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Oil Shocks and the Russian Economy: Inflation Perspective

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Abstract

This paper aims to assess the effect of oil shocks on the Russian economy, focusing on but not limited to inflation, throughout 2000–2019, with the following main points with respect to economic policy: switching to inflation targeting in 2014 and undergoing several iterations of the fiscal rule. The paper focuses on estimating a Bayesian time-varying parameter VAR model, additionally calculating the oil price pass through to inflation using the Phillips curve approach and modelling impulse responses to oil shocks using non-Bayesian vector autoregressions. The broad conclusion is that after 2014 the response of total consumer price inflation to positive oil price shocks went negative from being weakly positive before, a development likely to be attributed to the fiscal rule suspension for the most of 2015–2018 period.

Keywords: oil shocks, oil exporters, economic policy, Russia, time varying parameters

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When a person dies, one does not stop loving him, does one?

Disclaimers and acknowledgements

I would like to put forward a major disclaimer that should be taken into consideration while reading the paper: the aim of the thesis is to cover the pre-pandemic period. The reason behind the decision is twofold: firstly, economic processes went awry during the pandemic, messing up the data, secondly, the political situation that started unfolding in late February 2022 turned everything upside down. With me and my family currently being in Russia, the absence of comments on the recent developments would be appreciated out of apparent concerns. Consider this a love letter (or rather an obituary) to what Russia's economy used to be.

I have benefited from the advice by – and conversations with – Anders Olofsgård and Lars Svensson. I am also also grateful to Andrew Buckner, Lisa-Maria Jonsson, and Ivan Shchapov for their feedback and comments. All errors and shortcomings are my own.

Contents

1 Introduction

In this paper, I aim to focus on the oil prices pass-through to inflation while studying the properties of the Russian economy with respect to oil price shocks. The objective is to consider the role that the reforms introduced in late 2014, viz. inflation targeting, played for the economy, focused on – but not limited to – inflation dynamics.

To do so, I apply several methods. While the time-varying Bayesian vector autoregression (VAR) model provides the most comprehensive analysis, including time-varying impulse responses, simpler options, namely estimating the oil price spillover by means of Phillips curve, and estimating a non-Bayesian VAR, lead to the results that conform with the former approaches. Several specifications are used to ensure the validity of the results, with the models being estimated for total and core CPI.

The results demonstrate that the global oil price pass-through to domestic inflation changed from weakly positive to negative. While the declining pass-through is conventionally a sign of a better policy conduct, the result I obtain for Russia is the pass-through not simply declining but turning negative.

Taking into consideration the spillover mechanism complexity, positive oil price shocks for an oil-exporting economy are a double-edged sword. At first sight, the effect must be positive, with the economy benefiting from commodity exports. Still, it might lead to overheating and increased imported inflation. Thus, policy measures should be taken to isolate the economy from oil price shocks, both negative and positive, a development seen to an extent in the decrease of the positive correlation between the country's gross domestic product and oil price.

What should be acknowledged is limited internal validity of the study, with the analysis being not strictly causal. To establish causal relationships in this case, one needs a well-performing identification strategy able to discern the effects of different reforms. Regarding external validity, the methods that I use may be employed to study other oil-exporting economies, probably with country-specific modifications.

The paper is organised as follows. In Section 1, literature review is carried out, outlining various approaches and coverage of the issue. Section 2 covers Russia's economic policy relevant for the period 2000 - 2019, together with some stylised facts on energy prices for Russia. Section 3 features data description, and Section 4 presents the methods used by the author, including Phillips curve estimation, vector autoregressions, and Bayesian time-varying parameter VARs. Results are presented and discussed in Section 5.

2 Literature review

The literature on oil price spillover to inflation is quite extensive, being split up in several threads discussed below. Many papers cover the impact of oil price on other economic variables as well, in addition to inflation. Although the pass-through literature mostly focuses on commodity importers, as the issue is more straightforward in this case, commodity exporters are often considered in a sample, with the same methods being applied. Moreover, commodity exporters are a more interesting specimen to study with respect to other macroeconomic variables reacting to oil price shocks, not just inflation. However, one should be more careful in interpreting the results for commodity exporters due to the fact that respective commodities are endogenous to the economies. Main literature strands with respect to oil shocks spillover are the following: either estimating the spillover using Phillips curve or using vector autoregressive (VAR) models which give a broader picture.

With respect to the former, Hooker (2002) is a seminal paper, estimating the effects of oil price changes on inflation in the United States with a Phillips curve allowing for structural break. The author shows that since around 1980, oil prices affect core inflation measures to a lesser extent, with a plausible explanation being a change in monetary policy reaction. Chen (2009) considers 19 advanced economies in the Phillips curve framework, finding that the spillover has decreased over time with changes in monetary policy and lifting trade restrictions.

Still, the evidence from the Phillips curve environment is not unanimous with respect to possible explanations of the pass-through. Gelos and Ustyugova (2019) suggest that the reasons behind changes in oil price pass-through are fuel intensity and pre-existing inflation levels rather than the conduct of monetary policy. Moreover, a number of papers highlight the difference in the factors behind the pass-through depending on whether an oil price change is caused by supply or demand shocks, e.g. Kilian (2009), Peersman and Van Robays (2012), and Baumeister and Peersman (2013).

Another strand of literature identifies the effect of oil price shocks on inflation using vector autoregressions. Blanchard and Gali (2007) compare the effects of oil price shocks in 1970s and 2000s for a set of industrial counties. They use, firstly, a VAR with a break in mid-1980s, and, secondly, rolling bivariate VARs. The authors show that the effects of oil price shocks are significantly smaller later on in the sample. Choi et al. (2017) use a panel VAR approach to show that the impact of oil price shocks has faded in recent decades both for advanced and emerging economies with a better conduct of monetary policy – moreover, they confirm a rule-of-thumb idea that positive oil price shocks have a larger effect compared to negative ones. Mallick and Sousa (2012) use both Bayesian structural VAR and sign-restrictions VAR to estimate the effects of commodity price and monetary policy shocks for a number of economies, including such commodity exporters as Russia and Brazil. Belomestny, Krymova, and Polbin (2021) employ a time-varying parameters VAR (TVP-VAR) on the Russian and Norwegian economies. Another paper using Bayesian methods is Akram and Mumtaz (2015) who set up a Bayesian TVP-VAR to study the effects of oil price change and monetary policy for Norway. Filis and Chatziantoniou (2014) estimate structural VARs to assess the impact of oil price shocks on a panel of oil importers and oil exporters, including Norway and Russia. Alekhina and Yoshino (2018) use VARs to assess the oil prices change impact specifically for Russia's economy, together with estimating the Taylor rule equation.

De Gregorio, Landerretche, and Neilson (2007) combine both methods on a sample of emerging and advanced economies. Firstly, they estimate the pass-through coefficient using a generalised Phillips curve approach, finding that the coefficient dropped in 1980s. Next, they use rolling windows VARs to estimate accumulated effects of a unit oil price shock on inflation, confirming that the coefficient has declined over time.

The broad conclusion in the related literature is that oil price pass-through to inflation has declined over time, with explanations thereof being manifold, but a lot of them pointing towards more responsible policies. Moreover, for commodity exporters, the general influence of oil shocks decreases with the introduction of relevant policies.

In this paper, I aim to use the Phillips curve and vector autoregression methods in the context of an oil-exporting economy, namely Russia, thus bringing together several literature strands. Applying several methods helps consider the issue from several perspectives. While the Phillips curve estimation is more theory-based, vector autoregressions are more empirical, allow for more variables and hence add to internal validity of the research by controlling for more factors. The pass-through coefficient obtained from Phillips curve estimation and the impulse responses of inflation to oil price shocks have the same underlying concept, thus they are likely to point in the same direction, mutually confirming the general trend of the tailwinds shifting. For a more comprehensive view, I estimate a Bayesian TVP-VAR model which provides descriptive evidence on the shifts in the processes in the Russian economy, including counterfactual analysis for oil price and monetary policy shocks, and time-varying impulse responses. Bayesian analysis is more robust with respect to shorter time series as it augments the data by means of simulation based on probabilities.

3 Background

3.1 Imported inflation in small open economies

In the setup of small open economy, which Russia conventionally is (see e.g. Tishin, 2019), there are several channels by means of which global inflation gets imported.

Firstly, there is the direct channel of import prices increasing. With tradable goods, the channel is pretty straightforward, either for final consumer goods or for resources used to produce final consumer goods. For non-tradables, the impact is defined by a share of imported resources and technologies used for production. This channel influences the supply-side inflation. To quantify the role of this channel, let us look into the figures for the share of import in final consumer goods. For foods, the data from the Russia's Federal State Statistics Service are available, estimating the share of imported components in food retail. As of late 2019, the share thereof was 27%, having decreased from well over 30% before 2014. For non-foods, no official data are available, but Salikhov and Kondratiev (2021) estimate the share of imports in non-food retail at 75% for 2020 without major fluctuations within the last decade. Thus, a certain share of retail goods is susceptible to direct spillovers from global inflation, with some share thereof driven by fuel prices, and supply-side inflation is indeed relevant for both oil exporters and oil importers.

Secondly, global inflation can be imported indirectly, if economic activity is elevated on a global scale, thus propelling inflation. This channel operates by means of shifts in demand. Currently, it is mostly founded upon ultra-loose monetary conditions allowing for increased lending and hence elevated demand.

Moreover, there is a specific channel related to the second one which pertains to commodity exporters. Whenever commodity prices are growing, economic activity in the commodity exporter flourishes, causing inflation. Strengthening of the local currency is supposed to offset it by dampening the demand for local goods on the global market – still, only to an extent. While the effect might seem positive, it quickly turns into demand-side inflation (Filis and Chatziantoniou, 2014). This channel is valid for both elevated global demand for a commodity and shrinking global supply thereof. The effects of the imported inflation in a commodity-oriented economy are discussed in Kozlovtceva et al. (2020).

So, in brief, there are both direct and indirect channels of global inflation being imported into Russia. Kiselev and Zhivaykina (2020) show that the share of inflation imported through these channels constituted approx. 30% of the price variation in Russia, below the average of 40% for the sample of non-EU countries. They also find that the share of imported inflation is lower in commodity-exporting economies, such as Russia, Norway, and Brazil. Thus, despite Russia being an oil exporter, it is still likely that international oil prices have a bearing, either direct on indirect one, on domestic inflation.

3.2 Economic responses to oil price shocks

In line with the previous section, the effect of oil price changes on the domestic inflation is twofold and it does not solely depend on whether the country is an oil exporter or an oil importer.

Economic theory suggests that as oil prices rise, so do production costs, hence potential output contraction. For oil exporters, this is to an extent offset by increased investment and labour productivity. Also, a rise in oil prices corresponds to more profits from exporting the commodity. Moreover, for an oil exporter an oil price increase is likely to strengthen the exchange rate of a domestic currency, unless a really elaborate fiscal rule is implemented.

Multiple studies have demonstrated that in the 1980s there was a shift in how economic variables respond to oil price shocks, even as central banks grew more attentive towards mitigating inflation pressures, hence a more muted response to oil price shocks. Moreover, International Energy Agency (2006) shows that the economies in a state of growth are more resilient to positive price shocks inflation-wise, as increasing productivity and investment absorb cost production shocks. While the shift might seem more straightforward in the case of oil importers, it is reasonable for oil exporters to demonstrate this shift as well, since central banks over time become more aware of both inflation and economic activity.

In terms of monetary policy reaction, there persists a trade-off between output and inflation rate. While turning hawkish might seem a natural reaction to an external price shock, there might be negative consequences thereof with respect to production. The trade-off is relevant for both oil importers and exporters.

3.3 Russia's policy background

With respect to economic policy, a major shift happened around 2014, when inflation targeting was introduced. What partially instigated the reforms was the oil price drop of 2014. An account of what policy mechanisms used to be and what they have become after 2014 is presented below.

Although the 1990s do not fall within the scope of this paper, a brief description of policy events is necessary for understanding the context. Immediately upon the collapse of the Soviet Union, economic policy mostly centered around ameliorating the freefall in industrial production and manufacturing, as well as the widening budget deficit, with the Russian ruble being in a free float. Later in the 1990s, as the economy started to recover, the priorities shifted to curbing inflation rates, which topped at over 1000% YoY in September 1993. Ruble exchange rate was selected as a means thereof, and during 1995-1997 the national currency gained strength in real terms (though still devaluing in nominal terms) with the inflation rate going down into double digits and standing at 11.3% in December 1997. Then, in 1998, another crisis hit, caused by the country defaulting on its debts. The inflation skyrocketed to over 100% in 1999.

To support economic recovery, the Bank of Russia (Russia's central bank) embarked upon a managed float policy (IMF AREAER, 2001) with currency interventions as a main policy instrument in early 2000s. The exchange rate targeted was a currency basket comprised of USD and EUR. Another novelty introduced in 2004 was the fiscal rule which has been amended several times since then – the broad idea is setting aside extra oil and gas budget revenues. The fiscal rule has also been suspended several times to support the economy by injecting extra budget revenues, e.g. after the Global financial crisis (GFC). Bolstered by high oil prices, the Russian economy started to look up after being severely battered in the 1990s, and it kept growing after the GFC, with growth rates above the potential estimated at 1.5 – 1.8% year-on year (YoY) (Sinyakov et al., 2015).

Still, there was another battle to fight. In 2014, Russia's economy suffered a double whammy of sanctions imposed in response to Russia's "reclaiming", as Russian officials put it, the Crimean peninsula together with Brent oil prices dropping from over USD 130 per barrel to around USD 40 per barrel. Maintaining the exchange rate proved to be quite costly under the circumstances, and the Bank of Russia spent over USD 42 bn on FX interventions in October-December 2014. As this proved to be quite inefficient, a transition to the inflation targeting regime accelerated, with the RUB going into free float in late 2014. Under the new mandate, the Bank of Russia was to focus on price stability with policy rate as a main instrument. Due to the currency crisis caused by the above-stated reasons, inflation shoot up into double digits throughout 2015, but was then curbed, averaging 3.68% YoY vs. the target of 4% in 2017-19.

Another aspect pertinent to Russia's economy is the fiscal rule that has gone through several iterations over the years. As mentioned above, the first fiscal rule in Russia was introduced in 2004, with a part of state oil tax revenues above the cut-off oil price flowing into a separate fund supposed to cover budget deficit and external debt payments. The amount of spending from the fund was not limited, and, while in the fund, the money was supposed to be kept in foreign currencies. In 2008, the mechanism of the fiscal rule was amended. Oil revenue transfers to the state budget were limited over time to 3.7% of GDP, and the rest was supposed to be transferred to the country's sovereign wealth fund. However, it turned out that the limited oil revenue transfers were not sufficient for budget financing, and hence the oil revenue initially placed into the fund was transferred back to the state budget. In 2013, the fiscal rule was reverted to its initial configuration with certain amendment, namely changing the cut-off price setting and including gas revenues in the fiscal rule. However, this iteration of the fiscal rule was suspended shortly due to oil prices plummeting in 2014. Afterwards, the fiscal rule remained dormant until 2018. The 2018 modification of the fiscal rule was suspended in the second half of 2018 as the ruble depreciated drastically, and then it was functional until February 2022. Thereunder, oil and gas budget revenues above the cut-off price of 2017USD 40 are to be transferred to a sovereign wealth fund able to invest in domestic and foreign assets.

Currently, and for the most of the post-2014 period, several mechanisms that might have damaged the link between oil price inflation and CPI have been at play. Firstly, in the inflation targeting framework oil price forecasts are a measure of potentially elevated economic activity, hence the ability of the central bank to adjust the rates in order to counteract potential overheating and, consequently, inflation. Secondly, the fiscal rule, that currently sterilises oil and gas revenues by setting aside extra ones whenever the oil price exceeds the cutoff set at 2017USD 40 per Brent barrel, was switched on and off. Moreover, there is another mechanism that was introduced in 2018, the so-called damper mechanism. It virtually disbanded domestic fuel prices from global oil prices by means of an agreement with domestic oil companies implying that they are not to increase oil prices above the CPI level, while the difference between export oil prices and domestic fuel prices is either reimbursed to the companies if they sell at a discount on the domestic market or extracted from the companies if domestic prices exceed export ones. While the former two mechanisms control for indirect oil price spillovers to inflation, the latter one aims at curbing direct effects.

Additionally, the case of Russia's reforms is similar to that of Norway, although with a lag. The latter, also being an oil exporter, switched to inflation targeting in the early 2000s, with the formal introduction of the fiscal rule and creating a sovereign wealth fund, Oljefondet, in 1996. Norges Bank used to target the NOK exchange rate to a basket of currencies, and then switched to inflation targeting. Although fiscal rule configurations differ for each country (Norway directs all state oil revenues to the sovereign fund while Russia only does so for an amount exceeding the cut-off price), the macroeconomic gist of the reforms should be comparable, correcting for the size of economies.

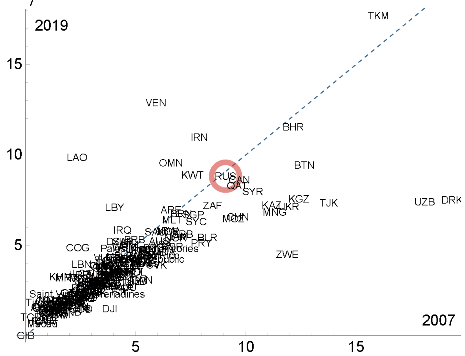
3.4 Stylised facts

Conventionally, oil shocks act as a harbinger for higher inflation rates through the channels discussed in Section 2.1. Oil price shocks have mostly been positive throughout the 20th century (the Yom Kippur War of 1973, the Iranian Revolution of 1979, and the First Gulf War of 1991). In the 21st century, oil price shocks, both positive, such as the Arab Spring, and negative, e.g. the aftermath of the GFC, persisted in having an impact on inflation, although it subsided to an extent.

Below follow some numbers pertinent to the role of energy and oil prices in Russia's economy and CPI.

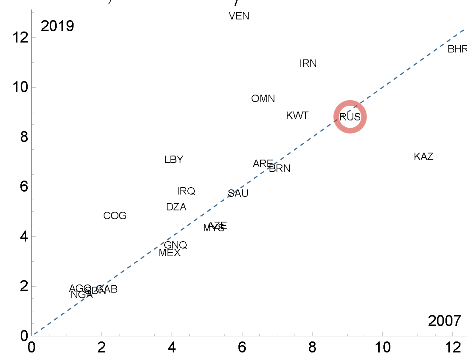
Firstly, let us consider energy intensity. Russia's figure for energy intensity is quite high as compared to both 197 world's jurisdictions and OPEC + countries. The figures, taken from US Energy Information Agency, exclude the countries if no data is available for either 2007 or 2019. The comparison of energy intensity on a global scale and for OPEC+ countries is presented in Figure 1a and Figure 1b, respectively. Russia's energy intensity as measured in 100 British thermal units per one 2015 USD

Figure 1a: Energy intensity, 100 Btu/2015$ GDP PPP



Source: US EIA

Figure 1b: Energy intensity, OPEC+ countries, 100 Btu/2015$ GDP PPP

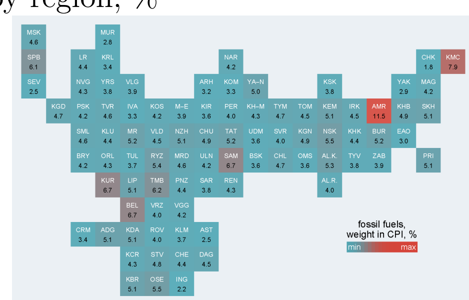


Source: US EIA

GDP PPP has not changed significantly since 2007. From this prospect, the influence of oil prices on the economy should not have changed, as the energy intensity has remained roughly the same even as most economies decreased their energy intensities.

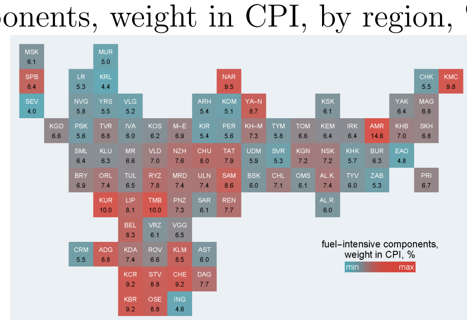
Additionally, let us examine the direct share of fossil fuels in Russia's consumer price index as reported by the Federal State Statistics Service (Rosstat). Currently, the weight of fossil fuels is relatively uniform region-wise (presented in Figure 2a), and the weight in all-Russian CPI stands at 4.7%. Still, if I add fossil-fuel intensive elements, such as transportation and some utilities, the distribution becomes more uneven (presented in Figure 2b). In the latter case, the weight of such constituents in Russia's CPI corresponds to 6.8%. Moreover, one is to keep in mind indirect impacts of fossil fuels on the price of various goods due to transportation costs. The weights are adjusted on an annual basis, and there have been no major changes throughout the period relevant for this paper.

Figure 2a: Fossil fuels, weight in CPI, by region, %



Source: Rosstat

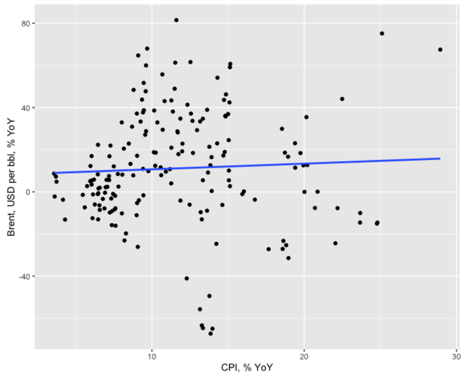
Figure 2b: Fossil fuel intensive components, weight in CPI, by region, %



Source: Rosstat

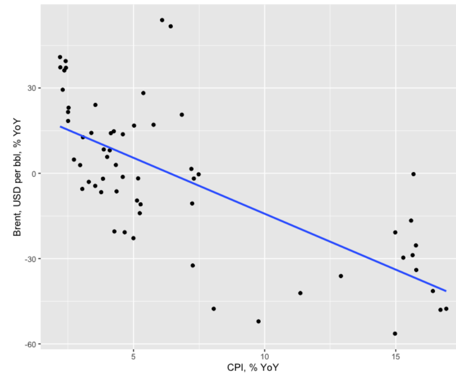
Next, consider a simple link between oil price inflation and CPI for Russia before and after inflation targeting. Below, the plots displaying annualised CPI and oil price inflation for periods 2000-2014 and 2015-2019 are presented. Oil price inflation is measured as the year-on-year change in Brent prices in USD per barrel and RUB per barrel, respectively, in Figure 3a and Figure 3b for USD and Figure 4a and Figure 4b for RUB. In both cases, while the link before late 2014 is (weakly) positive, it turns negative thereafter.

Figure 3a: CPI and USD oil price inflation before Dec 2014



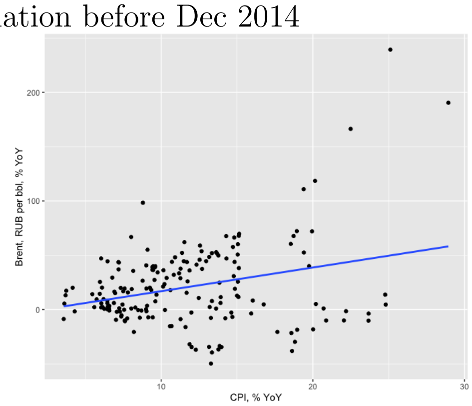
Source: FRED, CBR

Figure 3b: CPI and USD oil price inflation after Dec 2014



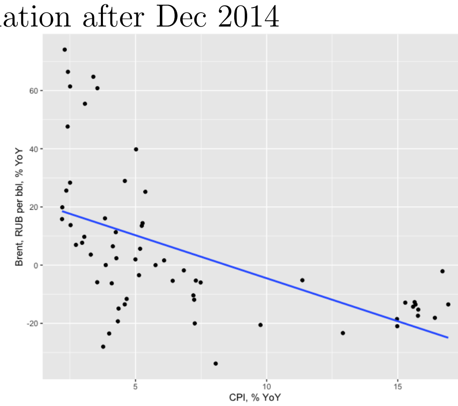
Source: FRED, CBR

Figure 4a: CPI and RUB oil price inflation before Dec 2014



Source: FRED, CBR

Figure 4b: CPI and RUB oil price inflation after Dec 2014



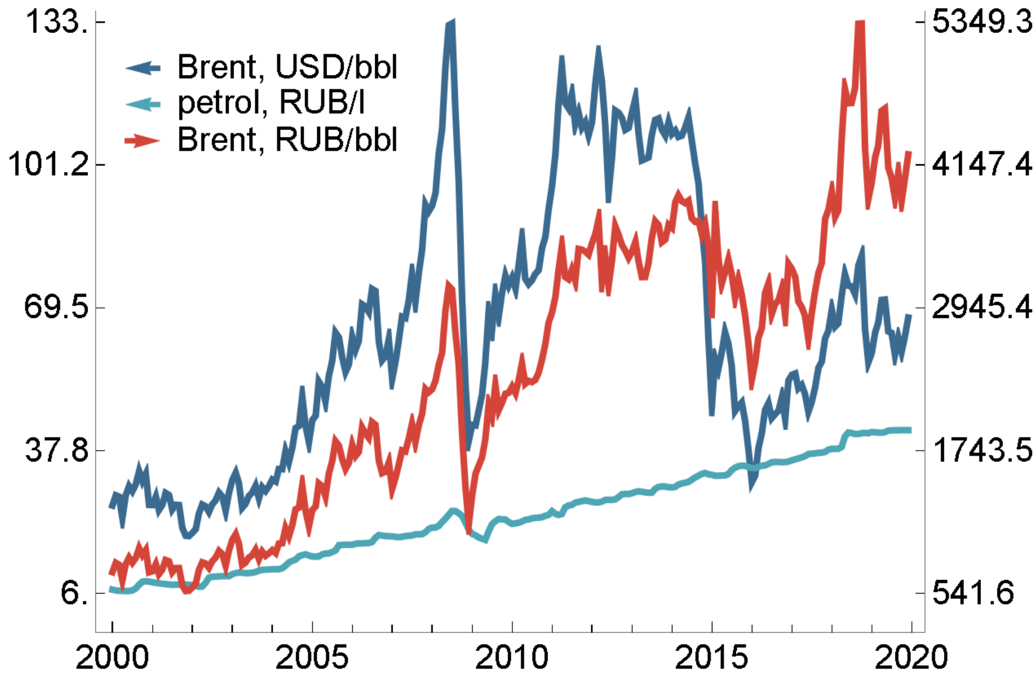
Source: FRED, CBR

Finally, let us examine changes in global and domestic oil prices. The former is expressed in USD and RUB per Brent barrel, while the latter is the RUB price for a liter of AI-92 fuel. Figure 5 shows that the changes in global oil price do not always translate into domestic fuel price changes, and even less so after 2018, when domestic fuel prices were decoupled from global ones.

Further, I look at changes in CPI, USD Brent price, RUB Brent price, and RUB fuel price expressed in YoY terms. Figure 6 demonstrates that prior to 2014 the dynamics of domestic fuel price were more closely aligned with those of global oil prices. However, after 2014 the changes turned less volatile and shifted closer to the CPI dynamics. These developments hint that the shift in fuel price setting must have happened, at least to an extent, before it was put on paper in 2018; it was rather an organic shift brought about by the set of monetary and fiscal reforms.

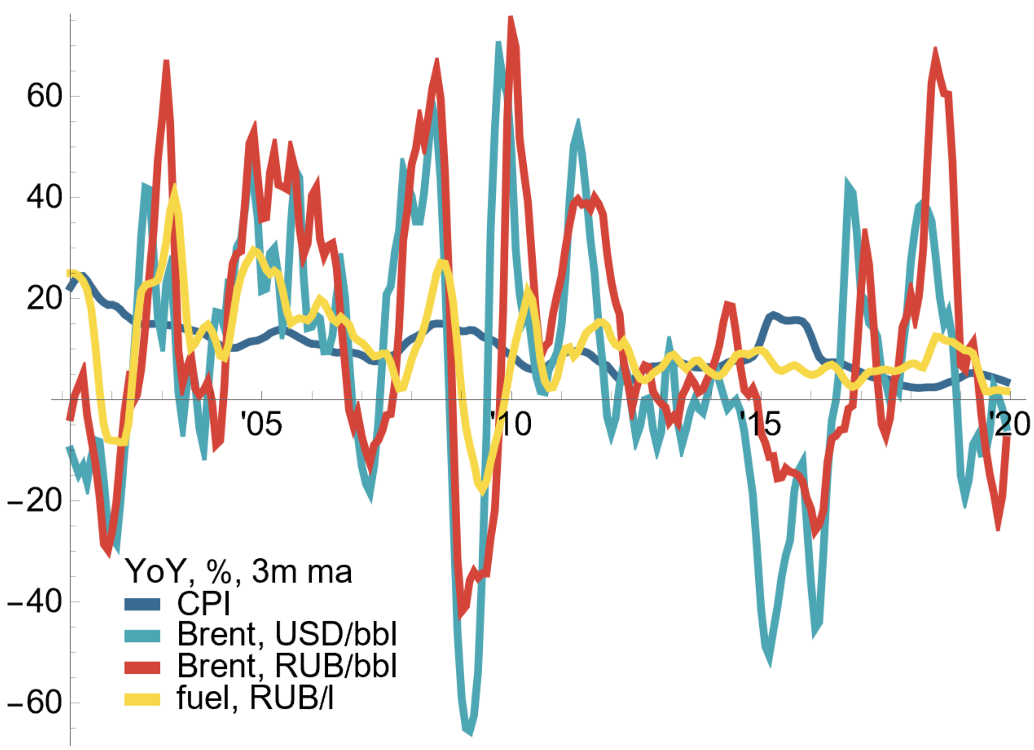
Thus, I establish that, in absence of major changes in either economy's energy intensity or fuel's share in the CPI, there must have been a change in the relationship between oil price and inflation. It is likely that this change was accompanied by a change in the relationships between other macroeconomic variables.

Figure 5: Global oil prices and domestic fuel price



Source: FRED, Rosstat

Figure 6: YoY changes in CPI, Brent price, and fuel price



Source: FRED, Rosstat

4 Data

To estimate the models discussed in detail in the next section, I use both Russia-specific and global data, with the former coming either from Russia's Federal State Statistics Service or the Bank of Russia, while the latter has been accessed via Federal Reserve Economic Data and encompasses data sourced by the US Energy Administration and the Federal Reserve System. Moreover, in the former category, Russia's short-term rate comes from the OECD database, and the nominal effective exchange rate comes from the Bank for International Settlements. Most data cover the period from 2000 up to 2019 with a monthly frequency. The period prior to 2000 is not included for two reasons: firstly, Russia's economy was volatile in the 1990s following the collapse of the Soviet Union, secondly, oil prices were low in the 1990s and had no significant impact on the country's economy (see Alekhina and Yoshino, 2018). A table featuring the series used and the source is included in Appendix 1.

To estimate Phillips curves, as presented in Section 4.1, monthly total CPI and core CPI have been used (with the latter starting only from 2003), together with the Brent oil price and industrial production index detrended using the Hodrick-Prescott filter with an appropriate frequency for monthly data. Monthly CPI is seasonally adjusted to exclude season-specific tendencies which are pertinent to some CPI categories (see Appendix 2 for seasonally adjusted vs regular CPI). Core CPI which is calculated as total CPI less food less fuel is less volatile and allows to discern the direct and indirect oil price spillovers (see Appendix 3 for a more detailed description of the two measures).

For non-Bayesian vector autoregressions, I use both total and core CPI, Brent oil price, industrial production index, USDRUB exchange rate, Russia's short-term rate, US Federal funds effective rate, and money supply M2. The choice of variables is suggested by De Gregorio et al. (2007), and I transform the variables to render them stationary, since that is the precondition to perform a VAR analysis. The following transformations have been made prior to the estimation: M2 has been seasonally adjusted prior to the log transformation (as money supply in Russia historically tends to upsurge every December), the CPI has been seasonally adjusted as well, and industrial production index has been detrended using the Hodrick-Prescott filter. Seasonal transformation has been carried out using the X-13ARIMA-SEATS seasonal adjustment algorithm. Moreover, some variables (see Section 4.2 for details) have been log-transformed. As a result, all variables except for the rates are approximately stationary and pass the Augmented Dickey-Fuller test indicating that there is no unit root. The ADF test results and the charts featuring the time series are presented in Appendices 4 and 5, respectively..

For Bayesian TVP VARs I use log differences of total (seasonally adjusted) and core CPI, detrended real GDP, short-term rate, log difference of nominal effective exchange rate index. The choice of variables and respective transformations aligns with Akram and Mumtaz (2015), and the data used are monthly instead of quarterly. It should be noted that the GDP data are not officially calculated on a monthly basis, thus I use the estimates provided by Russia's Ministry of Finance.

5 Methods

I employ three different methods, namely Phillips curve estimation, vector autoregression, and a Bayesian time-varying parameter vector autoregression. The latter one is more comprehensive, being the mainstay of the analysis, while the former two are more exploratory.

5.1 Phillips curve estimation

A Phillips curve with several lags of inflation, output gap, and oil price change is estimated, following De Gregorio, Landerretche, and Nelson (2007). I use data of higher frequency (i.e. monthly instead of quarterly) and modify the model accordingly: instead of four quarterly lags, I use twelve monthly lags. The specification is consistent with Zubarev (2018) who estimates several Phillips curve specifications for the Russian economy – however, without calculating the oil price pass-through.

The main specification for the Phillips curve is the following:

$$\pi_t = \alpha + \sum_{i=1}^{12} \hat{\beta}_i \pi_{t-i} + \sum_{i=0}^{12} \hat{\gamma}_i (y_{t-i} - \overline{y}_{t-i}) + \sum_{i=0}^{12} \hat{\theta}_i \mathrm{oil}_{t-i}^{US\$}, \tag{1}$$

where π is the monthly variation of consumer price index (CPI), y is the monthly variation of the industrial production index, with $\overline{y}$ being a Hodrick-Prescott filtered version thereof (i.e. $y_t - \overline{y}_t$ acts as a measure of the output gap) and $\mathrm{oil}^{US\$}$ being the monthly variation of the price of a Brent crude barrel in US dollars.

From (1), a measure of pure oil price change pass-through into inflation, as suggested by De Gregorio et al. (2007), is obtained:

$$\phi = \frac{\sum_{i=0}^{12} \hat{\theta}_i}{1 - \sum_{i=1}^{12} \hat{\beta}_i} \tag{2}$$

The pass-through coefficient measures the impact of oil price changes relative to the total changes in CPI excluding the autoregressive CPI part, thus capturing all the spillovers.

The Phillips curve is estimated using running windows of width equal to 60, i.e. five years, to obtain enough datapoints that would be consistently estimated given monthly data frequency.

Additionally, as a validity check, I estimate (1) and calculate (2) using the measure of core inflation, i.e. CPI less food less fuel and thus making sure that the spillover effect is not solely confined to fuel's share of the CPI.

Moreover, as Cunado and Perez de Gracia (2005) suggest, the relationship between global oil prices and domestic inflation may vary based on whether oil prices are measured in domestic currency or US dollars. This idea might be particularly relevant for commodity exporters, as oil price has a bearing on a country's terms of trade and exchange rate. Thus, I modify (1) to include oil price expressed in terms of the national currency, obtained by multiplying oil price in US dollars by the average USDRUB exchange rate. Thus, the specification is the following:

$$\pi_t = \alpha + \sum_{i=1}^{12} \hat{\beta}_i \pi_{t-i} + \sum_{i=0}^{12} \hat{\gamma}_i (y_{t-i} - \overline{y}_{t-i}) + \sum_{i=0}^{12} \hat{\theta}_i \text{oil}_{t-i}^{RUB} \tag{3}$$

From this modified specification, I calculate the oil price pass-through similar to (2), both for core and total CPI.

5.2 Vector autoregressions

Another way to assess the impact of oil prices on inflation is to perform analysis using impulse response functions based on vector autoregressions. This type of analysis accounts for more variables and hence gives a more comprehensive picture of the macroeconomic processes, while impulse response analysis enables one to identify shocks and their impact on other macroeconomic variables.

To estimate the impact of one standard deviation oil price shock on the consumer price index, firstly I set up a vector autoregression broadly following De Gregorio et al. (2007) with some alterations. While De Gregorio et al. (2007) perform estimations using rolling windows, I settle on a regular vector autoregression due to the limited time period, as the data from the 1990s are not reliable.

The estimations include both a constant and a time trend, the data used are monthly, and the model is estimated using ordinary least squares (OLS). The general representation of the system of equations is the following:

$$\mathbf{y}_t = c + b_i t + \sum_{i=1}^{p} \mathbf{\Phi}_i \mathbf{y}_{t-i} + \varepsilon_t, \tag{4}$$

with $\mathbf{y}$ being the vector of variables of interest and ε representing normally distributed errors in time t.

In the basic case, $\mathbf{y}$ includes the following variables: Russia's short-term rate, natural logarithm of the money supply M2 (here, we replace M1 used by De Gregorio et al. (2007) by M2 due to data availability, as trends in M1 and M2 are similar for Russia), natural log of the CPI, natural logarithm of the industrial production index, natural logarithm of the Brent oil price in US dollars, the US federal funds rate representing global monetary conditions, and natural logarithm of the USDRUB exchange rate.

To estimate the oil price pass-through, I perform impulse response analysis. Impulse responses of interest are the responses of CPI to a one standard deviation oil price shock. They are estimated for 10 periods ahead, together with 95% confidence intervals.

As the lower triangular Choleski decomposition is used to realise the impulse response functions, the variables are ordered based on their exogeneity, from less endogenous to more endogenous. The least endogenous variable is the oil price, followed by the US effective rate, Russian short-term rate (proxying the monetary stance), exchange rate, money supply, industrial production, and CPI.

Ordering the oil price as the least endogenous is consistent with Alekhina and Yoshino (2018) who study the oil-price pass-through specifically for Russia. Despite being in line with the existing literature, ordering the oil price as the most exogenous might seem questionable for oil exporters. Still, the issue of pushing the oil price either up or down is more pertinent to politics than to economic policy (at least in Russia's case) and is unlikely to be driven mostly by macroeconomic variables included in the VAR. Moreover, while domestic economic conditions might impact the supply side, the demand for oil is still global, hence the exogeneity of oil price. One more point to note is that oil price setting is a dynamic interaction wherein several oil exporters are at play, and not all of them have enough capacity to actually impact the market, while their incentives to do so are largely dependent on the costs of oil extraction defined by nature and technology (for details, see e.g. Asker et al., 2019). In a nutshell, the decisions to alter the current price level is both based not on the current macroeconomic variables but rather on long-term expectations and political issues and can be downplayed by other oil exporters. Thus, I abstain from challenging existing literature and follow the precedent already set, considering the oil price the most exogenous of the variables.

The results are also qualitatevely robust to changing the ordering of Russia's short-term rate due to the changes in the Bank of Russia policy instruments discussed above.

5.3 Time-varying parameter VARs

Along the lines of Akram and Mumtaz (2016), I estimate a Bayesian time-varying parameter VAR model to study the time-varying properties of the Russian economy. The model accounts for multivariate stochastic volatility, i.e. the error covariance matrix is not constant, allowing for variation in volatilities. While Akram and Mumtaz use quarterly data for Norway's economy, I employ monthly data on the Russian economy due to a shorter timespan. The baseline model includes data from 1999 to 2019, and with 50 observations for setting a prior and two lags, the actual estimates start in March 2003. Apart from this, I employ their method, and below I briefly recapitulate the points necessary for understanding the model, the estimation methods, and the results. I also add to their model by calculating time-varying impulse responses later on.

The model has the following specification:

$$\begin{bmatrix} O_t \\ Z_t \end{bmatrix} = c_t + \begin{bmatrix} B_{1,t}(L) & 0 \\ B_{2,t}(L) & B_{3,t}(L) \end{bmatrix} \begin{bmatrix} O_t \\ Z_t \end{bmatrix} + v_t \tag{5}$$

O_t is the detrended real oil price, and Z_t is a data vector including the macroeconomic variables of interest (a full account of the variables follows below), c_t is an intercept vector, $B_{i,t}$ with $i = 1, 2$ is a lag polynomial, and v_t represents innovations.

The oil price is assumed to be pre-determined with respect to country-specific variables and follows an autoregressive process. The price is for a barrel of Brent oil in US dollars, corrected for the price level and detrended using the Hodrick-Prescott filter with a frequency of 14,400.

The variables included in the Z_t vector are the following: $Z_t = \{Y_t, \Delta p_t, R_t, \Delta q_t\}$, where Y_t is the cyclical component of real GDP, Δp_t is the first difference of natural logarithms of the CPI, R_t is the short-term three-month rate, and Δq_t is the first difference of natural logarithms of the nominal effective exchange rate index measured as a weighted exchange rate with respect to the currencies of a country's trade partners.

Additionally, I augment the model by using the core CPI measure. However, this specification results in an even shorter timespan, as the figures are only available from January 2003, thus the actual estimation, given 50 observations for the prior and two lags, starts in mid-2007.

The coefficients behave in accordance with the following law of motion:

$$\tilde{\phi}_{l,t} = \tilde{\phi}_{l,t-1} + \eta_t, \tag{6}$$

where $\tilde{\phi}_{l,t}$ is a vector of time-varying coefficients, and η_t is a conformable vector of innovations.

$$VAR(v_t) = \Omega_t = A_t^{-1} H_t (A_t^{-1})' \tag{7}$$

is the covariance matrix of innovations, where A_t is a lower triangular matrix with non-zero and non-one elements evolving as driftless random walks:

$$\alpha_t = \alpha_{t-1} + \tau_t \tag{8}$$

H_t is a diagonal matrix with $h_{i,t}$ in the main diagonal being defined by geometric random walks:

$$\ln h_{i,t} = \ln h_{i,t-1} + \tilde{v}_t$$

The vector of innovations is assumed to be normally distributed in the following way:

$$\begin{bmatrix} v_t \\ \eta_t \\ \tau_t \\ \tilde{v}_t \end{bmatrix} \sim N(0, V) \text{ with } V = \begin{bmatrix} \Omega_t & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & G \end{bmatrix} \text{ and } G = \begin{bmatrix} \sigma_1^2 & 0 & 0 & 0 & 0 \\ 0 & \sigma_2^2 & 0 & 0 & 0 \\ 0 & 0 & \sigma_3^2 & 0 & 0 \\ 0 & 0 & 0 & \sigma_4^2 & 0 \\ 0 & 0 & 0 & 0 & \sigma_5^2 \end{bmatrix} \quad (9)$$

The equations (5)–(9) are estimated using the Bayesian methods. A detailed account of the priors follows below, while the posteriors are simulated using the Carter and Kohn algorithm (see Appendix 6), and stochastic volatilities are drawn using the date blocking scheme introduced in Jacquier et al. (1994).

A pre-sample to define initial conditions for the VAR coefficients ϕ_0 using an ordinary least squares estimate includes 50 observations. Suppose $\hat{v}^{ols}$ is the OLS estimate of the VAR covariance matrix on the first 50 observations, then:

- the prior for the H_t matrix diagonal is defined as $\ln h_0 \sim N(\ln \mu_0, I3)$ where μ_0 are the diagonal elements of the Cholesky decomposition of $\hat{v}^{ols}$;
- the prior for the off-diagonal A_t elements from (3) is $A_0 \sim (\hat{a}^{ols}, V(\hat{a}^{ols}))$, where $\hat{a}^{ols}$ represents the scaled off-diagonal elements of $\hat{v}^{ols}$, and the elements of $V(\hat{a}^{ols})$ are ten times the absolute value of the corresponding elements of $\hat{a}^{ols}$;
- the prior for Q from (5) is of inverse Wishart distribution, with $Q_0 \sim IW(\overline{Q}_0, T_0)$, and $\overline{Q}_0$ equal to $var(\hat{\phi}^{ols}) \times 10^{-4} \times 3.5$, T_0 equal to 50, i.e. the length of the initialisation sample; the prior for S is inverse Wishart as well, while the prior for G is inverse gamma.

Generally, the choice of priors follows Primiceri (2005), as they are intuitive and can be conveniently applied.

6 Results

6.1 Phillips curve

I have estimated oil price pass-through coefficients as discussed in Section 4.1. In a nutshell, I use an autoregressive distributed lag model which includes the lagged values of variation in the CPI, oil price, and industrial production as explanatory variables, together with the CPI as a dependent variable. It should be noted that some outliers, observed either in the early 2000 or during the Great financial crisis, have been removed using the interquantile range method. The break around late 2014 is more pronounced for core CPI due to its lower volatility, it is both observed visually and confirmed by applying the Bai and Perron (2003) algorithm. At the same time, the coefficient obtained from total seasonally adjusted CPI is more volatile. Nonetheless, the break is still there and again confirmed by the Bai and Perron (2003) algorithm. In the graphs, the number of observations (and hence the breakpoint position) differs for total CPI and core CPI due to the data limitations discussed in Section 3 and thus a shorter timespan for core CPI. The coefficients are plotted in Figure 7a and Figure 7b, respectively.

Additionally, I re-estimate the coefficients using the international oil price expressed in local currency. The main conclusion of the coefficient changing its sign around the time of reforms is still valid, and the coefficients are more negative for the RUB oil price, except for a one-off spike in 2019 for core inflation.

Figure 7a: Oil price pass-through to core CPI

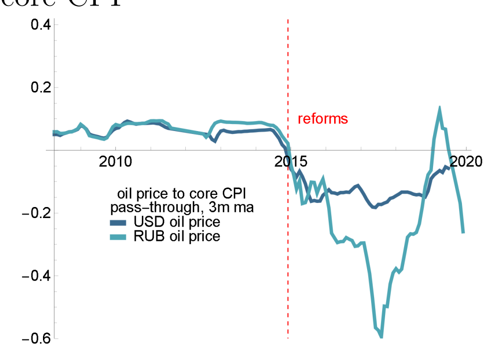
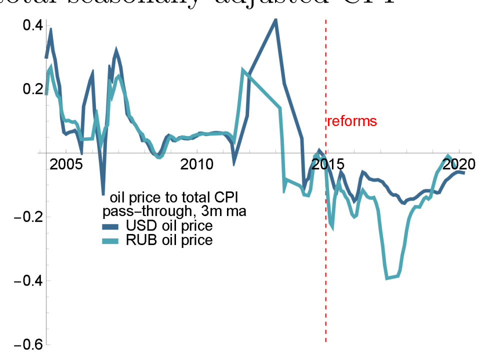


Figure 7b: Oil price pass-through to total seasonally adjusted CPI



6.2 VARs

Next, I estimate VARs as described in Section 4.2. The number of lags is 2 as chosen to minimise Hannan-Quinn information criterion which provides consistent estimates of the orders (i.e. has desirable sampling properties), and works well with large samples. For a more extensive motivation in choice of the criteria, see Chapter 4 in Lütkepohl (2005).

The underlying assumption is that there was a break in the regression in 2014 due to the monetary policy regime change discussed in Section 2. To test this assumption, I perform a Chow test for structural breaks for the moment around end-2014 in the VAR estimated for the whole period between 2000 and 2019. The results of the test do not support the null hypothesis of the coefficients being stable for the break in December 2014. Thus, as a baseline, I run two separate vector autoregressions of the same specification for two time periods.

The VARs are estimated for both total CPI and core CPI. Next, I estimate impulse responses of CPI to a one standard deviation shock in oil price. The results for total CPI are presented in Figure 8a and Figure 8b, while Figure 9a and Figure 9b feature the corresponding impulse responses for core CPI.

In both cases, while the impulse responses before reforms are hardly statistically significant, with the confidence intervals including zero, they move into negative territory after reforms, more so for the total CPI, and less so for core CPI.

Figure 8a: CPI, impulse response to oil price shock, before Dec 2014

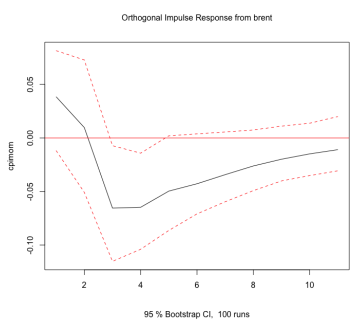


Figure 8b: CPI, impulse response to oil price shock, after Dec 2014

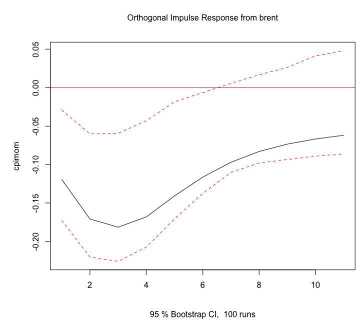


Figure 9a: Core CPI, impulse response to oil price shock, before Dec 2014

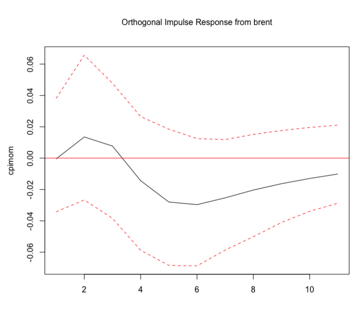
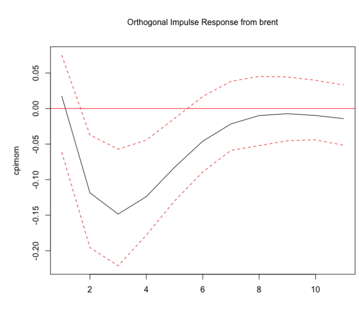


Figure 9b: Core CPI, impulse response to oil price shock, after Dec 2014



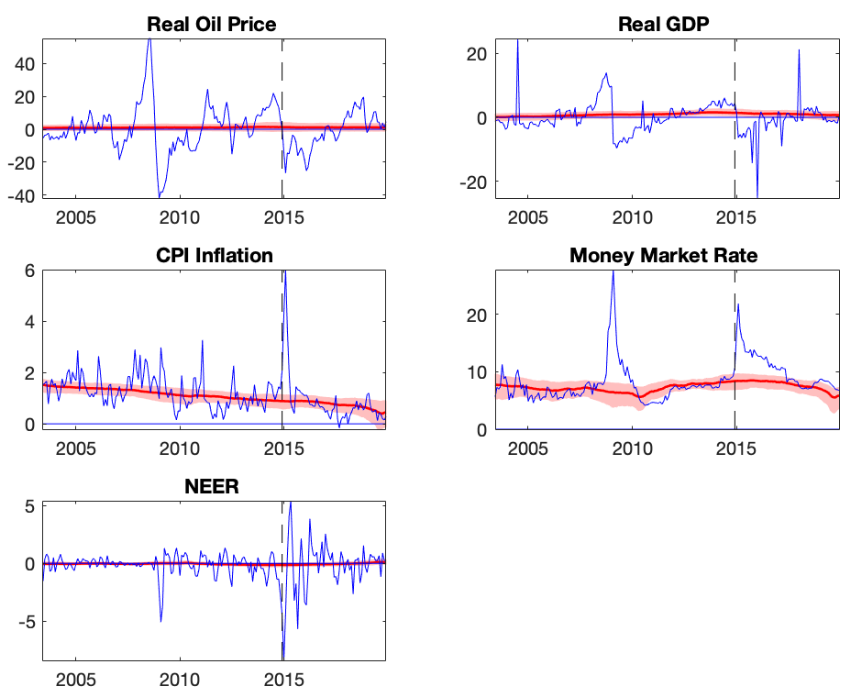
6.3 TVP VARs

6.3.1 Time-varying trends

Firstly, I consider time-varying trends of each respective variable by estimating the long-run unconditional means displayed in Figure 10a and Figure 10b for the measures of total and core inflation, respectively.

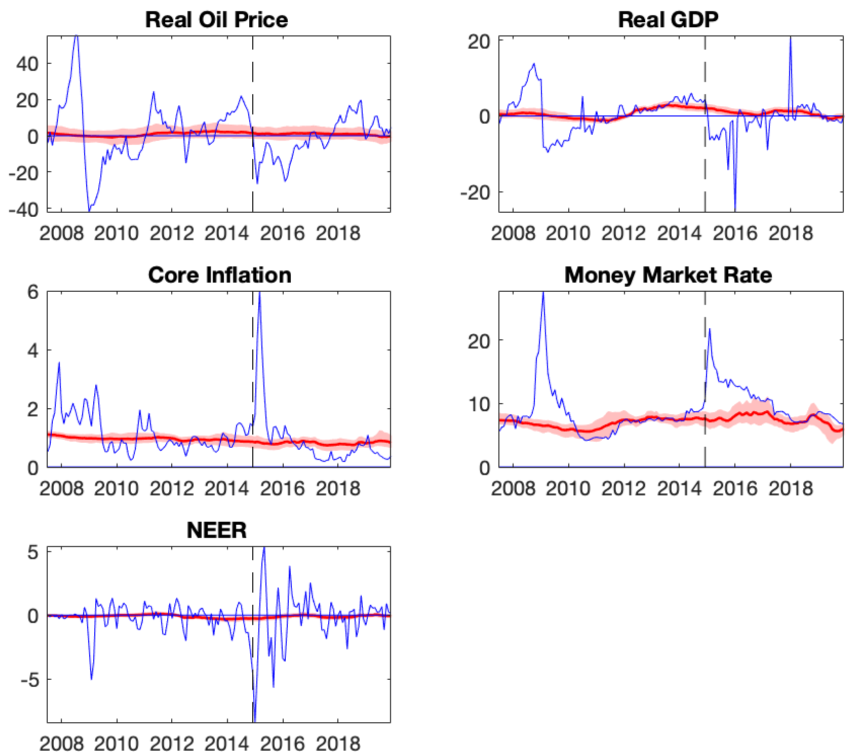
The most notable development is a persistent downtrend in the CPI inflation, while the detrended real oil price and real GDP demonstrate no significant shifts. The mean for the detrended nominal effective exchange rate remains approximately the same, with the actual data being volatile around the transition to the free float. The money market rate fluctuates to an extent, exhibiting a downward trend since 2014. At the same time, the long-run mean for the core inflation trends down to a smaller extent. As the core inflation excludes the most volatile components, viz. fuel and foods, the above-stated discrepancy might point towards either a decreasing impact of volatile components or a decreasing volatility thereof, with a possible reason being better policy conduct. Thus, if any policy measures were efficient throughout this period, they are likely to have targeted the more volatile total CPI.

Figure 10a: Long-run means – CPI



Red line is the median estimate, blue line is the actual data, and the shaded area is a 68% confidence interval

Figure 10b: Long-run means – Core inflation



Red line is the median estimate, blue line is the actual data, and the shaded area is a 68% confidence interval

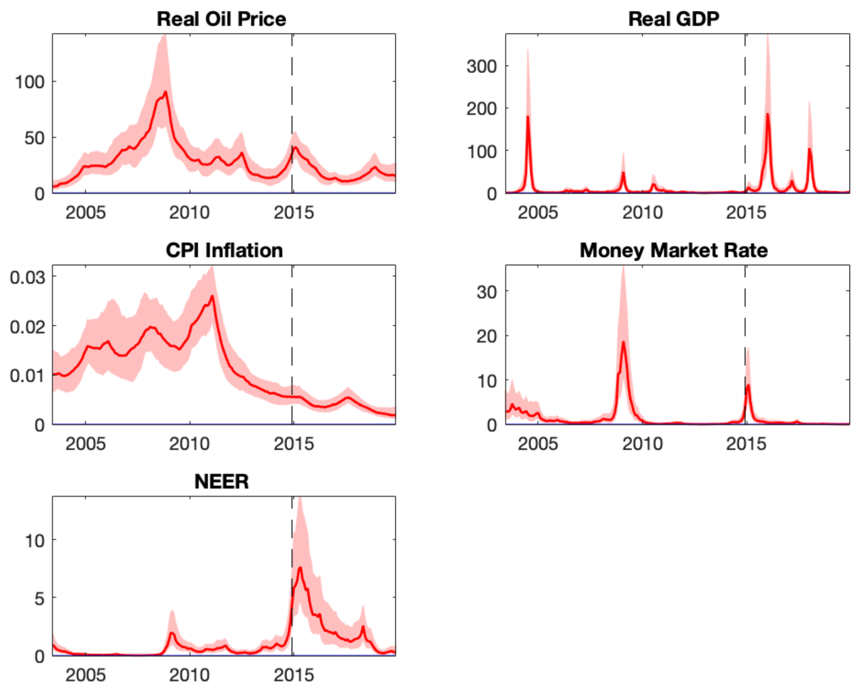
6.3.2 Volatility

To capture the evolution of macroeconomic volatility, I present stochastic volatility of shocks for total CPI and core inflation in Figure 11a and Figure 11b, respectively. Several facts stand out here. Firstly, the stochastic volatility in exchange rate increases after the reforms, consistent with the transition to the free float exchange rate regime, as the central bank ceases to "protect" the exchange rate. Secondly, the volatility of shocks to total CPI trends lower over time.

Additionally, I plot unconditional standard deviations for total CPI and core inflation in Figure 12a and Figure 12b, respectively. It should be noted that the volatility of shocks to the exchanges rate translates into the variation in the exchange rate changes, while the variation in total CPI does not trend down in a fashion similar to the volatility of shocks.

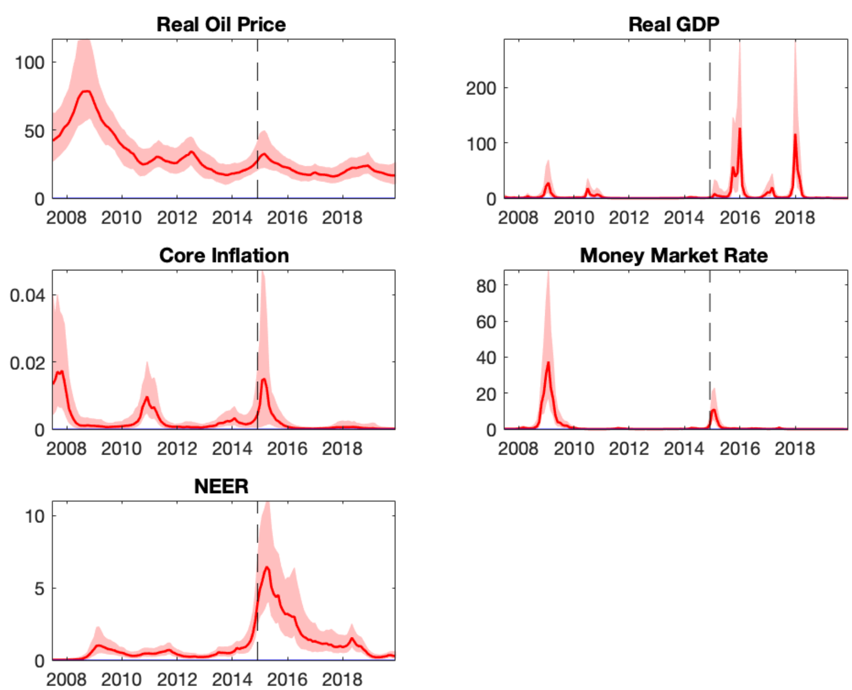
Moreover, I perform estimation assuming that there are no oil shocks and no monetary policy shocks. The results, presented in Appendix 7, mostly conform with the ones stated above. One thing to note is that a CPI spike in early 2014 becomes less pronounced in the absence of oil price shocks, confirming that the spike was to a large extent caused by a drop in oil prices of 2014. This fact is in line with the economic intuition of oil exporters being negatively influenced by decreasing oil

Figure 11a: Stochastic volatility – CPI



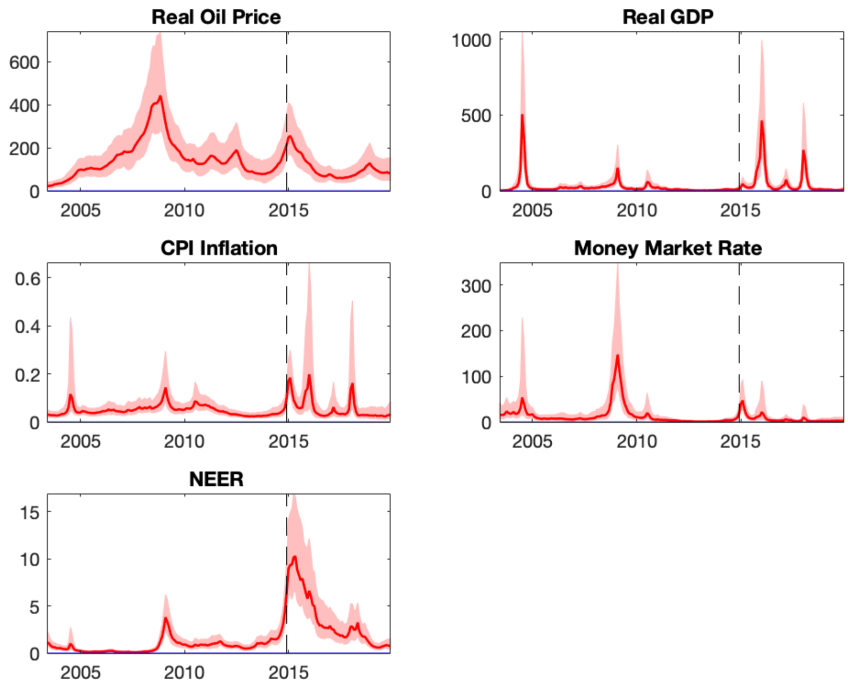
Red line is the median estimate and the shaded area is a 68% confidence interval

Figure 11b: Stochastic volatility – Core inflation



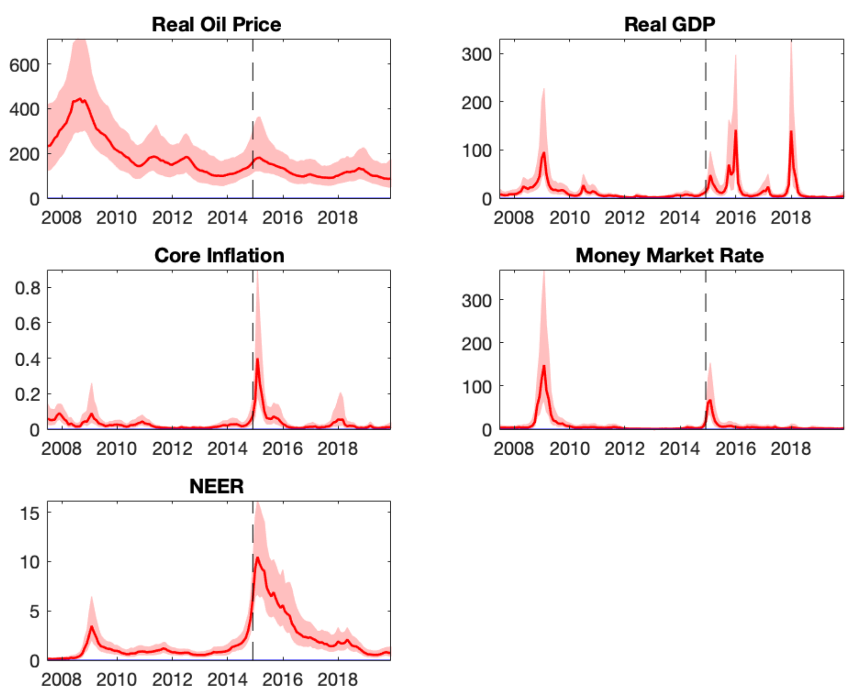
Red line is the median estimate and the shaded area is a 68% confidence interval

Figure 12a: Unconditional standard deviation – CPI



Red line is the median estimate and the shaded area is a 68% confidence interval

Figure 12b: Unconditional standard deviation – Core inflation



Red line is the median estimate and the shaded area is a 68% confidence interval

price.

6.3.3 Dynamic correlations

To study time-varying comovements, I estimate long-run dynamic correlations, each estimated for a specific point in time and corresponding to a cycle of 60 years. The measure comes from Croux et al. (2001) based on the VAR implied spectral density matrix of endogenous variables:

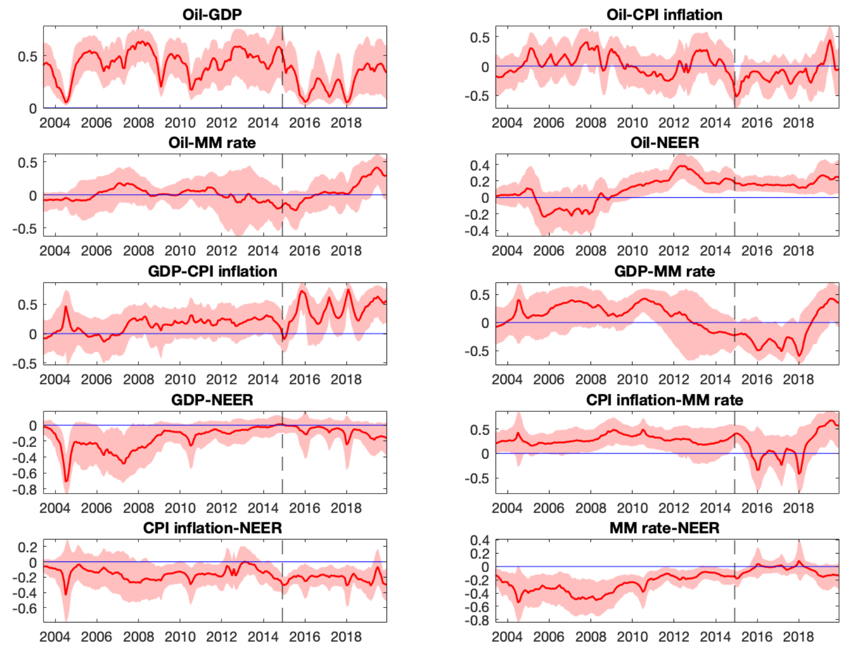
$$\frac{\hat{c}_{ij}(\omega)}{\sqrt{\hat{f}_t^{ii}(\omega)\hat{f}_t^{jj}(\omega)}},$$

where i and j are the variables of interest, $\hat{c}_{ij}(\omega)$ is the cospectrum between the variables at frequency ω, and $\hat{f}_t^{ii}(\omega)$ is the spectral density matrix. To put it simple, spectral density is analogous to autocorrelation, but measured in terms of frequency rather than time. Thus, the dynamic correlation as specified above for the bivariate case demonstrates the degree of the variables being synchronised. The measure is bound by -1 and 1, and the upper bound means that the variables are perfectly synchronised.

Figure 13a and Figure 13b display the dynamic correlations between the variables included in the VAR. The figures demonstrate that the Russian economy covaried less with oil prices for some time after 2014. However, the correlation rolled back after a couple of years. Another feature of note is that the correlation between oil price and money market rate has been trending up after 2014, while the correlation between oil prices and CPI, after being weakly positive before 2014, dived into a negative territory (although borderline significant), returning to positive in 2019. A similar trend is seen in the correlation between GDP and the money market rate, hinting at monetary policy stimulus after the hit of 2014. At the same time, the dynamic correlation between money market rate and nominal effective exchange rate has gotten closer to zero over time, up from being significantly negative in 2000s.

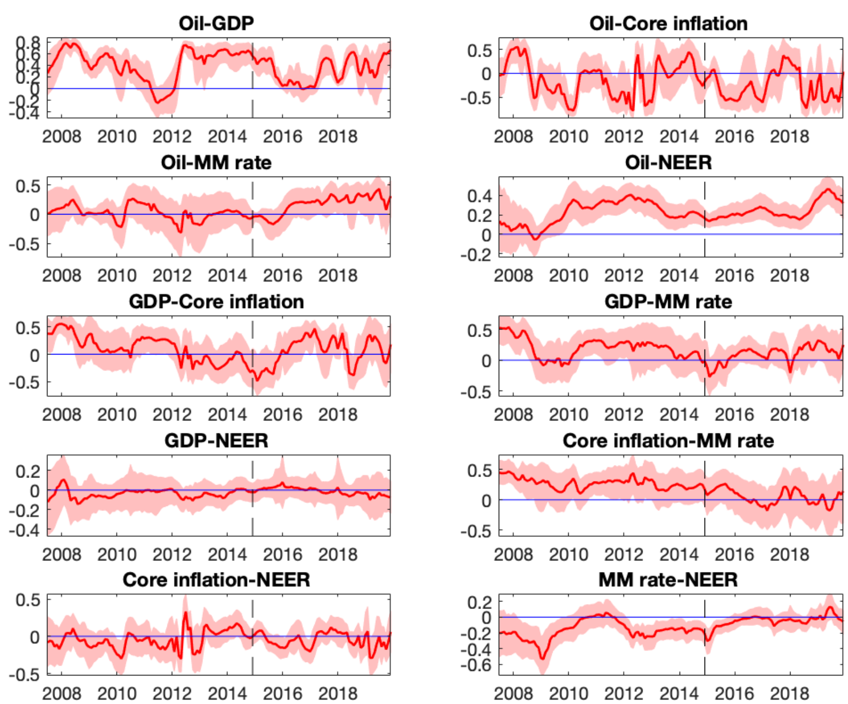
Dynamic correlation between oil and exchange rate has been positive since the Great financial crisis, i.e. higher oil prices correspond to currency appreciation. What seems puzzling is that in the post-2014 period the correlation has been positive and approximately level for some time, despite the fiscal rule having occasionally been suspended (see Section 2 for a brief recap of the evolution thereof). The effect is valid for both core inflation and total CPI.

Figure 13a: Dynamic correlations – CPI



Red line is the median estimate, the shaded area is a 68% confidence interval

Figure 13b: Dynamic correlations – core inflation

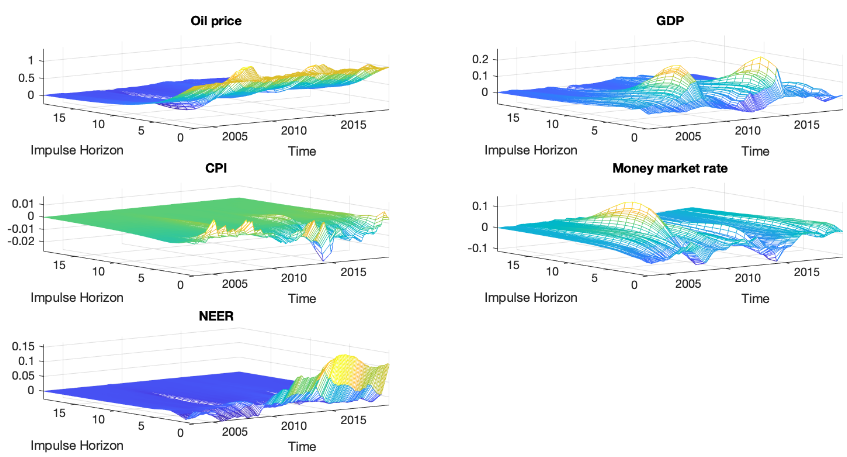


Red line is the median estimate, the shaded area is a 68% confidence interval

6.3.4 Impulse responses

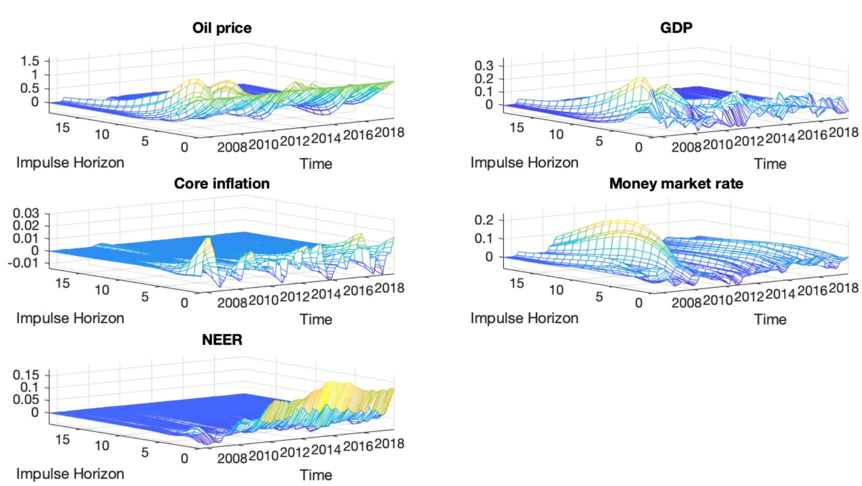
I extend the method employed by Akram and Mumtaz (2016) by calculating impulse responses for time-varying parameter models for a vector of variables, incl. oil price, GDP, measures of total/core inflation, money market rates, and nominal effective exchange rate, in a fashion similar to Primiceri (2005). This is a natural addition to the VAR analysis presented above, as the time-varying impulse responses provide more evidence on the response dynamics. The impulse responses to a one standard deviation oil price shock are orthogonal, they are calculated for the models with total and core inflation, and the responses can be contemporaneous. The results are presented in Figure 14a and Figure 14b, respectively.

Figure 14a: Impulse responses – CPI



Orthogonal impulse responses to a one standard deviation oil price shock

Figure 14b: Impulse responses – core inflation



Orthogonal impulse responses to a one standard deviation oil price shock

In line with economic intuition for an oil exporter, GDP responds positively to an oil price shock. Towards the end of the period, the response becomes more muted, pointing towards a potential decrease in the economy's oil dependency, which is partly confirmed by non-commodity exports gradually increasing. The response of the money market rate has no notable pattern or shift following policy changes, and nominal effective exchange rate responds positively (i.e. the national currency appreciates). The response of the exchange rate is in line with the economic intuition, with the national currency appreciating to a smaller extent at times when the fiscal rule was operational.

While core inflation demonstrates no response pattern, the total CPI responses turn negative in late 2014 and remain so until mid-2019. This is in line with the results obtained from regular VARs in the previous section. A potential explanation thereof is a de-facto suspension of the fiscal rule in 2015-17, as, based on the economic intuition, in the absence of fiscal rule ceteris paribus the national currency of an oil exporter should strengthen in response to an oil price increase, thus driving down the imported inflation. Additionally, the period of the fiscal rule suspension in 2H2018 has expanded the length of the CPI response being negative. In this period, the response remained negative, although much closer to zero compared to 2015-17.

6.4 Discussion

In brief, the results above show that there indeed have been shifts in the relationships between macroeconomic variables over time and around 2014, including, but not confined to, global oil price and inflation.

With respect to the global oil price pass-through, numerical results demonstrate that the pass-through to domestic inflation did change for Russia after 2014. The results of the Phillips curve estimation are qualitatively robust to the oil price being expressed in domestic currency. Moreover, the time-varying impulse responses paint a comparable picture.

A weakly positive pass-through turned into a significantly negative one, which essentially means that rising oil prices contribute to inflation slowing down. This is broadly in line with Norway's case as studied in Bjørnland (1997), where impulse responses of total CPI to oil price shocks are in the negative territory in the period between 1973–1994, i.e. in the absence of both fiscal rule and inflation targeting. Moreover, there is no definite switch in the pattern of the money market rate response to oil shocks in Russia's case with transition to inflation targeting. Thus, monetary policy changes are unlikely to have been the driver behind the negative pass-through. Still, there could be several other channels playing a part here.

A plausible option would be to attribute this to the fiscal rule developments, with the total CPI inflation impulse response going negative due to the local currency strengthening to a greater extent when the fiscal rule is suspended.

Moreover, administrative mechanisms of changing the domestic fuel pricing might have been the reason behind the changing pattern, as fuel price spillover to inflation has a more direct bearing on domestic CPI compared to the global oil price.

Still, the last factor is difficult to quantify. The very direct channel of oil price spillovers, i.e. the price of fuel, does impact the domestic CPI. With the fuel pricing mechanism amended in 2017-2018, the change in domestic fuel prices became essentially endogenous to inflation rate. Moreover, the initial research question pertains to the global oil price shocks, and hence this point does not directly fall within the scope of this paper.

However, I find no indication that monetary policy intervened with the influence of oil price shocks, both direct and indirect. Moreover, two out of three methods show that there have been no significant changes with respect to core CPI, thus indicating that the changes mostly pertain to a more volatile inflation measure.

A natural question that occurs to anyone is whether the identification strategy is suitable. While acknowledging the fact that, for oil exporters, the bearing of the oil price is more complicated compared to oil importers, I believe that, in line with the existing literature, the methods I use are applicable to oil exporters as well. What, however, should be noted is that the influence of oil price on the oil-exporting economy is not solely confined to inflation rate, hence the necessity for a comprehensive estimation of the economy, in this case performed by Bayesian methods, and the results thereof are in line with those of the pass-through estimation using the Phillips curve for total CPI.

Bayesian analysis confirms that there has been a change in the dynamic correlation between oil price and inflation following the reforms. Moreover, I have found that the stochastic volatility of the CPI in the pre-reform period is connected to the oil price shocks. Time-varying impulse responses also point toward a negative oil price pass-through to inflation after 2014.

What, however, should be acknowledged is that the analysis I have performed is not strictly causal, as it leans more towards descriptive measures, although confirmed by means of Bayesian estimation. The impulse responses are not exactly a causal analysis either, as the model is not fully structural and hence might fail to capture some causal relationships and to identify shocks in a proper way. To establish causality, one needs to come up with proper identification mechanisms that would be able to distinguish between the effects of each respective policy change. Still, most of the methods I use point to the same results, showing that the results are robust.

7 Conclusion

I have studied the time-varying properties of Russia's economy with a focus on oil price shocks pass-through to inflation using Bayesian techniques. While there indeed is a qualitative switch from weakly positive to negative in the inflation responses to a positive oil price shock in late 2014, it is unlikely to be attributed to the effects of monetary policy, but rather to the fiscal rule developments.

The results, in addition to a TVP–BVAR, are mostly confirmed by Phillips curve estimation and a non-Bayesian VAR, indicating that in late 2014 there was a break in the macroeconomic relationships in the economy.

A further point on the research agenda might be extending the sample to other oil-exporting counties to have a better understanding of the impact of policy shifts on macroeconomic responses. Further on, one can motivate a dynamic stochastic general equilibrium (DSGE) model by the existing empirical results to identify causal relationships in a better way.

With respect to policy conclusions, one might argue that, in order to isolate the economy from external shocks, the response of domestic inflation to oil shocks should be contained in the insignificant interval close to zero, and thus discretionary policy resulting in switching the fiscal rule on and off is not the best option. However, it has been shown (Isakov et al., 2022) that the Russian fiscal rule suspensions are more likely to be guided by overshoots in USDRUB volatility rather than broader economic considerations. If the starting point had been somewhere in late 2021, a rational path would have been to gradually shift towards a more systematic macroeconomic policy. However, as of today, in May 2022, the Russian economy is likely to undergo a complete overhaul, one way or another.

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Appendix 1: Data sources

Series	Source
Consumer price index, total	Rosstat
Consumer price index, core	Rosstat
Money supply M2	Bank of Russia
Industrial production index	Rosstat
RUB exchange rate	Bank of Russia
Nominal effective exchange rate	Bank for International Settlements
Fuel price (Russia)	Rosstat
Short-term rate	OECD
Federal funds effective rate	Federal Reserve via FRED
Brent oil price	US Energy Administration via FRED

Appendix 2: Seasonal adjustment

Figure 15: CPI MoM, %, original vs. s.a.

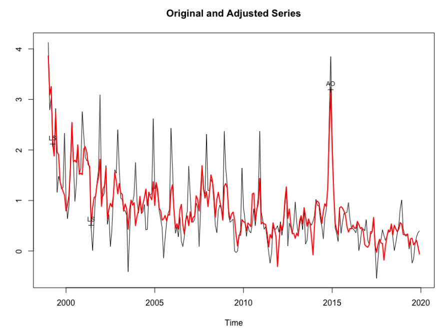
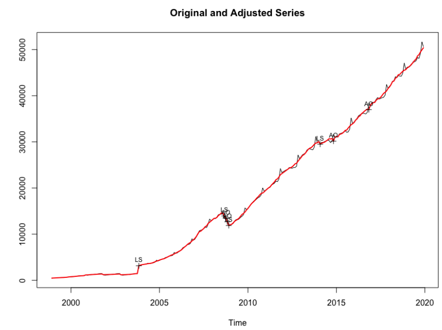


Figure 16: M2, RUB mn, original vs. s.a.



Appendix 3: CPI vs. core CPI

Consumer prises in Russia are reported by the Federal State Statistics Service (Rosstat). Prices are observed on a weekly/monthly basis in 282 localities across the country. The details of the monthly indices, which are employed in this paper, follow below.

The measure of total CPI includes 556 items, including goods (both food and non-food) and services. This measure is quite volatile, being subject to seasonality.

Core CPI is less volatile due to the goods with high price seasonality being excluded. The measure of core CPI includes 413 goods and services. The item groups excluded from total CPI to obtain core CPI are the following: fruit and vegetables, alcoholic drinks, fuel, clothes subject to seasonality (e.g. overcoats), medicines, transportation, and education services.

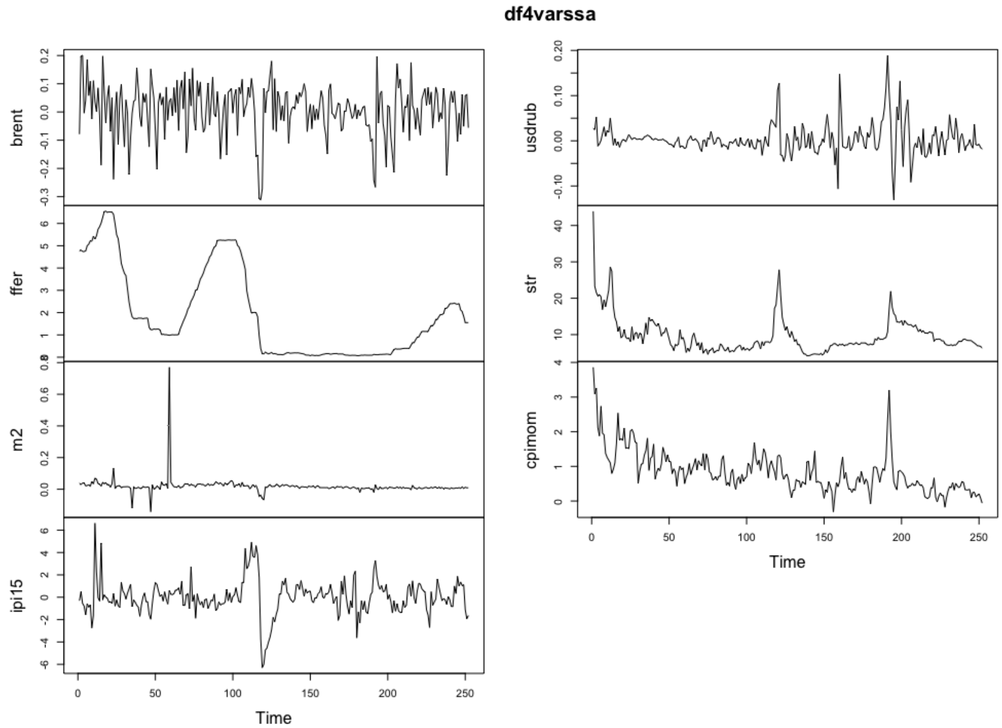
Appendix 4: ADF test results

In the Augmented Dickey-Fuller Test, the null hypothesis is that there is a unit root in a time series. With no drift and no trend, the critical value of the test statistics is -1.95 at the 95% significance level.

Variable	**Test statistics**	H_0 **rejected**
Brent	-9.9683	yes
USDRUB	-9.9755	yes
M2	-8.5984	yes
Federal funds effective rate	-1.7564	no
Short-term rate	-2.1363	yes
Inflation	-3.4612	yes
Industrial production	-6.2751	yes

Appendix 5: Stationary series

Figure 17: Time series for VARs



Source: FRED, Rosstat, OECD, Bank of Russia

Appendix 6: Carter and Kohn algorithm

Carter and Kohn (1994) introduce a forward filtering backward sampling algorithm that I use to simulate the coefficients and off-diagonal elements of the covariance matrix. A brief outline of the algorithm are presented below.

Initially one needs to employ the Kalman filter to produce filtered states. Firstly, the conditional forecast error is obtained which is given by $y_t - \hat{y}_{t|t-1}$ and the variance thereof. Then the filtered values are estimated in the following way:

$$b_{t|t} = b_{t|t-1} + K_t(\hat{y}_{t|t-1}) \tag{10}$$

$$Var_{t|t} = Var_{t|t-1} + K_t H Var_{t|t-1} \tag{11}$$

where

$$K_t = Var_{t|t-1} H' F_t^{-1} \tag{12}$$

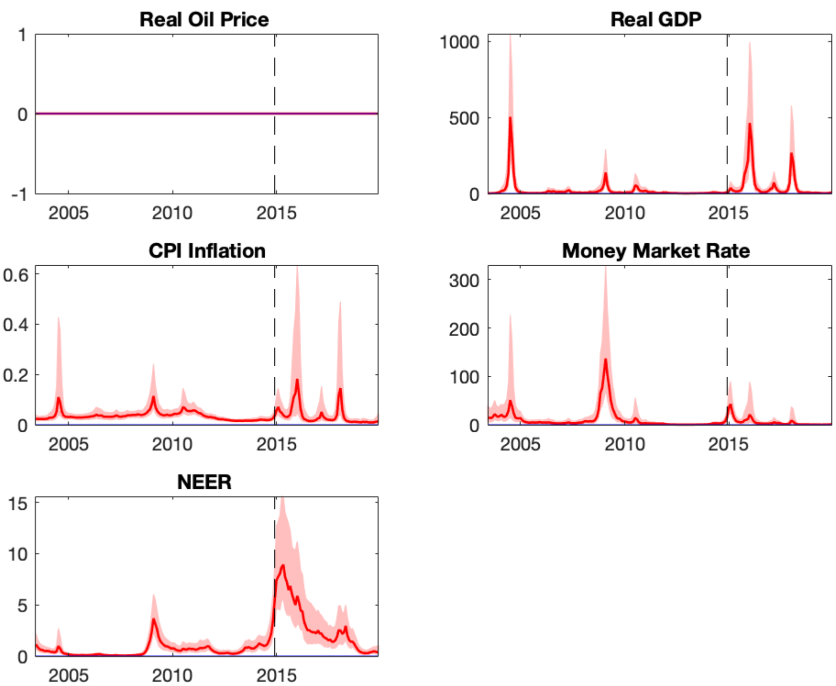
is proportional to the Kalman gain and F_t is the variance of the conditional forecast error.

Next, I draw from the multivariate normal distribution defined by betas and variances we have obtained.

Then I proceed with the backward sampling having the sequence of filtered states $\{b_{t|t}\}_{t=1}^{T}$ and $\{Var_{t|t}\}_{t=1}^{T}$. Starting at time T, I draw β_T^+ from the multivariate normal distribution with the location and scale parameters defined by the last filtered state, i.e. $b_{T|T}$ and $Var_{T|T}$. For $t = T-1, T-2, ...1$, we draw β_t^+ from the multivariate distribution defined by EA_t and VA_t determined by the filtered states together with the forecast error variation.

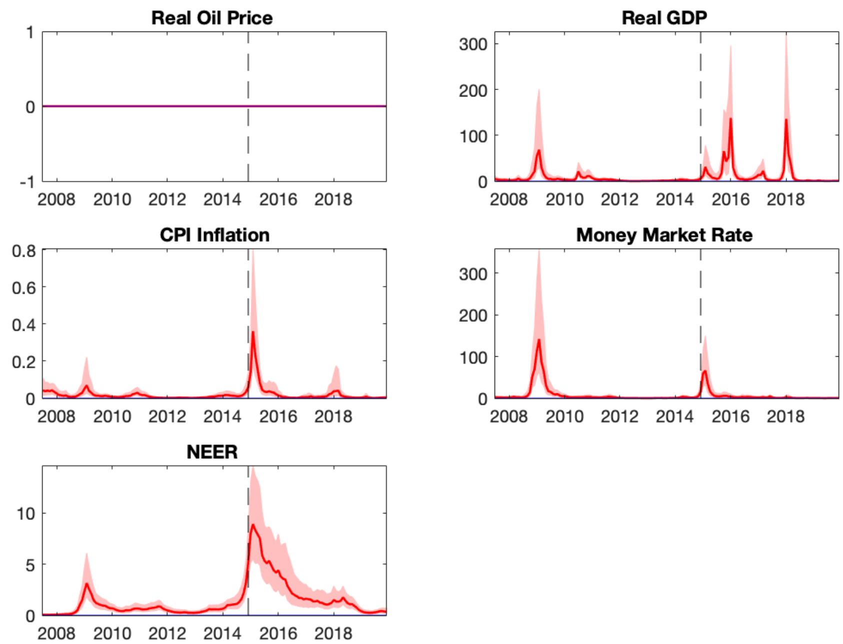
Appendix 7: Volatility excluding oil price and monetary shocks

Figure 18a: Unconditional standard deviation – CPI – no oil price shocks



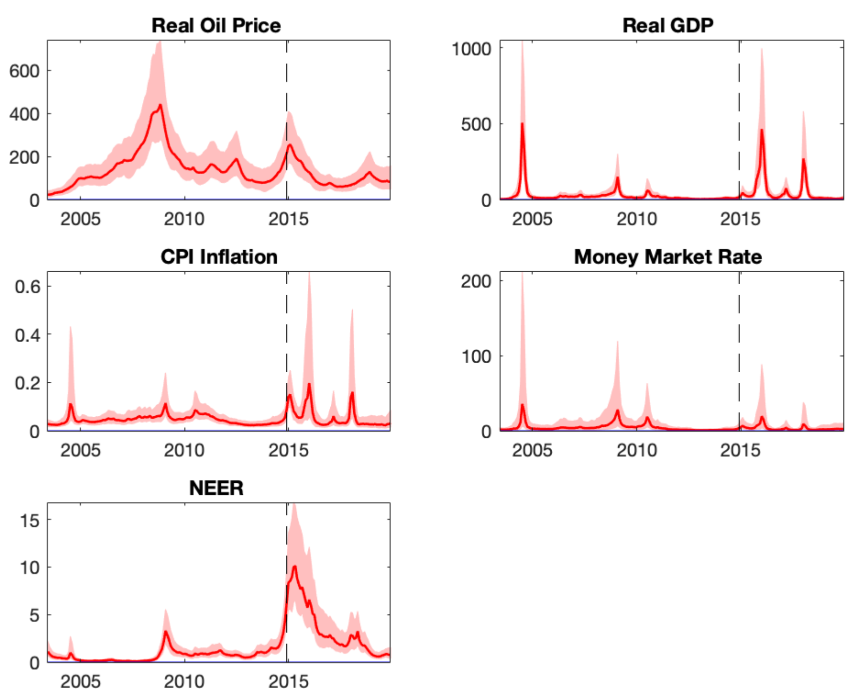
Red line is the median estimate and the shaded area is a 68% confidence interval

Figure 18b: Unconditional standard deviation – Core inflation – no oil price shocks



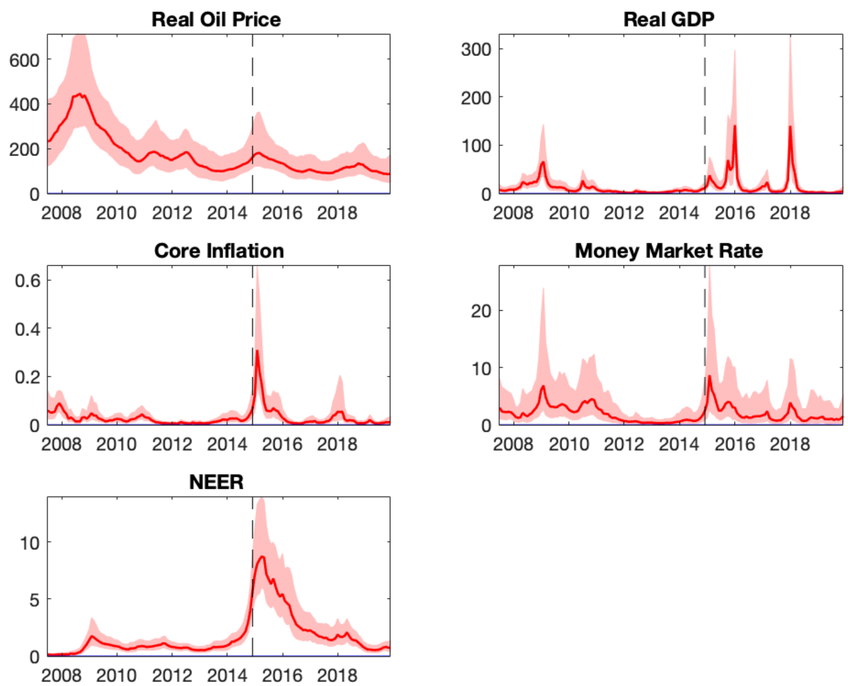
Red line is the median estimate and the shaded area is a 68% confidence interval

Figure 19a: Unconditional standard deviation – CPI – no monetary policy shocks



Red line is the median estimate and the shaded area is a 68% confidence interval

Figure 19b: Unconditional standard deviation – Core inflation – no monetary policy shocks



Red line is the median estimate and the shaded area is a 68% confidence interval