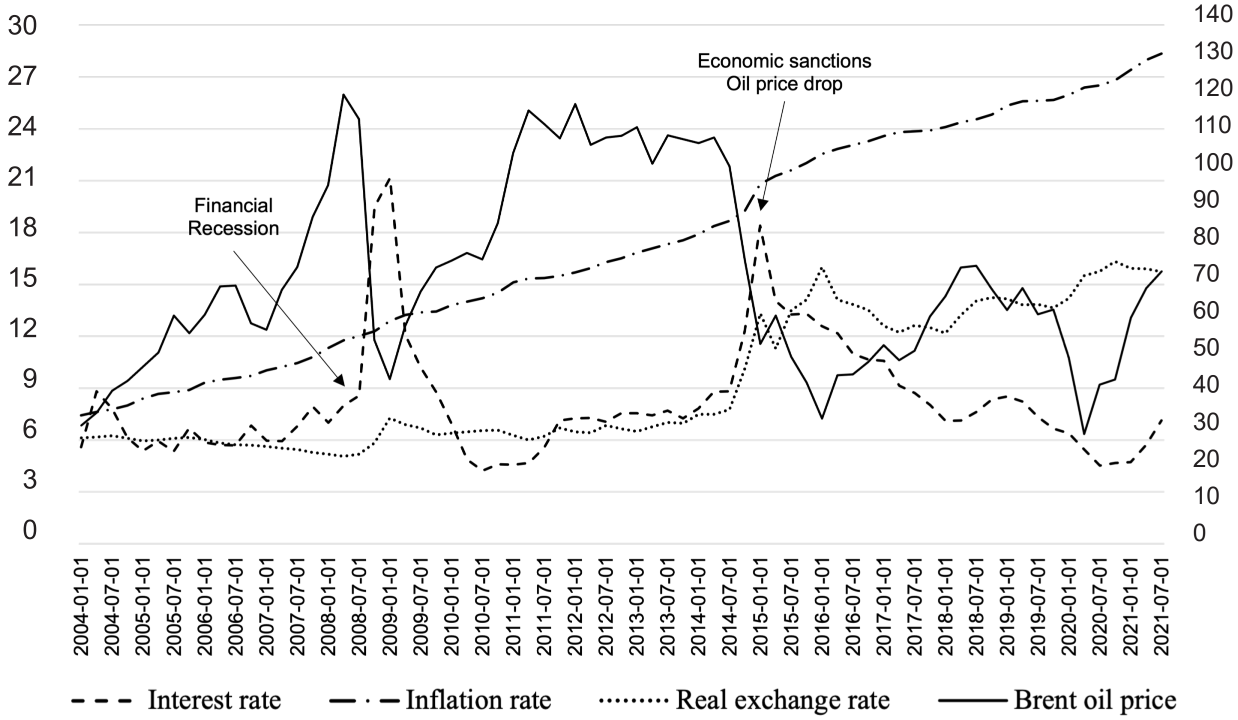
The early 2000s marked a notable era often referred to as the "golden period" for the Russian economy. Following the election of a new government, a series of pro-growth reforms were swiftly implemented to establish stability (Popova *et al*., 2017). The period is also sometimes dubbed the "well-fed 2000s" due to the steadily improving well-being experienced by the country's citizens. Incomes witnessed growth, accompanied by a rise in consumer expenditures and an increased demand for imported goods and services. The stability of the domestic currency, coupled with the continuously surging oil prices that reached unprecedented heights in the summer of 2008, played a crucial role in propelling the Russian economy to significant growth during that time.

The onset of the 2008 financial crisis instigated a sharp decline in oil prices, attributable to a substantial reduction in consumer and business demand for petroleum. The Global Financial Crisis, a period characterized by intense strain on global financial markets and banking systems spanning from mid-2007 to early 2009, unleashed a wave of economic turmoil worldwide. A collapse of the US housing market triggered widespread economic disruptions, plunging most global economies into deep recessions. Consequently, the demand for energy experienced a significant decline, precipitating a notable slump in oil and gas prices. Within a mere six months, oil prices plummeted from approximately $130 USD to below $40 USD, directly affecting oil-exporting countries and companies due to a substantial downturn in energy revenues. Throughout the 2008 crisis, the Russian economy, including its mining sector, exhibited a negative response to the oil price shock (Balashova and Serletis, 2020). GDP growth recorded negative figures during the period, indicative of a prolonged recession lasting over a year. Nevertheless, Yoshino and Alekhina (2016) demonstrated that the Russian economy rebounded at an accelerated pace following the crisis, largely due to the highly effective measures implemented by the government.

In the aftermath of the 2008 Global Financial Crisis, efforts were undertaken by OPEC countries to stabilize the oil market and its prices. Notably, OPEC members made a historic commitment to reducing oil production, marking the first such agreement in eight years. The agreed-upon reduction in oil supply amounted to 4.2 million barrels per day, with Saudi Arabia, as the largest producer within OPEC, implementing the most substantial production limitations. As a result of these measures, oil prices experienced an upward trajectory, surpassing $70 USD per barrel. A significant positive oil price shock transpired in the first half of 2011, with prices surging from $80 USD to $120 USD per barrel. This surge in prices led to a considerable increase in Russia's petroleum export revenues, which was driven by various factors, including the Arab Spring, the civil war in Libya and a nuclear power plant explosion in Japan (Popova *et al*., 2017). The volatility in oil prices during that period was attributed to widespread concerns regarding potential disruptions in supply from the region. Consequently, an upward trend in oil and gas revenues in Russia was witnessed, with its value soaring from 3.8 trillion roubles to 5.6 trillion roubles (Russian Finance Ministry, 2022). The Russian federal budget revenue details (Figure A1), and crude oil and oil product export details (Figure A2) are presented in the Appendix.

Global oil price volatility has a direct impact on key monetary policy indicators in Russia. Notably, the Russian interest rate exhibits a counter-cyclical pattern, whereby an increase in oil prices results in a reduction of the interest rate, and conversely, a decrease in oil prices leads to an increase in the interest rate (see Figure 2). This dynamic underscores that a higher oil price generates greater inflows of foreign reserves onto the domestic market, exerting downward pressure on the interest rate. Conversely, lower oil prices result in reduced income, heightened demand for borrowing and an increased interest rate. The interest rate reached its peak during the 2008 financial crisis, and the second-highest peak occurred in 2014 amid economic sanctions and a drastic decline in oil prices. While the real exchange rate remained stable until 2014 despite the substantial inflow of oil revenue, it depreciated thereafter, primarily driven by the imposition of sanctions and the decline in oil prices. Furthermore, inflation exhibited a steady increase of 32% from 2015 to 2021 (see Figure 2).

Figure 2: Progression of Russian monetary policy indicators and Brent oil prices (2004–2021)



Note: The left axis represents interest rate; the right axis represents inflation and exchange rates and Brent oil price.

Source: Data retrieved from FRED (EIA, 2022 and OECD, 2022)

Subsequently, in 2014, the global landscape experienced a dramatic plunge in oil prices. This drop was triggered by the substantial expansion of the US and Canadian shale oil production, also known as tight oil, which considerably expanded their market share. Furthermore, increased oil supply resulting from production growth in Saudi Arabia, Libya and Iraq further contributed to the downward pressure on oil prices (Nyangarika and Tang, 2018). Concurrently, a slowdown in the Chinese economy during that period led to a decrease in demand across commodity markets. The drop in oil prices was swift, with prices plummeting from over $100 per barrel to nearly $50 USD per barrel. The decline persisted into 2015, with prices reaching below $40 USD per barrel. Overall, the period spanning from 2014 to 2016 was marked by extreme volatility of the oil market. The sharp decline in oil prices resulted in a recession in Russia's GDP growth. Additionally, the shock had a profound impact on the Russian exchange rate, leading to a depreciation of the Russian rouble (Alekhina and Yoshino, 2019). The influence of the oil price shock on the domestic exchange rate in Russia can be attributed to the fact that petroleum primarily generates foreign currency revenue. It is widely acknowledged that the world oil price serves as the most significant external factor influencing the US dollar-to-rouble ratio in the Russian economy (Nyangarika and Tang, 2018). Furthermore, the international response to Russia's geopolitical decisions also contributed to the weakening of the Russian currency and an economic downturn. In response to the invasion of Ukraine and the annexation of Crimea, the United States and the European Union imposed sanctions on Russia, further exacerbating the adverse effects on its currency and economic trajectory.

The latest oil price shock was primarily triggered by a significant decline in demand stemming from the global market slowdown caused by the outbreak of the coronavirus pandemic in 2020. In response to the pandemic, numerous countries implemented travel restrictions, imposed export limitations and enforced bans on commercial activities, leading to an economic recession on a global scale. Consequently, industrial production worldwide experienced a substantial downturn, resulting in a reduced energy demand and a subsequent decrease in global oil prices. The sharp decline in global trade in goods and services due to COVID-19-related restrictions further constrained economic activities across the globe. As international trade and overall production declined, the demand for crude oil diminished, consequently exerting a downward pressure on its market price.

Following that, in early March 2020, Saudi Arabia initiated a price war against Russia by informing its buyers about OPEC's intention to increase oil production. This move was in response to Russia's refusal to decrease oil production and stabilize crude oil markets, as the production of shale oil in the United States was expanding. Additionally, global oil demand was declining amidst the economic crisis caused by the pandemic. The production increase led to a sharp decline in oil prices, plunging to their lowest level since 2002 and dropping below $20 USD per barrel. This price drop on the global market was the most significant since the Gulf War in the early 1990s (Gupta *et al.*, 2020). The oversupply of oil on the market even resulted in negative values for West Texas Intermediate (WTI) futures, marking the first occurrence of such an event in history. As the marginal production costs of oil in Russia are considerably higher than those of OPEC countries, the price war had a significant adverse impact on Russia. The world oil price fell below the costs of production and transportation, causing Russian oil companies to suffer substantial revenue losses. In April 2020, Russia and Saudi Arabia eventually reached an agreement to cut production. However, the negative effects of the pandemic outbreak proved to be more enduring than the positive effects generated during the truce (Ma *et al*., 2021). Nevertheless, oil prices rebounded by the end of 2020 due to production cuts and the global rollout of vaccinations, as well as the gradual easing of COVID-19 restrictions. These factors fostered optimism and stimulated global markets.

3. Theoretical Background

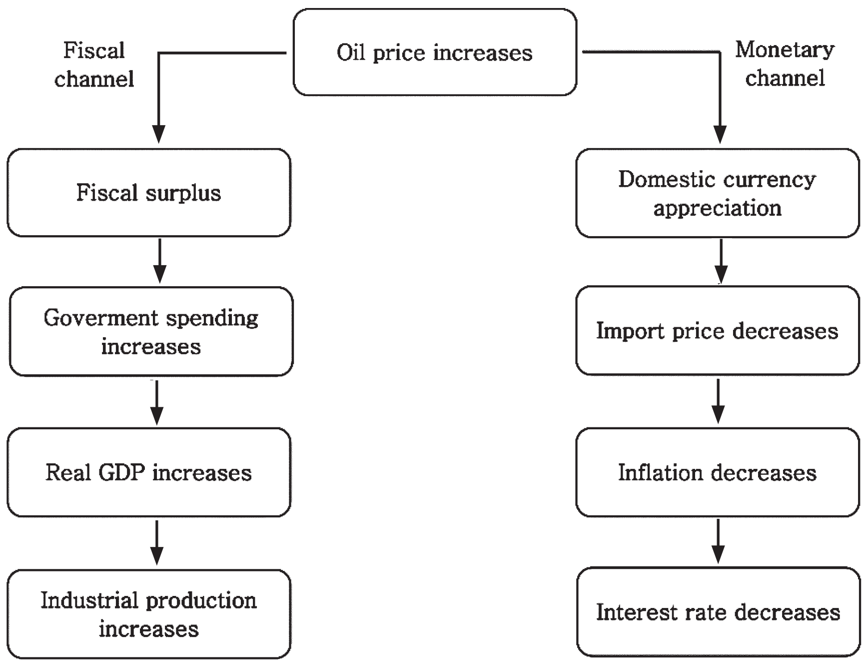
In the literature, the term "natural resource curse" has evolved to signify the relatively lower economic growth experienced by resource-rich countries in contrast to those that are resource-poor. This scenario often arises when substantial oil reserves present challenges, giving rise to a phenomenon commonly known as the "Dutch disease" (*e.g.*, Corden and Neary, 1982; Auty and Warhurst, 1993; Sach and Warner, 1995). This economic condition is characterized by the contraction of non-resource sectors and a notable decline in the country's price competitiveness as the domestic currency appreciates. From one perspective, high oil prices possess the capability to yield substantial advantages for resource-rich countries, leading to a notable upsurge in export earnings. These increased revenues not only elevate government income but also enable a substantial level of governmental spending (Auty, 2001). In contrast, relying heavily on income from oil can potentially initiate a marked decrease in other industries, resulting in diminished competitiveness for the country on the global stage (Gylfason, 2001). For a more comprehensive perspective on the literature regarding the natural resource curse, one can turn to studies conducted by van der Ploeg (2011) and Frankel (2012). Consequently, the apparent blessing of abundant oil reserves can, over time, transform into a curse for developing countries.

Low oil prices reduce oil exporters' revenues, leading to domestic currency depreciation as foreign exchange earnings decline. On the one hand, domestic currency depreciation reduces the affordability of imports. This could directly affect domestic companies and households, which become less capable of purchasing goods and services from abroad, decreasing the population's well-being. On the other hand, domestic currency depreciation can increase exports as domestic products now become more competitive on the world markets (Popova *et al*., 2017). Nevertheless, this pattern is often not applicable to resource-rich developing countries such as Russia, where the lack of adequate potential and capabilities among producers hinders their ability to generate manufactured goods for the international market.

The impact of oil prices on the Russian economy can be observed through both fiscal and monetary channels, as illustrated in Figure 3. From a fiscal perspective, an increase in oil prices benefits the Russian economy through taxes levied on the export of energy resources. This generates a fiscal surplus, enabling the government to increase its spending and stimulate real GDP growth (Benedictow *et al*., 2013, Ju *et al*., 2016, Taghizadeh-Hesary *et al*., 2019). This effect is particularly pronounced in larger economies with significant oil exports, such as Russia, the UAE and Saudi Arabia. The study by Ito (2012) demonstrated that the Russian Federation's GDP and inflation were vulnerable to world oil price shifts from 1995 to 2009. Additionally, Alekhina and Yoshino (2019) found a significant impact of domestic oil and gas producers' price movements on aggregate supply and demand in Russia from 2000 to 2016. The common expectation is that when oil prices rise, economies rich in natural resources tend to benefit significantly in the short run.

From a monetary perspective, changes in oil prices significantly affect the economy, including the domestic currency, prices and interest rates. Oloko *et al*. (2021) argued that monetary policies tend to adapt to oil price shocks, especially in countries that have either floating exchange rate regimes with inflation targeting or pegged exchange rate regimes with non-inflation targeting monetary policies. When oil prices rise on the market, it leads to a greater inflow of foreign currency onto the domestic market. This increased capital flow causes the domestic exchange rate to appreciate, resulting in lower prices for imported goods and services. Since imports play a substantial role in the total consumer goods sector, the overall effect of higher oil prices is deflationary, leading to a decrease in the general price level. In response, the Taylor rule, which provides guidelines for setting interest rates, suggests a reduction in interest rates.

Figure 3: Channels of macroeconomic response to oil price increase



Source: Author's own elaboration

The behaviour of inflation in response to oil price shocks can exhibit distinct patterns in resource-rich countries. Higher oil prices lead to higher levels of economic activity and spending on the domestic market. This surge in economic activity can potentially lead to increased demand for goods and services, which, in turn, can drive up overall prices, contributing to inflationary pressures (see, *e.g.*, Lescaroux and Mignon, 2008; Tang *et al*., 2010). Additionally, higher oil prices can directly affect production costs across various sectors of the economy, further contributing to inflation. Conversely, when oil prices fall, the revenue generated from oil exports decreases, prompting the government to cut spending or implement austerity measures, leading to reduced economic activity (Mohaddes and Pesaran, 2017). As a result, demand for goods and services might decrease, potentially leading to a downward pressure on prices, a phenomenon known as disinflation. Yoshino and Alekhina (2016) found a positive relationship between domestic oil prices and the inflation rate in Russia from 2000 to 2008, implying that elevated oil prices corresponded with higher inflation on the Russian market. Nevertheless, this correlation was not significant in the period 2008–2016.

The relationship between oil price shocks and inflation is also influenced by factors such as economic diversification, reliance on oil exports, monetary policy effectiveness and global economic conditions. The CBR demonstrates proactive responses by adjusting interest rates and employing monetary tools to manage inflation in Russia, especially since 2014 (Tuzova and Qayum, 2016). Despite a significant drop in oil prices after 2014, Russia's inflation rate continued to rise, with GDP increasing by only 0.4% in 2014, while the inflation rate surged from 7.68 to 9.58% by the last quarter of 2014 and to 16.2% in the first quarter of 2015 (WB Group, 2015). Tuzova and Qayum (2016) emphasized the CBR's efforts to curtail consumer price growth and maintain lower inflation levels. Hence, in contrast to the theoretical expectations, Russian inflation and global oil prices may exhibit countercyclical behaviour.

Additionally, a significant portion of consumer goods in Russia is reliant on imports. The Federal Customs Service of Russia highlights that cars and machinery constitute nearly half of the total imported goods, followed by chemical products (approximately 19%), food and raw materials (12.3%) and other small miscellaneous imports in 2017 (Alekhina and Yoshino, 2019). Consequently, a rise in oil prices could potentially have an adverse impact on the inflation rate due to the appreciation of the local currency.

With the dominance of the petroleum industry in the Russian economy and its crucial role as a revenue source for the federal budget, non-oil sectors have faced a lack of incentives for growth and development (Popova *et al*., 2017). The majority of foreign direct investments have been directed towards the oil and gas sector, which has limited the expansion of other industries. As a result, Russian macroeconomic indicators are heavily dependent on an external and volatile factor. In response to this vulnerability, the Russian government has implemented various measures and policies to effectively stabilize the economy in the aftermath of oil price shocks. Russia established the Stabilization Fund in 2004, in direct response to a sudden surge in oil prices. This fund was created with the objective of accumulating and reinvesting oil revenues into foreign bonds, providing support to the federal government budget. However, in 2008, the fund was divided into two separate entities, namely the Russian National Wealth Fund (NWF) and the Reserve Fund, in order to streamline and enhance its effectiveness.

The primary purpose of the NWF is to ensure the long-term sustainability of Russia's economy by investing in various assets that generate returns. It is intended to support the pension system and finance future projects that contribute to economic development and diversification. The Reserve Fund was created to act as a buffer against short-term economic shocks, particularly fluctuations in oil prices. It was designed to cover budget deficits in times of revenue shortfalls, helping maintain government spending stability (Russian Finance Ministry, 2022). The NWF has a longer-term focus, aiming to secure resources for future generations and contribute to Russia's economic growth and development over time. The Reserve Fund has a more immediate purpose, serving as a short-term financial cushion to address sudden economic challenges and maintain fiscal stability.

The price of oil, much like other commodities, is predominantly determined by the global market. Fluctuations in oil prices are heavily influenced by the overall state of the global economy. During periods of economic growth and prosperity, when economies are thriving and production is operating at full capacity, there is an increased demand for energy, which in turn drives up oil prices. Conversely, during economic recessions and crises, industrial production declines, leading to reduced petroleum demand and subsequently lowering oil prices. While market forces and the state of the global economy remain key drivers of oil price fluctuations, the actions of organizations such as OPEC can introduce additional factors that affect the dynamics of the oil market. It is crucial to consider both these market influences and the strategic decisions made by major players in order to comprehend the complexities of oil price movements.

The dynamics of oil markets are also shaped by the presence of oil futures contracts, which are binding agreements that grant their holders the right to purchase petroleum at a predetermined price. Various factors can contribute to unexpected changes in oil prices, leading to what is known as an oil price shock. Kilian (2009) identified three types of oil price shocks: supply shocks, aggregate demand shocks and precautionary demand shocks. A supply shock occurs when there is a sudden disruption in the availability of oil. This could be caused by unexpected events such as geopolitical conflicts or natural disasters that affect oil production. When such disruptions occur, the price of oil tends to increase, prompting other regions to ramp up their production to meet the heightened demand.

An aggregate demand shock, on the other hand, is associated with the volatility of global business cycles. For instance, during the 2020 coronavirus pandemic, there was a sharp decline in oil demand as global markets faced shutdowns and economic activities contracted. This reduction in demand had a significant impact on oil prices. The third type of shock is the precautionary demand shock, which arises from expectations and uncertainties within the oil market. An example of this type of shock occurred during the Arab Spring in 2011. The protests that emerged in several Middle Eastern and North African countries, major oil-producing regions, raised concerns about potential disruptions in oil supply, leading to an increase in oil prices.

Considering a strong relationship between world oil prices and Russian macroeconomic performance, studies suggest a significant correlation between global oil prices and Russia's macroeconomic performance (*e.g.*, Pönkä and Zheng, 2019; Balashova and Serletis, 2020). These fluctuations in oil prices can serve as a predictive tool for changes in Russia's economic growth. Oil prices are procyclical and act as leading indicators of economic activity in the country, making them valuable in anticipating future recessions. Scholars have proposed various strategies and recommendations to reduce Russia's reliance on oil, commonly referred to as "black gold". It is also advised to reduce dependence on energy resources by transitioning from an industrial economy to an innovative one, enhancing the investment climate to attract foreign investors. These measures aim to mitigate the adverse effects of overreliance on oil and promote sustainable economic development.

4. Data and Methodology

To analyse the interdependence of the oil price volatility and the economy of Russia, we use quarterly data from 2004Q1 to 2021Q4, which creates 72 observations for each of the chosen variables. The period includes three main oil price shocks of the last two decades: the 2008 financial recession, the oil market oversupply in 2014, and the COVID-19 pandemic and oil price war between Saudi Arabia and Russia in 2020. The macroeconomic variables chosen for this analysis can be observed in Table 1. Descriptive statistics for the variables are presented in Table A1 in the Appendix.

To examine the impact of global oil price fluctuations on Russian macroeconomic indicators, we selected four key variables: the industrial production index (IPI), the exchange rate, the consumer price index (CPI) and the interest rate. The IPI serves as an indicator of economic output performance and represents the fiscal channel. It measures the real output in the mining, manufacturing and energy sectors compared to a specified base year. By focusing on the IPI, we can analyse changes in business cycles within the country. Given the significant role of the industrial sector in the Russian economy, this variable holds great importance in our analysis. In addition to capturing total manufacturing output, it also provides insights into production capacity levels, representing the estimated production volume that a country can sustain. The IPI is expressed as a percentage change relative to the base year, which, for this study, is set as 2015.

Table 1: Data definition

Notation	Variable	Data
ipi_t	Industrial production index	Production of total industry, 2015 = 100
π_t	Inflation rate	CPI inflation rate, 2015 is base year
i_t	Interest rate	3-month or 90-day rates and yields
$e_t^{\frac{rub}{usd}}$	Exchange rate	Rouble-US dollar exchange rate
p_t^{oil}	Oil price	Price of Brent crude oil, dollar per barrel
Δy	GDP growth	Gross domestic product by expenditure in constant prices

Note: Data for IPI are seasonally adjusted.
Source: Data retrieved from FRED (EIA, 2022 and OECD, 2022)

The monetary channel is explained by currency appreciation. We used the rouble to US dollar exchange rate since oil-exporting countries settle deals mainly in US dollars. As crude oil is traded in US dollars, its price fluctuations on the market directly affect the domestic currency of Russia. The inflation rate evaluates the rate at which the level of prices rises in the economy, marking a decline in a currency's purchasing power. The chosen inflation index for this analysis is the consumer price index (CPI), which measures an annual percentage change in the average price of a consumer basket consisting of goods and services. It will serve as an indicator of an increase in the costs of living in the economy.

The interest rate is the amount a lender charges on the amount loaned to the borrower. It is also a vital monetary policy tool used by countries' central banks to mitigate inflation rates and influence the country's economic activity by raising or reducing investment and consumption in the economy. We use the 3-month or 90-day rates and yields, or the interbank rate, which represents the interest charged on short-term loans between financial establishments. As an indicator for the oil price, we use Brent crude oil prices, as it is the most widely used global oil price benchmark and because the Russian export oil prices are pegged to this oil blend. GDP growth is measured in constant prices.

We used the vector autoregressive (VAR) method to study the impact of oil price volatility on the Russian macroeconomic indicators. The method was developed by Sims (1980) and is based on the Granger causality test (Granger, 1969). The difference between the VAR model and other autoregressive models is the fact that it predicts bidirectional influences between time series. The standard vector autoregressive model is expressed below:

$$y_t = a_1 + \sum_{i=1}^{\rho} b_{1i} y_{t-i} + \sum_{i=1}^{\rho} b_{2i} x_{t-i} + v_{1t} \tag{1}$$

$$x_t = c_1 + \sum_{i=1}^{\rho} d_{1i} y_{t-i} + \sum_{i=1}^{\rho} d_{2i} x_{t-i} + v_{2t} \tag{2}$$

The VAR model has advantages due to the fact that macroeconomic indicators are linear functions of the past values of themselves, and each series is a linear function of the past values of other macroeconomic variables. For our analysis of the influence of the oil prices on the macroeconomic indicators, we estimate four linear regression models with different dependent variables. The four models correspond with the four macroeconomic indicators:

$$\ln ipi_t = \alpha_0 + c \ln ipi_{t-1} + \alpha_2 \ln cpi_{t-1} + \alpha_3 \ln reer_{t-1} + \alpha_4 ir_{t-1} + \alpha_5 \ln oilp_{t-1} + e_t \tag{3}$$

$$\ln cpi_t = \beta_0 + \beta_1 \ln cpi_{t-1} + \beta_2 \ln ipi_{t-1} + \beta_3 \ln reer_{t-1} + \beta_4 ir_{t-1} + \beta_5 \ln oilp_{t-1} + \varepsilon_t \tag{4}$$

$$\ln reer_t = \delta_0 + \delta_1 \ln reer_{t-1} + \delta_2 \ln ipi_{t-1} + \delta_3 \ln cpi_{t-1} + \delta_4 ir_{t-1} + \delta_5 \ln oilp_{t-1} + \int_t \tag{5}$$

$$ir_t = \gamma_0 + \gamma_1 ir_t + \gamma_2 lnreer_{t-1} + \gamma_3 lnipi_{t-1} + \gamma_4 lncpi_{t-1} + \gamma_5 lnoilp_{t-1} + u_t \tag{6}$$

We assume that the oil prices are exogenously given to the Russian Federation, and thus Russian macroeconomic indicators do not possess the possibility of influencing the world oil prices. The next assumption is also that the variables in the model influence each other and also are influenced by their past values. The term ln is the natural logarithm of the variables. The logarithmic form of the variables is chosen in order to convert the values of the indicators into percentage change. The interest rate is the only variable not converted to a logarithmic form, as it is already expressed in levels. The parameters *ipi*, *cpi*, *reer*, *ir* and *oilp* indicate the following variables: industrial production index, consumer price index (inflation rate), real exchange rate, interest rate and Brent oil price. The terms α, β, δ and γ represent the response coefficients. The terms e_t, ε_t, ϵ_t and u_t are random errors, which represent uncertainty in the models. If the actual value of the dependent variable does not correlate with the value that the model predicts, the error term does not equal zero and indicates the existence of other factors that might be influencing the dependent variable.

5. Results

5.1 Unit root

Analysing time series can sometimes be limited by unpredictable patterns, making it harder to assess the data statistically. In order to prove that the changes of a variable over time are not randomized, it is necessary to check the time series for stationarity. Stationarity refers to the statistical properties that generate a time series, such as mean and standard deviation, which do not change over time. To ensure the absence of non-stationarity in the series employed for analysis, it is necessary to conduct unit root tests to assess their stationarity. A unit root is a stochastic or random trend of a variable, a random and unpredictable pattern, meaning a time series with a unit root is non-stationary.

The Augmented Dickey–Fuller (ADF) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests were employed for this purpose. To facilitate the analysis, the variables (except the interest rate) were transformed into their logarithmic form. The ADF test examines the presence of a unit root in the time series, which indicates non-stationarity. However, the ADF test has a relatively low power to reject the null hypothesis. Therefore, we supplemented our analysis by employing the KPSS test, which provides further confirmation. The null hypothesis of the ADF test assumes the existence of a unit root, implying non-stationarity in the time series. Consequently, if the ADF test fails to reject the null hypothesis, it is not advisable to utilize the variable for empirical analysis. On the other hand, the KPSS test posits the absence of a unit root, indicating stationarity in the time series. Therefore, by employing both tests, we obtain a more comprehensive assessment of the stationarity properties of the variables. The tests were conducted on the variables in both their original levels and their first differences, representing changes from one period to the next. This allows us to examine the transformation required to achieve stationarity and identify any trends or patterns within the data.

The results of the tests are presented in Table 2. The results with an asterisk are stationary at a 1% significance level. It is notable that with the exception of the inflation variable, all the data series are non-stationary and thus unsuitable for the analysis. It is important to note that the ADF test has a relatively high type I error rate, which means that rejecting a null hypothesis might be incorrect. This can be the case with the results for the inflation rate, which is stationary according to the ADF test. We checked the KPSS test results to verify this outcome, which indicates that the inflation rate time series is non-stationary only in its first difference. As a result of the ADF and KPSS tests, we use the first differences of logarithms of the variables, as they were proven to be stationary time series and thus cannot be influenced by randomness. Through this rigorous analysis of stationarity and unit root properties, we ensure the validity and robustness of our subsequent empirical analysis, enabling a more accurate examination of the relationships and dynamics between the variables under investigation.

Table 2: Unit root tests, 2004Q1–2021Q4

Level	ADF test	KPSS test	First difference	ADF test	KPSS test
log p_t^{oil}	−2.672	0.857	**Δlog p_t^{oil}**	−7.103*	0.071*
log(ipi_t)	−1.132	0.265	**Δlog($proind_t$)**	−6.456*	0.052*
GDP_growth	−2.284	0.245	**ΔGDP_growth**	−6.123	0.041
log $e_t^{\frac{rub}{usd}}$	−0.198	0.845	**log $e_t^{\frac{rub}{usd}}$**	−7.591*	0.079*
log(π_t)	−3.713*	1.213	**Δlog(π_t)**	−5.673*	0.062*
i_t	−2.791	0.326	**Δi_t**	−7.425*	0.029*

Note: * The selected time series is stationary at the 1% significance level.
Source: Author´s own calculations

5.2 Granger causality

The Granger causality test evaluates the directional causation between Brent crude oil prices and key macroeconomic indicators, specifically the industrial production index and the consumer price index, across the entire dataset and two distinct sub-periods: 2004–2008 and 2008–2021. The test allows examining whether a given time series is capable of forecasting another, which is questioned in the null hypothesis. If one variable (Y) is proved to "Granger-cause" the other variable (X), it means that the past values of Y contain information that might be useful in estimating the values of X. The statistical significance of the analysis results is based on a p-value. One can reject the null hypothesis if the probability value is less than a 5% significance level.

The selected results of the Granger test are represented in Table 3. The first null hypothesis suggests that the world oil prices do not cause a change in industrial production in Russia. The results are statistically significant for the full sample and the period after 2008; thus, we reject the null hypothesis. It confirms that by observing changes in the world oil prices, one is able to predict the changes in the Russian industrial production index or in the output of the Russian industry sectors. From the first quarter of 2004 to the third quarter of 2008, the oil prices did not Granger-cause Russia's production index, whereas in the period after 2008, the production index was affected by changes in the oil prices.

Table 3: VAR Granger causality test (Russia, 2004Q1–2021Q4)

	2004–2021		2004–2008		2008–2021	
Null hypothesis	χ^2**-stat**	***p*-value**	χ^2**-stat**	***p*-value**	χ^2**-stat**	***p*-value**
p_t^{oil} **does not cause** ipi_t	9.243	**0.004****	1.098	0.332	3.235	**0.047****
p_t^{oil} **does not cause** $reer_t$	4.156	0.116	0.392	0.827	1.124	0.302
p_t^{oil} **does not cause** π_t	1.883	0.257	2.345	0.156	0.134	0.897
p_t^{oil} **does not cause** i_t	2.924	0.228	4.894	**0.065***	1.532	0.323
ipi_t **does not cause** p_t^{oil}	1.214	0.533	0.087	0.932	0.542	0.604
$reer_t$ **does not cause** p_t^{oil}	0.089	0.877	1.224	0.812	0.018	0.834
π_t **does not cause** p_t^{oil}	9.237	**0.005****	1.676	0.425	3.341	**0.065***
i_t **does not cause** p_t^{oil}	1.453	0.253	0.165	0.866	1.498	0.233

Note: Variables are in first log-difference forms (except i_t, which is in first-level difference) and represent the rejection of the null hypothesis at the 5% and 10% significance level, respectively.
Source: Author´s own calculations

The second null hypothesis implies that the oil price volatility does not cause changes in the exchange rate of the Russian economy. We cannot reject the null hypothesis for the full sample or for two different sub-samples. The results are very similar to the third hypothesis regarding the role of oil prices on the inflation rate. In the hypothesis of whether oil prices cause changes in interest rate, we reject causality for the full sample, but it is significant only for the period from 2004 to the third quarter of 2008. It shows that one of the determinants of the interest rate level was the oil price before the 2008 financial crisis. However, the causality is not strong, and the rejection of the null hypothesis is possible only at a 10% significance level.

As an outcome of the test results of the causality direction from the Russian macroeconomic indicators to the world oil prices, we found that only inflation significantly affects both the full sample and the period after the 2008 financial crisis. During the period from 2008 to 2021, the biggest shock to the inflation rate was the Russian economic crisis of 2014, as the US and the EU imposed economic sanctions against the Russian Federation. The economic sanctions and the fall in the oil prices during that period caused a severe capital outflow and a depreciation of the Russian domestic currency. It all contributed to the increase in the consumer price index in the following year.

5.3 Impulse response analysis

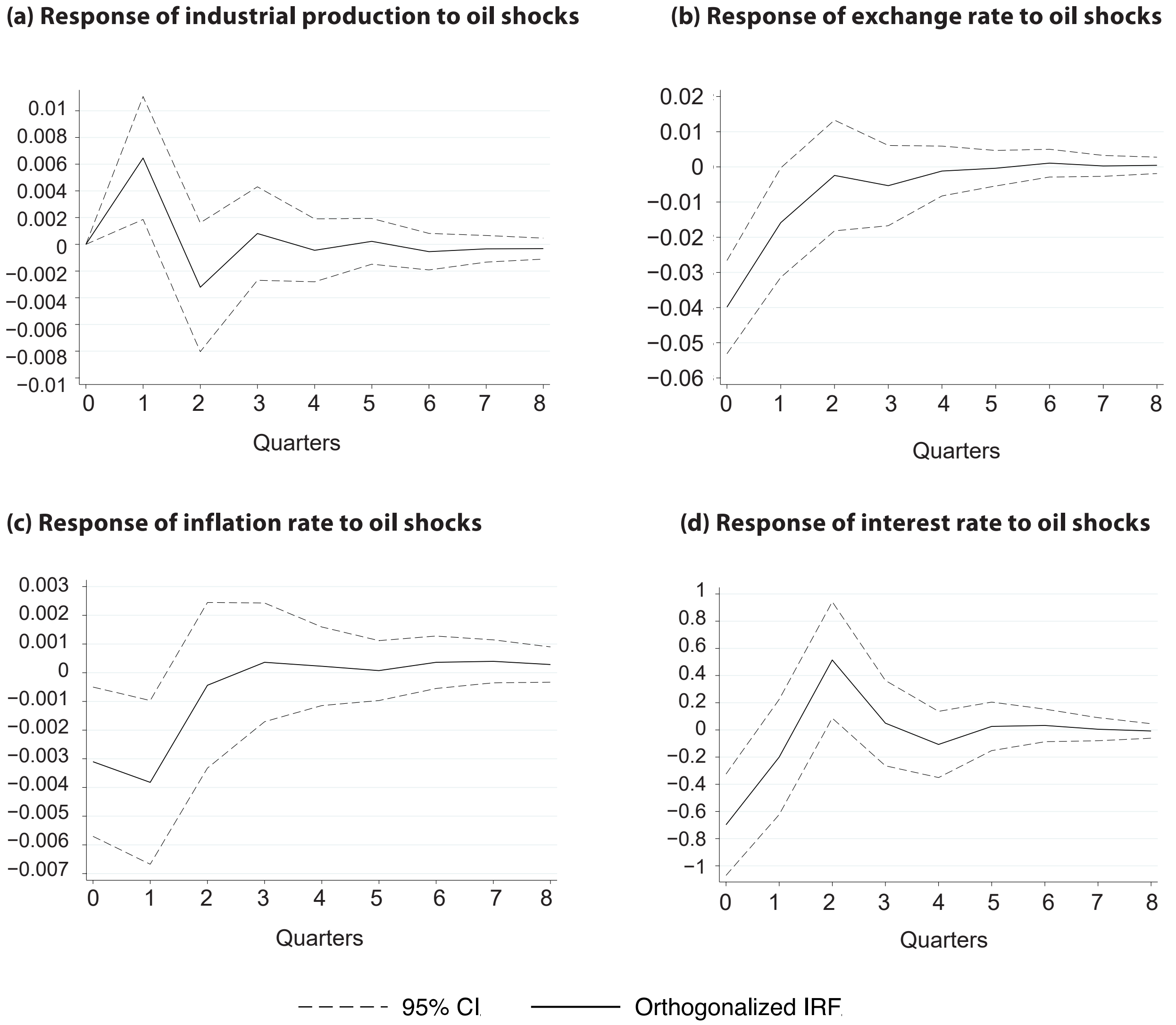
The impulse response function (IRF) analysis was utilized to illustrate the progression of variables within the VAR model. The IRF analysis describes the progression of the variables in reaction to a shock or a change in one or more of the variables in the model along a specified time horizon. It allows assessing the transmission of a shock within a system of equations and is an essential tool in empirical causal analysis. A shock to a dynamic system is an impulse or a brief input signal that causes an impulse response. In other words, a change in a variable is, to a certain degree, passed to other variables. The responses of the variables were estimated with one standard deviation shock for eight consequent periods, namely quarters.

Figure 4a depicts the response of the industrial production index to the oil price shock. According to the IRF outcome, Russia's production index is positively affected by oil prices. Thus, if there is an increase in oil prices, the production output of Russian industry sectors also increases. The results show that a 1% increase in oil prices leads to a 0.6% increase in the industrial production index (IPI). However, this effect is significant only for one period. After that, at a 95% significance level, the impact is insignificant, with the confidence interval reaching zero. In conclusion, an oil price shock has a positive effect on the Russian IPI for the first period after it occurred.

With the rise in oil prices, Russian oil producers experience a surge in revenues, creating opportunities to expand production and export values or even consider constructing new drilling or refining facilities. Furthermore, as profits within the Russian federal budget increase, the federal exchange reserves also grow, leading to a strengthening of the domestic currency. This appreciation of the rouble translates to reduced costs for domestic manufacturers importing goods. As previously discussed, the most notable imported items include mechanical and electrical machinery, which play a pivotal role in bolstering Russian industries. As their costs become more accessible, it facilitates the acquisition of necessary equipment, significantly enhancing the production capacities of these industries and thereby driving up the production index.

The impact of oil price shocks on the exchange rate shows a negative response, indicating that a 1% increase in oil prices leads to a more than 4% appreciation of the Russian domestic currency (Figure 4b). Since oil prices are predominantly determined in US dollars on the global market, the US dollar plays a dominant role in settling most transactions. A positive shock in oil prices boosts Russia's foreign exchange reserves, which strengthens the domestic currency, resulting in its appreciation. Our findings support this relationship; however, the negative impact is only significant in the initial period or the first quarter following the occurrence of the oil price shock. Subsequently, the confidence interval reaches zero, suggesting that the impact becomes insignificant.

Figure 4: Response of Russian macroeconomic indicators to oil shocks



Note: The time series covers the period from 2000Q1 to 2021Q4, represented in the first differences of logarithmic form. Impulse responses for a span of eight quarters are provided.

Source: Author´s own elaboration

The impact of an oil price shock on the inflation rate is significant during the initial period and the relationship is negative (Figure 4c). This indicates that a 1% increase in world oil prices would lead to a decrease in the price level in Russia by approximately 0.3%. Similarly to the response of the exchange rate, a positive oil price shock leads to a strengthened domestic currency due to increased foreign exchange reserves. Consequently, this makes imported goods more affordable for domestic consumers. Given Russia’s heavy dependence on imports, especially for intermediate and final products, the country’s reliance on imported items is substantial. Among the most imported goods by value in 2021 were automobiles, machinery, electrical equipment and motor vehicle components (Russian Finance Ministry, 2021). This underscores the significance of foreign hardware and other imported goods for Russian industries. Additionally, imported products represent a significant portion of the consumer basket. As their costs decrease, domestic producers face intensified competition, especially those that are less developed and unable to produce at a lower cost, placing them at a disadvantage.

The relationship between world oil prices and the Russian interest rate is negative (Figure 4d). Based on the analysis findings, a 1% increase in oil prices would lead to a decrease in interest rates in Russia by 0.7%. This negative relationship can be attributed to the impact of oil price volatility on the inflation rate. When oil prices drop, it tends to lead to a rise in the price level in Russia. As per Taylor's rule, when inflation rates exceed the desired level, the central bank should respond by increasing interest rates to counteract the upward pressure on prices in the economy.

To further validate the findings, a robustness check has been conducted by substituting the industrial production index with GDP growth as the macroeconomic indicator. The results align with the baseline model, confirming the consistency of our findings (see Figure A3). The response of GDP growth to an oil price shock is positive, indicating that a 1% increase in oil prices leads to a 7% increase in GDP for the first period, followed by 9% and 8% increases for the subsequent second and third periods, respectively. However, beyond the third period, the impact becomes statistically insignificant, with the confidence interval approaching zero. In summary, oil price shocks consistently exhibit a positive and robust effect on Russian GDP growth for up to three quarters after their occurrence.

The detailed examination of impulse response functions (IRFs) shows that the Russian Federation's macroeconomic variables react sensitively to changes in oil prices. These connections stem from the interrelationships among these variables, as assumed at the beginning of the analysis. This implies that the effects of oil price shocks on the Russian interest rate can be understood through their impact on inflation rates. Similarly, the link between oil prices and the Russian exchange rate can shed light on how the economy's price level responds.

6. Conclusion

Due to its abundant natural resources, Russia has a strong dependence on its exports, particularly in the form of raw materials. The trade in these resources plays a vital and irreplaceable role in the country's economy. Despite being one of the world's major oil producers, Russia lacks the ability to exert control over global oil prices. Instead, it becomes subject to the impact of oil price fluctuations, rendering its macroeconomic performance vulnerable to oil price shocks.

This research examined oil market dynamics spanning from 2004 to 2021, with a specific focus on how these dynamics affect Russian macroeconomic indicators. The core objective of this study was to investigate the consequences of oil price fluctuations on these indicators, aiming to quantify the magnitude and direction of their reactions to oil-related shocks. Employing a structural VAR model, this research endeavoured to offer valuable insights into the intricate connection between oil price shifts and the Russian economy.

The findings indicate a positive response of the industrial production index (IPI) to oil price shocks. The results suggest that a 1% increase in oil prices corresponds to a notable 0.6% expansion in real industrial production within the Russian economy. This growth is notably observed across the energy, mining and manufacturing sectors. These findings highlight the vulnerability of Russian business cycles to changes on the oil market, emphasizing the significant influence of oil price fluctuations on the country's industrial production.

The analysis confirms a negative relationship between oil price fluctuations and key macroeconomic factors such as inflation, exchange rates and interest rates. Specifically, when there is a 1% drop in oil prices, the Russian domestic currency experiences an appreciation of over 4%, while the price level in the economy increases by 0.3%. As a result, the CBR responds by raising interest rates, which could potentially increase by 0.7%. This vulnerability of the Russian domestic currency to energy market volatility poses a threat to sectors of the economy that rely heavily on imported goods and services. The rising prices of foreign goods contribute to an overall increase in the price level in Russia, amplifying the impact on the economy, which is significantly dependent on imports.

The results confirm that the Russian Federation needs to address its economic overreliance on natural resource exports. A crucial step in this direction is diversifying the sources of revenue in the federal budget, as the current heavy reliance on oil and gas revenues poses risks. By supporting and nurturing other sectors and industries within the economy, Russia can reduce its dependency on the extraction and export of raw materials, thereby mitigating the symptoms associated with the Dutch disease. It is essential to recognize that the significant oil and gas revenues should not only serve as a safety net during economic downturns but also be strategically invested in non-petroleum assets. By directing these funds towards other sectors, Russia can foster economic growth, stimulate innovation and create a more balanced and sustainable economy. Such investments will contribute to the development of a diverse range of industries, reducing the country's vulnerability to fluctuations in oil prices and enhancing its overall economic resilience.

Furthermore, the research should be extended to encompass recent years, particularly focusing on the post-COVID and post-war periods. This expanded timeframe will enable an examination of whether COVID had a more profound impact and whether recent sanctions have been effective. Additionally, increasing the frequency of data collection (moving from quarterly to monthly data) could lead to more refined outcomes in the VAR model. Given the intricate nature of the interrelationships among macroeconomic indicators, the utilisation of a more endogenized VART model can offer improved results.

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Conflicts of interest: The author hereby declares that this article was not submitted or published elsewhere.

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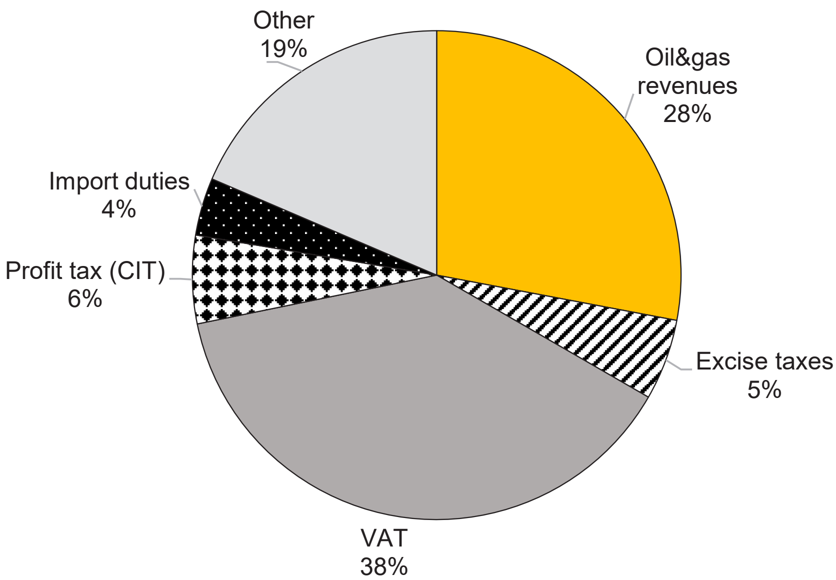
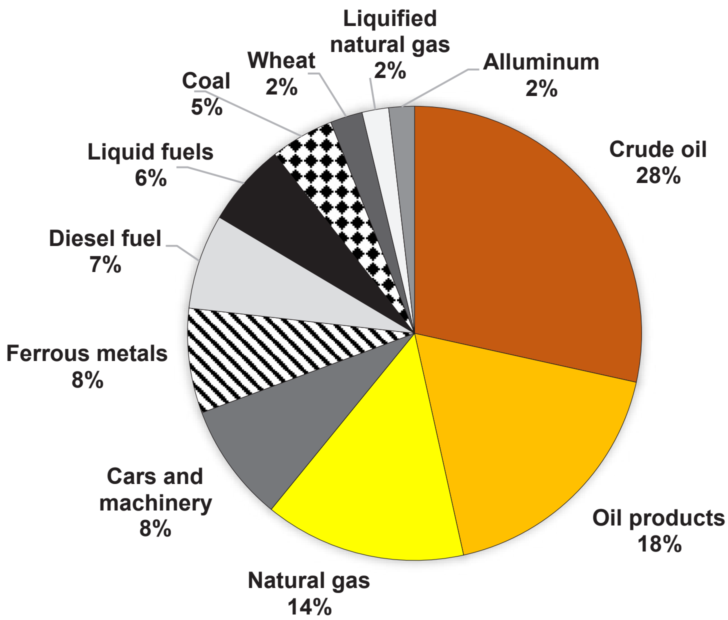
Appendix

Figure A1: Federal budget revenues of the Russian Federation in 2021 (by sections)



Source: Data retrieved from Russian Finance Ministry (2022)

Figure A2: Oil-related exports of the Russian Federation in 2021



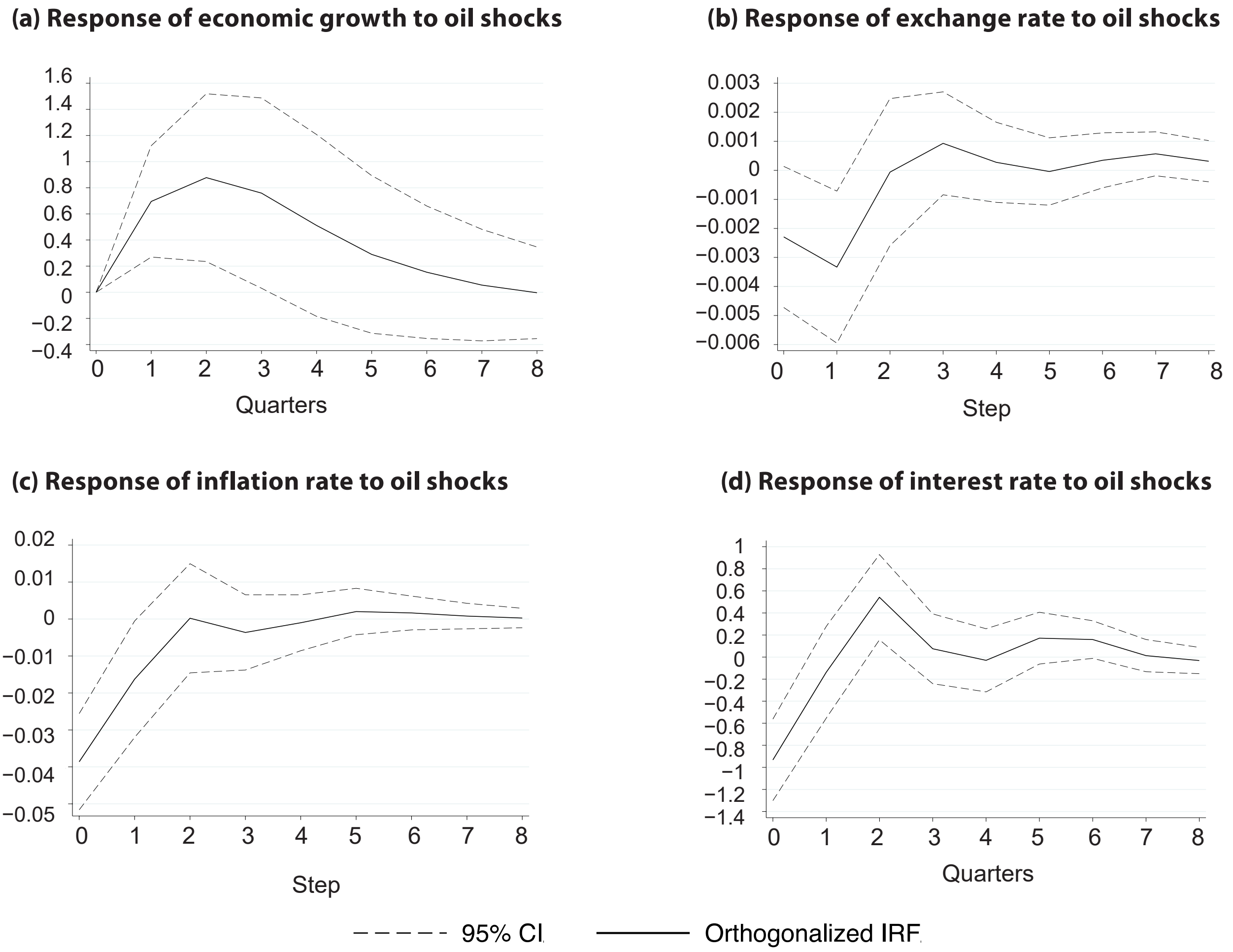
Source: Data retrieved from Russian Finance Ministry (2022)

Table A1: Descriptive statistics

	2004–2021			2004–2008			2008–2021		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
ipi_t	93.53	70.56	116.43	81.05	70.56	90.33	98.09	76.10	116.43
π_t	81.05	34.69	132.26	44.31	34.69	56.09	94.48	57.41	132.26
i_t	8.15	4.23	21.14	6.64	5.34	8.83	8.71	4.23	21.14
$e_t^{\frac{rub}{usd}}$	43.30	23.63	76.22	26.93	23.63	29.17	49.29	27.26	76.22
p_t^{oil}	71.95	29.70	121.20	65.97	31.99	121.20	74.14	29.70	118.71
Δy	2.76	−9.40	11.00	7.74	5.00	11.00	0.95	−9.40	7.57

Source: Author´s own calculations

Figure A3: Response of Russian macroeconomic indicators to oil shocks



Note: Time series covers the period 2000Q1–2021Q4 in the first differences of logarithmic form. Impulses for eight quarters are presented.

Source: Author´s own elaboration