Oil Prices Shocks and the Russian Economy

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Abstract

We investigate the relationship between the price of oil for domestic companies and main economic activity in Russia, measured as the price-adjusted output of agricultural production, mining, manufacturing, production and distribution of electricity, gas and water, construction, transport, retail and wholesale trade. In addition, we use indices of industrial production, mining, production, and the production and distribution of electricity, gas and water separately to examine the effects of oil price changes on various activities. We find that oil prices are procyclical and lead the business cycles. Considering the response to oil price shocks, we find that positive shocks in oil prices have had a positive and statistically significant impact on almost all types of Russian economic activity. Taking into account possible structural changes led by the economic crisis in Russia in 2008-2009, we find a negative response to a positive shock in oil prices in eight months both for main economic activity and mining. Examining causal relationships, we find the domestic oil prices do Granger cause main economic activity, industrial production and manufacturing which is consistent with the cyclical properties.

Key words: Russian economy, business cycle, oil price shock, Granger causality

1. Introduction

Russia is one of the world's leading producers and exporters of oil and natural gas. Oil and gas sector products accounted for more than 65% of Russian exports before the fall in mineral prices in 2015, and made up more than half of Russian export in 2017-2018. Russia's main competitors in the global oil and refined oil market are Saudi Arabia and other OPEC countries, note that the United States has taken the lead in this market (Ruble 2019). Crude oil, oil products, and natural gas accounted for more than 50% of the Federal budget revenue in 2014 (Sergi and Berezin, 2018) and more than 46% in 2018[1]. So it is not a question whether the economic activity in Russia is tied with the world market for crude oil. However, whether Russia suffers from the Dutch disease (Pavlova *et al.*, 2017) or mainly benefits from growing global demand for commodities is a debate among economists.

Among studies on the impact of oil prices on macroeconomic and financial indicators in Russia, it is worth to mention papers on the impact of oil prices on the Russian stock market (Hayo and Kutan, 2005; Peresetsky, 2011; Korhonen and Peresetsky, 2016; Balashova, 2018). The co-integrated VAR model is used to empirically investigate the effects of oil price and monetary shocks on the Russian economy covering the period 1995:Q3-2007:Q4 in Ito (2008). In Kuzmenko *et al.* (2017), the vector error correction model (VECM) based on Johansen co-integration techniques, is used to examine whether GDP growth in Russia is tied up with crude oil prices and the real effective exchange rate. Moreover, the influence of oil prices on GDP

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[1] Minisrty of Finance of the Russian Federation
https://www.minfin.ru/ru/statistics/fedbud/?id_65=80041&page_id=3847&popup=Y&area_id=65

growth and other macroeconomic indicators in Russia is examined in Melnikov (2010) and Balashova *et al.* (2018).

However, the literature mainly considers the effects of world crude oil market prices on the Russian economy. We contribute to the literature by examining the interrelation of crude oil prices in the domestic market with the level of economic activity in Russia. Prices for crude oil in the domestic market depend upon prices in the global market, of course, but also depend upon fiscal policy and exchange rates. We examine the effects of changes in oil prices for domestic companies on various types of economic activity in Russia, considering main economic activity, industrial production, manufacturing, mining and production and distribution of electricity, gas and water.

To address the issue, we use several modern econometric tools. In section 1 we describe the data. In section 2, we investigate the relation between the cyclical component of oil prices and economic activity time series. In doing so, we use the Hamilton (2018) regression filter as a detrending method. We find that oil prices are procyclical which consistent with the literature (Serletis and Kemp, 1998). In section 3, we examine the time-series properties of the variables and test for unit roots using various alternative testing procedures. In section 4, using the results of unit root test, we design a bivariate VAR model linking economic activity and oil prices for domestic companies. We test for structural changes in the relationship between oil prices and economic activity caused by the economic crises 2008-2009. In section 5, we determine the framework within which we conduct the Granger causality analysis. The final section concludes the paper.

2. The Data

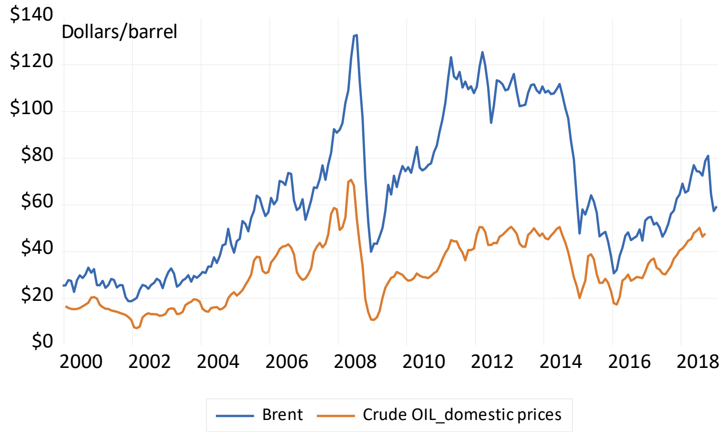
We use monthly data for output and the real domestic prices of oil for various sample periods depending on availability of comprehensive data.

The Russian Federation State Committee on Statistics (here and after Rosstat) measures the domestic price of oil as the average purchase price of crude oil for domestic companies. The average purchase price takes into account the influence of both the price factor and changes in the terms of purchase, the ratio in the acquisition of resources with different quality characteristics and different price levels, seasonality, etc. Rosstat provides data on oil prices at monthly frequency only since 2009: 01, and before that at quarterly frequency. So we use low to frequency quadratic conversion method for the period 2000-2008.

The dynamics for domestic oil prices follow the dynamics of global prices (see Figure 1). It is worth to note that in the Russian economy, oil companies are subject to two types of “oil” taxes: a mineral extraction tax and an export duty on oil and oil products whose rates are tied to export oil prices. The current taxation system for oil companies has been in force since 2002. The difference between the world market price and the local price is mainly export duties. Export duties on oil and petroleum products, in addition to their fiscal function, also perform the function of protecting the domestic market from rising prices for fuels, which occurs as a result of rising oil prices in world markets. However, many experts argue that these export duties, been essentially a subsidy, have a negative influence on the effectiveness of the Russian oil refining industry. Exchange rate fluctuations also add to these differences between domestic and export oil prices.

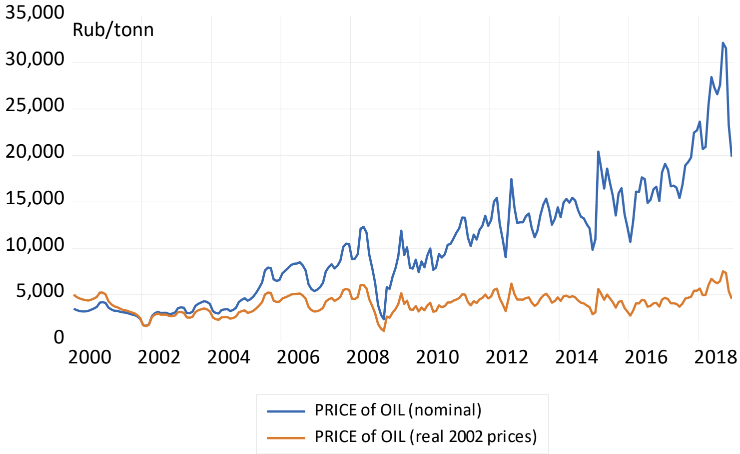
As can be seen in Figure 1, the discrepancy between oil prices in the world market and the domestic market was very high during the period 2008-2014. From August 1, 2008, the export duty was 495.9 US dollars per tone of exported oil, but was reduced following the fall in oil prices in the global market. However, the discrepancy between prices in global and domestic markets is decreasing. One of the reasons is the so-called tax manoeuvre in the oil industry. The preferential oil duty rate for several fields was introduced from the beginning of 2015 and is active when the oil price falls below a certain level. From January 1, 2019, the Russian government started a gradual decrease in oil export duties over the following six years. As a result, the export duty will decrease from 30% in 2018 to 0% in 2024 with a simultaneous increase in the mineral extraction tax.

Figure 1. Crude oil prices (domestic versus global)



We obtain a measure of the real price of oil by deflating the average purchase price of crude oil for domestic companies by the consumer price index (CPI). We study monthly time series data for Russia over the period from January 2000 to December 2018 (a total of 228 observations); see Figure 2. Prices are is rubles per tonne of crude oil for domestic companies.

Figure 2. Nominal and real domestic prices of crude oil



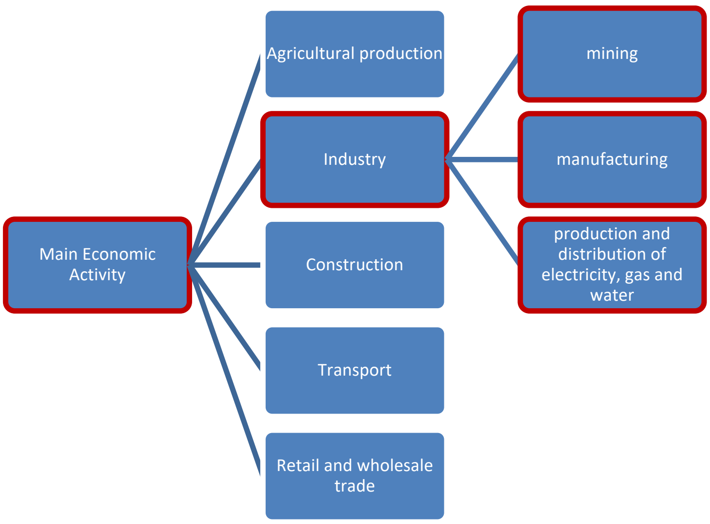
The quality of the data from the Russian official statistics has been repeatedly criticised by Russian and international experts (Eliseeva, 2011). Despite the noticeable improvements in collecting and providing data in recent years, research has to rely not only on Rosstat data, but also on data from international organizations and Russian research centers.

The price of oil for the domestic market affects the price of gasoline and other motor fuels, which in turn will change the costs for companies in all sectors of the economy. There is evidence in the literature that this influence is asymmetric (Ozmen, Akcelik 2017), but in this paper, we do not address the question of asymmetry.

To investigate the cyclical behavior of crude oil prices, we use the Industrial Production Index (IPI) for Russia, obtained from the OECD database.[2] Data on the production of goods in physical terms cover more than 200,000 large, medium-sized, and small organizations that account for 95 percent of total industrial output of the Russian Federation. The index includes estimates of hidden production by registered enterprises, and the production of entrepreneurs operating without a corporate legal entity. The data for these entrepreneurs are obtained from taxation records. In a large number of other studies the IPI is used as a proxy of the level of real economic activity (Elder and Serletis, 2010; Belyanova and Nikolaenko, 2012; Smirnov, 2015; Jahan and Serletis, 2019). We also examine the cross correlation and casual relationship between crude oil prices and manufacturing production. Data for the Manufacturing Production Index is retrieved from the OECD database, the classification type is OKVED - All Russian Classification of Types of Economic Activity, compatible with NACE Rev. 1.1. Note, that the OECD calculates these indices based on Rosstat data. However, since 2014, Rosstat has adopted the New Russian Classification of Economic Activities, OKVED2, and now provides new time series. The new index based on the new classification is available only from 2013:01. So, for consistency with previous data we used the OKVED classification and data, obtained from OECD (when available) and the Join Economic and Social Data Archive providing by High School of Economics.[3]

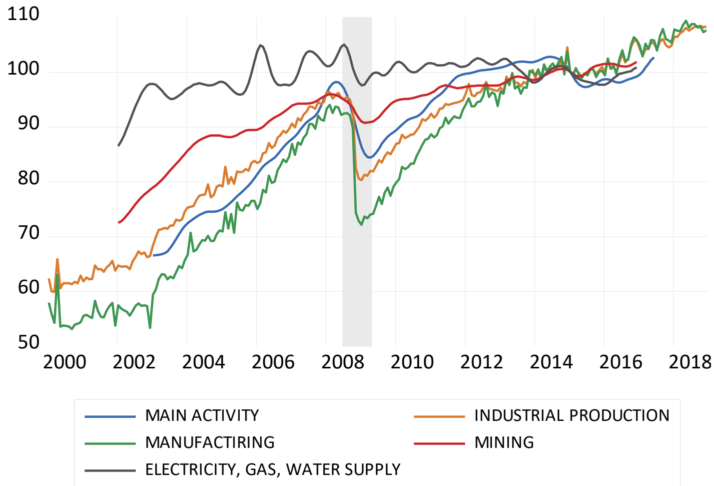
To examine the oil price relation with various economic activities we use various indices. The index of main economic activity is the price-adjusted output of agricultural production, mining, manufacturing, production and distribution of electricity, gas and water, construction, transport, and retail and wholesale trade (see Figure 3). The index is calculated based on the average annual prices of the previous year and converted to base period. The first observation for this time series is 2003:01, the last observation is 2017:06. We use separate indices of mining and the production and distribution of electricity, gas and water in order to examine the effect of changes in oil prices on various activities in the industry. This data is available from 2000:01 to 2016:12. We use seasonally adjusted values for all indices to smooth the time series (see Figure 4).

Figure 3. The breakdown of the main economic activity index



[2] https://stats.oecd.org/viewhtml.aspx?datasetcode=MEI_REAL&lang=en
[3] http://sophist.hse.ru/hse/nindex.shtml

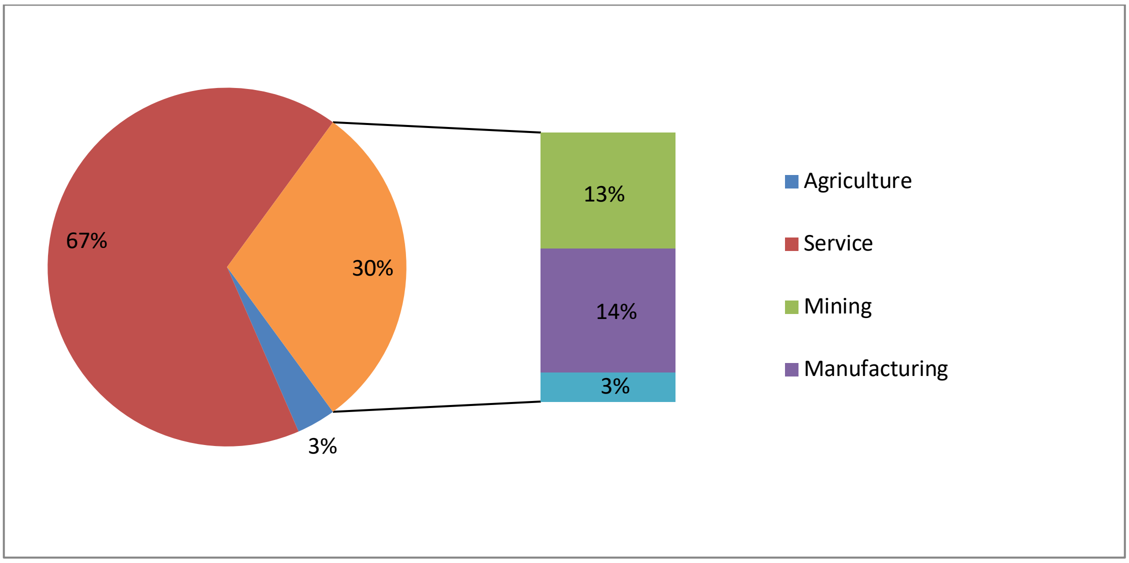
Figure 4. Seasonally adjusted industrial production indices and the main economic activity index



Note. The shaded area indicates a period of crisis in Russia as was reported in Belyanova and Nikolaenko (2012).

Industrial production accounted for almost 30% of GDP in 2018 with mining accounting for almost half of total industrial production according to Rosstat data (see Figure 5).

Figure 5. GDP composition, by sector of origin



Source. Based on Rosstat data, 2018

3. Business cycles and oil prices for domestic companies

3.1 The methodology

We investigate the cyclical properties of oil prices, using the new Hamilton (2018) regression filter, and estimate an OLS regression of Y_{t+h} on a constant and the most four recent values of Y as of date t,

$$Y_{t+h} = \beta_0 + \beta_1 Y_t + \beta_2 Y_{t-1} + \beta_3 Y_{t-2} + \beta_4 Y_{t-3} + \varepsilon_{t+h} \qquad (1)$$

with $h = 24$ as in Jahan and Serletis (2019). The residuals

$$\hat{\varepsilon}_{t+h} = Y_{t+h} - \hat{\beta}_0 + \hat{\beta}_1 Y_t + \hat{\beta}_2 Y_{t-1} + \hat{\beta}_3 Y_{t-2} + \hat{\beta}_4 Y_{t-3} \qquad (2)$$

give the de-trended (cyclical) components of the original time series Y.

Hamilton argues that this method is a better alternative to the popular HP filter as it “offers a robust approach to detrending that achieves all the objectives sought by users of the HP filter with none of its drawbacks” (Hamilton, 2018). Hamilton shows that HP filter produces a cyclical component with a spurious dynamics when applied to a random walk.

Having cyclical components of the logs of all the variables (main activity index, industrial production index, manufacturing, mining, electricity, gas, and water supply as well as the domestic oil prices), we calculate the correlation coefficient $\rho(X_t, Y^k_{t+j})$, measuring cyclical comovement of the examined indices Y^k with oil prices X. If the contemporaneous correlation is positive, we say, that the series X is procyclical. If the cross-correlation coefficient $\rho(X_t, Y^k_{t+j})$, $j>0$ has maximum in absolute value for $j>0$, we say that X is leading the cycle by j periods. In opposite case ($j<0$) we say that X_t is lagging the cycle. In case $\rho(X_t, Y^k_{t+j})$ has maximum value for $j = 0$, we say that X is synchronous with Y.

3.2 Empirical results

In Table 1 we report the contemporaneous and cross-correlation coefficients between the cyclical component of domestic crude prices and the cyclical components of various measures of economic activity in Russia at lags 1, 2, 3, 6, 9, and 12 and leads 1, 2, 3, 4, 5, 6, 9, and 12 months. The reason we include more leads than lags is the increasing correlation coefficients when increasing leads, for several measures of economic activity.

Table 1

Cyclical correlations between crude oil prices for domestic companies and economic activity indices

Series	j=-12	j=-9	j=-6	j=-3	j=-2	j=-1	j=0	j=1	j=2	j=3	j=4	j=5	j=6	j=9	j=12
Main Activity	-0.09	-0.09	0.01	0.166	0.230	0.30	0.369	0.429	0.478	0.511	**0.526**	0.521	0.494	0.365	0.266
Industrial Production	0.159	0.195	0.242	0.306	0.335	0.395	0.460	0.492	**0.495**	0.482	0.457	0.411	0.359	0.230	0.106
Manufacturing	0.182	0.219	0.258	0.323	0.351	0.415	0.479	0.512	**0.515**	0.500	0.475	0.427	0.374	0.253	0.139
Mining	0.028	0.087	0.047	0.072	0.110	0.153	0.206	0.259	0.290	0.298	0.309	0.317	**0.323**	0.254	0.106
Electricity, Gas,	-0.16	-0.07	-0.01	0.084	0.148	0.213	0.273	0.313	**0.330**	0.311	0.284	0.254	0.223	0.176	0.079

and Water Supply															

The results, shown in Table 1 indicate that oil prices are procyclical and lead the business cycle. The contemporaneous correlation between the cyclical component of the crude oil prices and main economic activity is not strong ($\rho(X_t, Y^1_t)=0.37$) however the correlation coefficient increases up to 0.53 when increasing leads ($\rho(X_t, Y^1_{t+4})=0.53$). The drop in crude oil prices in 2008 leaded the drop in economic activity in Russia. However, oil prices recovered faster than the economic activity in the main industries. The same is true regarding industrial production and manufacturing: the contemporaneous correlation is moderate, however, increases with a positive time shift.

The crude oil price drives the cycle of main economic activity by four months, industrial production, as well as manufacturing by two months.

Note that oil prices lead the business cycle in the mining industry by six months. As can be seen from Figure 2, output production in the mining industry is rather stable in recent years and was not profoundly affected by the 2008-2009 economic crises (in terms of physical quantities). The crude oil price drives the cycle of the electricity, gas, and water supply industry by two months, although the correlation is also weak.

Table 2 reports the contemporaneous and cross-correlation coefficients between the Industrial Production Index (as the main indicator of the business cycle) and other types of economic activity measures. Industrial production leads the main economic activity by 1 month. Manufacturing is strongly synchronous with total industrial production, mining leads the cycle by one month, while electricity, gas and water supply is synchronous, but correlates weakly with industrial production.

Table 2
Cyclical correlations between various economic activity indices and Industrial Production Index

Series	j=-12	j=-9	j=-6	j=-3	j=-2	j=-1	j=0	j=1	j=2	j=3	j=6	j=9	j=12
Main Activity	-0.028	0.203	0.446	0.667	0.719	0.761	0.787	**0.800**	0.798	0.784	0.675	0.505	0.230
Manufacturing	0.209	0.417	0.642	0.819	0.882	0.928	**0.985**	0.935	0.886	0.831	0.666	0.458	0.248
Mining	0.263	0.438	0.590	0.716	0.743	**0.753**	0.750	0.723	0.674	0.623	0.432	0.203	0.004
Electricity, Gas, and Water Supply	-0.092	-0.005	0.081	0.217	0.262	0.294	**0.306**	0.303	0.283	0.251	0.156	0.081	0.010

4. Unit Root Tests

To proceed further we need to check our variables for (weak) stationarity. We utilize the ADF test (Dickey and Fuller, 1981), the DF-GLS test (Elliott, Rothenberg and Stock, 1996), and the KPSS test (Kwiatkowski *et al.*, 1992). Results are shown in Table 3. We report *t*-statistics for the ADF and DF-GLS tests and LM-statistics for the KPSS test, and indicate with asterisks if the null hypothesis, H_0, is rejected at a certain level of significance. H_0 assumes time series to have a unit root for the ADF and DF-GLS tests and for KPSS test H_0 is the opposite. It is known that the ADF test has low power to reject H_0 (Cochrane, 1991), so we run KPSS to support the results, obtained from the ADF and DF-GLS tests.

Table 3
Unit root and stationary tests

	ADF H_0: nonstationarity		DF-GLS H_0: nonstationarity		KPSS H_0: stationarity		The order of integration
Series	intercept	intercept and trend	intercept	intercept and trend	intercept	Intercept and trend	I(d)
A: Log Levels							
Main Activity	-2.11	-2.13	0.39	-1.26	1.38***	0.28***	I(1)
Industrial Production	-1.39	-2.15	1.08	-1.88	1.78***	0.32***	I(1)
Manufacturing	-1.1	-1.9	0.96	-1.99	1.81***	0.26***	I(1)

Mining	-3.6***	-3.6**	0.7	-0.95	1.46***	0.28***	I(1)
Electricity, Gas, and Water Supply	-4.01***	-4.1***	0.16	-1.16	0.74***	0.33***	I(1)
Crude Oil	-4.5***	-5.3***	-3.65***	-4.03***	0.69**	0.06	I(0)
B: Logarithmic first differences							
Main Activity	-2.98**	-3.2*	-2.95***	-2.99**	0.29	0.05	I(0)
Industrial Production	-19.2***	-19.2***	-0.9	-1.98	0.14	0.05	I(0)
Manufacturing	-20.9***	-20.9***	-1.27	-2.48	0.07	0.05	I(0)
Mining	-5.1***	-5.5***	-2.82***	-5.53***	0.65**	0.16**	I(0)
Electricity, Gas, and Water Supply	-5.8***	-6.5***	-1.96**	-4.37***	0.23	0.06	I(0)
Crude Oil	-12.8***	-12.8***	-11.8***	-12.5***	0.05	0.06	I(0)

Notes. * denotes that H_0 is rejected at 10% level of significance, ** at 5%, and *** at 1%.
For the ADF and DF-GLS regressions, the lag length is automatically selected based on SIC. Critical values are different for different time series because of the different number of observations.
Time series are classified as I(1) or I(0) if at least four out of the six test variations point for this decision.

Note that the hypothesis of a unit root in the time series for oil prices is rejected by the ADF and DF-GLS tests. The hypothesis that oil prices are stationary is not rejected by the KPSS test. So in what follows, we use the oil price series in log levels (multiplied by 100 for convenience) and consider it as a stationary time series.

There is a contradiction between the results from the ADF and DF-GLS tests for the growth rate of industrial production. The KPSS test supports the hypothesis that this series is stationary. To make a decision we also conduct the Philips-Perron test (Phillips and Perron, 1988) which is a modification of the ADF test using more general assumptions. The adjusted *t*-statistics for industrial production is t = -19.2, and the critical value at the 1% level is -3.5, so H_0 is rejected. Based on these tests we conclude that this time series does not have a unit root.

We get similar results for the growth rate of manufacturing production. The null with the KPSS test (that the series is stationary) is not rejected at the 1% level for the growth rate of mining production. However, the ADF and DF-GLS tests suggest that this time series is stationary.

5. Oil price shocks and economic activity

In this section, we test the hypothesis that crude oil price shocks cause changes in industrial production and other economic activities.

5.1 The methodology

A shock to the real price of oil not only directly affects the oil price, but also is transmitted to economic activity (Barsky and Kilian, 2004; Lescaroux and Mignon, 2008).

We run bivariate VAR models investigating the impulse responses of each of 5 measures of economic activity to positive oil price shocks. As the oil price series is stationary, we use this variable in levels. For economic activity we use the logarithmic first difference. Thus, we assume that different types of economic activity Y^j (j=1÷5) and oil prices X are jointly determined by a VAR^j(p)

$$\Delta Y^j{}_t = a^{j1}{}_{11}\Delta Y^j{}_{t-1} + \ldots + a^{jp}{}_{11}\Delta Y^j{}_{t-p} + a^{j1}{}_{12}X_{t-1} + \ldots + a^{jp}{}_{12}X_{t-p} + c^j{}_1 + \varepsilon^j{}_{1t} \qquad (3a)$$

$$X_t = a^{j1}{}_{21}\Delta Y^j{}_{t-1} + \ldots + a^{jp}{}_{21}\Delta Y^j{}_{t-p} + a^{j1}{}_{22}X_{t-1} + \ldots + a^{jp}{}_{22}X_{t-p} + c_2 + \varepsilon^j{}_{2t} \qquad (3b)$$

with the lag length selected using the AIC. Thus, we have five VAR(p) models for each of the different economic sectors.

Industrial production and manufacturing production were highly affected by the 2008-2009 crises (see Figure 3). To account for possible structural changes, we also consider VARX(p) with a dummy variable accounting for structural change during the economic crisis 2008-2009 in Russia.

$$\Delta Y^j{}_t = a^{j1}{}_{11}\Delta Y^j{}_{t-1} + \ldots + a^{jp}{}_{11}\Delta Y^j{}_{t-p} + a^{j1}{}_{12}X_{t-1} + \ldots + a^{jp}{}_{12}X_{t-p} + c^j{}_1 + \delta^j{}_1 d2009 + \varepsilon^j{}_{1t} \quad (4a)$$

$$X_t = a^{j1}{}_{21}\Delta Y^j{}_{t-1} + \ldots + a^{jp}{}_{21}\Delta Y^j{}_{t-p} + a^{j1}{}_{22}X_{t-1} + \ldots + a^{jp}{}_{22}X_{t-p} + c_2 + \delta^j{}_2 d2009 + \varepsilon^j{}_{2t} \quad (4b)$$

Here $d2009$ =1 from 2008:04 to 2009:04 as a period of crisis in Russia and equal to 0 otherwise. We use (Belyanova and Nikolaenko, 2012) results, however there are other approaches, which suggest other time periods for the crisis in Russia, see the discussion in (Smirnov, Kondrashov and Petronevich, 2017).

The model consisting of equations (3a) and (3b), can be considered as a restricted version of the model consisting of equations (4a) and (4b), with two restrictions $\delta^j{}_1 = \delta^j{}_2 = 0$.

We explore the sequential modified likelihood ratio LR test to check whether to keep the dummy variable in the model or not. The LR statistic is

$$LR = (T - m)(\ln|\Sigma_r| - \ln|\Sigma_u|) \sim \chi^2(q) \quad (5)$$

where T is the number of observations, m is the number of parameters in each equation of the unrestricted system (including a constant). q is the number of restrictions, $\sum$ is the determinant of the residual covariance matrix in the restricted model, $\sum_r$, or unrestricted model, $\sum_U$. We employ the Sims (1980) small sample modification which uses (T-m) rather than T. We compare the modified LR statistic to the 5% critical values of the χ^2 statistic

We check for three restrictions:

H_0: $\delta^j{}_1 = \delta^j{}_2 = 0$ (6.1)

the model (3a) and (3b) against the model (4a) and (4b),

H_0: $\delta^j{}_1 = 0$ (6.2)

and

H_0: $\delta^j{}_2 = 0$ (6.3)

against the unrestricted model (4a) and (4b).

For each j in (3a) and (3b) or (4a) and (4b) $\boldsymbol{\varepsilon}_t = (\varepsilon_{1t}, \varepsilon_{2t})$` is a 2x1 white noise innovation process, with

$$E(\boldsymbol{\varepsilon}_t) = 0,\ E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t`) = \Sigma_\varepsilon,\ E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_s`) = 0 \text{ for } t \neq s.$$

The last statement implies that the vector of innovations is contemporaneously correlated with full rank matrix Σ_ε , but is uncorrelated with leads and lags of the innovations and uncorrelated with all of the right-hand side variables. Since only lagged values of the endogenous variables appear on the right-hand side of the VAR equations (3a) and (3b) and the innovations are assumed to be uncorrelated with lagged innovations and the exogenous regressors, standard orthogonality conditions hold and OLS yields consistent estimates.

We assume that innovations are contemporaneously correlated and have a common component which cannot be associated with a specific variable. In order to interpret the impulses, it is common to apply a transformation P to the innovations so that they become uncorrelated:

$$\mathbf{u}_t = P\boldsymbol{\varepsilon}_t \rightarrow (0,\mathbf{D}),$$

where $\mathbf{D}$ is a diagonal covariance matrix.

We utilize the Cholesky transformation, attributing all of the effect of any common component to the X variable (real oil prices). Thus we assume that oil price doesn't respond to the unexpected change in ΔY contemporaneously. On the other hand, ΔY responds to the unexpected change in the oil price contemporaneously.

5.2 Results on the model selection

As a first step we consider the model (3a) and (3b) with p = 12 and use a general-to-simple approach searching for the lag length. We summarize the results of choosing the lag order based on different selection criteria in Table 4. All the criteria are discussed in (Lütkepohl, 2005). SC selects more parsimonious models. However SC has been seen to lead to underfitting in some finite sample cases (Greene, 2008). We rely upon the AIC, which is in consensus with the LR-test and FPE criterion in our cases.

Table 4
Lag order selection for $VAR^j(p^j)$

	LR	FPE	AIC	SC	HQ	Selected p^j
Main Activity (j=1)	9	9	9	2	8	9
Industrial production (j=2)	6	6	6	0	2	6
Manufacturing (j=3)	6	6	6	1	2	6
Mining (j=4)	6	6	6	3	3	6
Electricity, Gas, and Water Supply (j=5)	8	8	8	2	3	8

Note. LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error. AIC: Akaike information criterion. SC: Schwarz information criterion. HQ: Hannan-Quinn information criterion

As a next step we use the selected lag order to check whether the model (4a) and (4b) better fits the data. We check for three restrictions (6) considering the impact of the crisis on economic activities. We use the modification of LR-test for small samples (5). Results are summarised in Table 5.

Table 5
Testing restrictions for model $VARX^j(p^j)$

	H_0: $\delta^j{}_1 = \delta^j{}_2 = 0$	H_0: $\delta^j{}_1 = 0$	H_0: $\delta^j{}_2 = 0$	The preferred model
Main Activity (j=1)	9.76*	1.25	10.94*	$\delta^1{}_1 = 0, \delta^1{}_2 \neq 0$
Industrial production (j=2)	16.34*	7.3*	12.3*	$\delta^2{}_1 \neq 0,\ \delta^2{}_2 \neq 0$
Manufacturing (j=3)	15.05*	5.76*	11.87*	$\delta^2{}_1 \neq 0,\ \delta^2{}_2 \neq 0$
Mining (j=4)	11.09*	8.60*	6.91*	$\delta^2{}_1 \neq 0,\ \delta^2{}_2 \neq 0$
Electricity, Gas, and Water Supply (j=5)	3.62	3.90*	1.68	$\delta^1{}_1 = 0, \delta^1{}_2 \neq 0$

Note. The 5 percent critical value from $\chi^2(q)$ for 2 restrictions is 6.0 and for one restriction is 3.84. * denotes the null hypothesis is rejected at the 5 percent level.

Based on the likelihood ratio test we reject the hypothesis that the crisis does not have an additional impact on our variables.

We utilize the preferred models for each j from Table 5 to calculate impulse responses and carry out pairwise Granger causality tests.

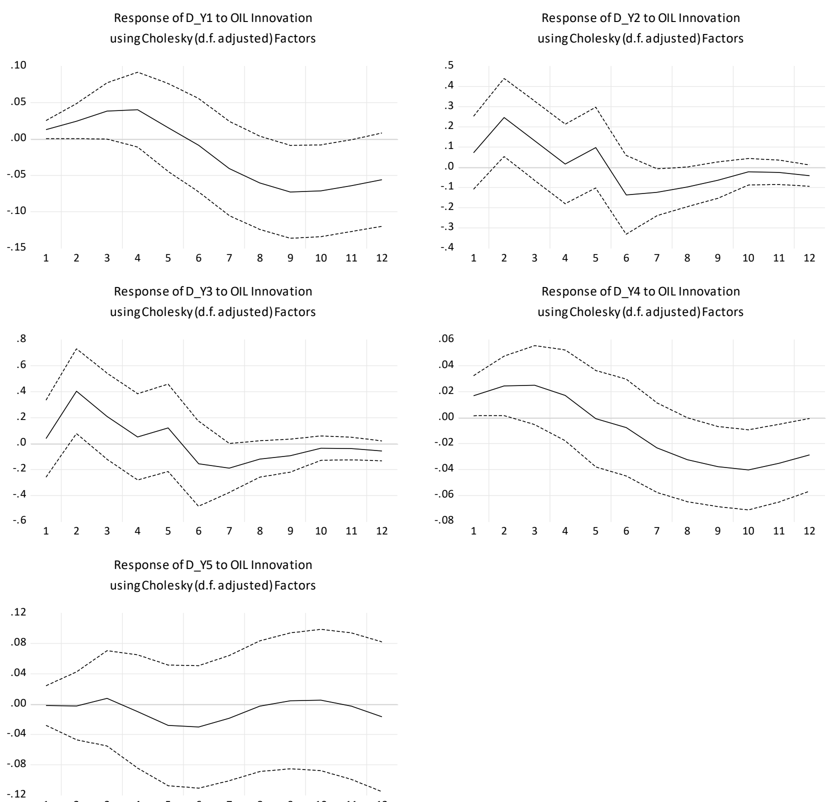
5.3 Impulse responses

We plot the responses of the 5 measures of economic activity to one standard deviation shock to the real domestic oil price (see Figure 6, dotted line are ±2S.E.).

We find that the growth rate of main economic activity, industrial production, manufacturing and mining increase on impact in response to an unanticipated increase in the real oil price. The effect is very short (the low bound of the confidence interval crosses the zero line in 4 months for the main economic activity, for the other activities the effect is even shorter). However, the growth rate falls later and returns to the baseline level within 12 months for total industrial production and manufacturing. The negative effect on the main activity and mining lasts longer. We want to emphasize that we consider the real oil price in the domestic market.

The growth rate of electricity, gas and water supply is neutral to an unanticipated increase in the real oil prices.

Figure 6. Response of various measures of economic activity to oil shocks



Notes. Here ΔY^j is denoted by D_Yj (j=1,5). The d.f. adjustment makes a small sample degrees of freedom correction when estimating the residual covariance matrix used to derive the Cholesky factor similar to modification used to calculate LR in (5).

Rising oil prices in the global market lead to higher prices in the domestic market, albeit smoothed by tariffs and taxes. The Russian economy benefits from increasing oil prices in the global market through money inflow, increasing investment and consumption. However, the budget rule for the Russian federal budget expenditures first applied in Russia in 2004, last modification was made in 2018, implies restrictions on government expenditures and thus mitigates the impact of fluctuations in oil&gas revenue on economic activity. On the other hand, rising oil prices in the domestic market lead to a decrease in economic activity. It is consistent with the shown above impulse response function, positive response to unexpected positive shock in oil prices changes to negative and then dies out.

6. Granger causality

We carry out pairwise Granger causality tests for preferred models using results reported in Tables 4 and 5 to test the joint significance of lagged endogenous variables other than the dependent variable in a certain equation. If testing equation (4a) for a certain *j* the null hypothesis that lagged oil prices are jointly insignificant is rejected, we say that oil prices Granger cause the growth rate of this type of economic activity. If in addition to this result while testing (4b) the null hypothesis that all ΔY_{t-p} are jointly insignificant is not rejected, we say that oil prices can be regarded as exogenous for the growth rate of this type of economic activity.

It is known that Granger causality tests are very sensitive to lag length. To address whether oil prices Granger cause the economic activity and avoid uncertainty in choosing the lag length, we run ADLX(p,q) regressions for each type of economic activity in Russia

$$\Delta Y^j{}_t = \sum_{p'=1}^{p^j} \beta^j_{p'} \Delta Y^j{}_{t-p'} + \sum_{q'=1}^{q^j} \gamma^j_{q'} X^j{}_{t-q'}. + c^j + \delta^j d2009 + \varepsilon^j{}_t \qquad (5)$$

where p^j=1,2,…,12 – the lag order for the growth rate of output -- q^j =1,2,…,12 – the lag order for the real oil prices, j=1,2,…,5 indicates the type of activity. Y^j (j=1÷5) is index of economic activity and oil prices *X* are assumed to be weakly exogenous.
We run 720 regressions to choose the optimal lag order p^j and q^j, based on the AIC criterion. Then we carry out Wald tests on the group of coefficients γ_j in equation (5) with the optimal lag structure. If the hypothesis H_0: $\gamma^j_{q'} = 0$ for all q is rejected, we conclude that changes in real oil prices do Granger cause changes in the growth rate of economic activity.

6.1 Results

For each $VARX^j(p)$, where p is chosen as described in Table 4, we report in Table 5 χ^2statistics and *p*-values. We conclude that changes in oil prices do Granger cause changes in the growth rate of economic activity if the null hypothesis in the first part of Table 6 is rejected at the 5 % level of significance and do not Granger cause if the null hypothesis is not rejected at the 5% significance level. The same rule is applied for the second part of Table 6, where we test whether changes in oil prices are Granger-caused by changes in the growth rate of economic activities.

Table 6
Granger Causality/Block Exogeneity Wald Tests

H_0: Oil Prices does not Granger-cause Economic Activity			
Dependent variable (the growth rate of)	χ^2	Probability	Decision
Main economic activity	19.33	0.023	Causality**
Industrial Production	23.05	0.000	Causality***
Manufacturing	21.26	0.001	Causality***
Mining	9.9	0.13	No causality
Electricity, gas, steam and water supply	8.7	0.37	No causality
H_0: Economic Activity does not Granger-cause Domestic Oil Price			
Independent variable (the growth rate of)	χ^2	Probability	Decision
Main economic activity	21.43	0.01	Causality***
Industrial Production	11.9	0.06	No causality*
Manufacturing	11.21	0.06	No causality*
Mining	20.26	0.003	Causality***
Electricity, gas, steam and water supply	11.5	0.18	No causality

Notes. * denotes that H_0 (no causality) is rejected at 10% level of significance, ** at 5%, and *** at 1%.

From these results we can conclude that oil prices Granger-cause industrial production and manufacturing activity in Russia which is consistent with the results reported in section 2. At the same time, lagged growth rate of industrial production and manufacturing cannot help to predict future changes in oil prices. Previous movements in oil prices do help explain movements in the growth rate of main economic activity even in the presence of the lagged value of this variable. However it is not sufficient to assert a casual relationship because the hypothesis that main economic activity does not Granger cause domestic oil prices is rejected. As one can see from Table 6, changes in real oil prices do not Granger cause changes in the growth rate of the mining and electricity, gas, steam and water supply industries.

As we already mentioned, Granger causality tests are very sensitive to lag length. So we run 144 OLS regressions for each type of economic activity to find optimal p^j and q^j values, based on the AIC criterion. The results are summaries in Table 5. We report AIC for p and q=3,6,9,12 and (p, q) combination for min(AIC|p=1:12, q=1:12).

Table 7
Optimal lag length for equations (5)

	p=3	p=6	p=9	p=12	Optimal(p*,q*) / AIC
Main economic activity					(10,6) / -2.15
q=3	-1.82	-1.99	-2.12	-2.12	
q=6	-1.80	-1.98	-2.13	-2.13	
q=9	-1.78	-1.95	-2.10	-2.10	
q=12	-1.75	-1.92	-2.07	-2.08	
Industrial production					(1,5) / 3.45
q=3	3.58	3.51	3.53	3.54	
q=6	3.48	3.48	3.50	3.51	
q=9	3.51	3.51	3.52	3.53	
q=12	3.49	3.50	3.51	3.52	
Manufacturing					(1,6) / 4.46
q=3	4.60	4.49	4.52	4.55	
q=6	4.46	4.47	4.50	4.53	
q=9	4.49	4.50	4.52	4.55	
q=12	4.50	4.50	4.52	4.55	
Mining					(7,2)/ -1.68
q=3	-1.65	-1.66	-1.64	-1.62	
q=6	-1.63	-1.65	-1.63	-1.59	
q=9	-1.62	-1.63	-1.61	-1.57	

q=12	-1.6	-1.63	-1.60	-156	
Electricity, gas, steam and water supply					(8,1)/ -0.63
q=3	-0.46	-0.54	-0.60	-0.59	
q=6	-0.44	-0.55	-0.59	-0.59	
q=9	-0.43	-0.53	-0.58	-0.56	
q=12	-0.40	-0.50	-0.55	-0.53	

Having chosen the optimal lag length (p*,q*) in (5) we test the restrictions H_0: $\gamma^{j}_{q'} = 0$ for all q. We have six restrictions in the equation for the main economic activity and manufacturing, five restrictions for industrial production, 2 restrictions for mining and one restriction for the electricity, gas, steam and water supply industry. We conclude that changes in real oil prices help to predict changes in the growth rate of considered types of economic activities if the null hypothesis is rejected at the 5% significance level. Results of Wald test are reported in Table 8.

Table 8
Wald tests for the restriction in equations (5) with the optimal lag length

	Chi-square	Probability	Decision
Main activity	15.69	0.016	Causality
Industrial production	14.39	0.006	Causality
Manufacturing	19.45	0.003	Causality
Mining	7.78	0.02	Causality
Electricity, gas, steam and water supply	0.40	0.53	No causality

Note. Decision is made at the 5% level of significance

Thus, the current price of oil in the domestic market helps to predict changes in the main economic activity, industry and its sectors, except for the electricity, gas and water production and supply sector. It can help in policy decision making. However, the nonlinear relationship between oil prices and economic activity should be taken into account. Rising in domestic oil prices caused by global prices swelling boosts economic activity in the next period from the supply side. But from the demand side, we expect decease of economic activity, which is shown by the impulse response function (fig. 6).

7. Conclusion

The relationship between the price of crude oil and the level of economic activity has attracted considerable attention in the literature, especially for advanced economies. Russia is one of the world's leading oil producers and exporters, and the Russian economy is rather sensitive to price fluctuations in the global oil market. In this paper, we investigate the relationship between oil prices in the domestic market and the level of different types of economic activities in Russia. The domestic oil prices tend to follow the global prices but also are affected by fiscal and monetary policy in Russia.

We use different approaches known in the literature to address this issue. First, we investigate cyclical properties of local oil prices. Our results indicate that oil prices are procyclical and lead the cycle of all considered types of economic activities in Russia. We also can conclude, that industrial production leads the cycle of main economic activity, but lags the cycle of mining.

Then we utilize a bivariate VAR model to examine the effect of oil price shocks on the level of economic activity. We find that positive oil shocks lead to an increase in the growth rate of main economic activity, industrial production, and manufacturing in Russia. However, the effect is rather short and the growth rates fall later and return to the baseline level within one year. Our results, for the most part, are consistent with the results of previous studies by Melnikov (2010) and Balashova et al. (2018) in their examination of the dependence of economic growth in Russia on the global oil prices. However, in this study we show that increase in oil prices in the domestic market prevent economic activity growth and results in a negative response in several months. So the cumulative positive effect of positive oil prices shock is short.

Our findings regarding the causal relationship between oil prices and growth rate of economic activities show that changes in real oil prices help to predict changes in the growth rate of main economic activity, industrial production, manufacturing and mining, and are consistent with our findings from the cyclical correlations investigation.

Our results are in general consistent with the recent evidence by Azad and Serletis (2019) in their investigation of the effects of oil price shocks in major emerging economies. Using the Elder and Serletis (2010) methodology, they show that oil price uncertainty has a negative effect on real output in India, Indonesia, Mexico, Russia, and Turkey, and a positive and statistically significant effect on real output in Brazil and China. They also show, using the Kilian and Vigfusson (Kilian and Vigfusson, 2011) test, that in general the null hypothesis of a symmetric relationship between the growth rates of the real oil price and real output cannot be rejected at conventional significance levels for China, India, Indonesia, Mexico, and Turkey. The null hypothesis, however, is rejected for Brazil and Russia.

References

Azad, Nahiyan F. and Serletis, A. (2019) 'Oil Price Shocks in Major Emerging Economies', Mimeo, Department of Economics, University of Calgary.

Balashova, S. (2018) 'The Russian Stock Market: Risks and Growth', in Sergi, B. S. (ed.) *Exploring the Future of Russia's Economy and Markets: Towards Sustainable Economic Development*. Emerald, pp. 29–49. doi: 10.1108/978-1-78769-397-520181003.

Balashova, S., Lazanyuk, I. and Matyushok, V. (2018) 'Growth Scenarios for the Russian Economy', in Sergi, B. S. (ed.) *Exploring the Future of Russia's Economy and Markets: Towards Sustainable Economic Development*. London: Emerald Publishing Limited, pp. 235–256. doi: 10.1108/978-1-78769-397-520181013.

Barsky, R. B. and Kilian, L. (2004) 'Oil and the Macroeconomy Since the 1970s', *Journal of Economic Perspectives*, 18(4), pp. 115–134. doi: 10.1257/0895330042632708.

Belyanova, E. V. and Nikolaenko, S. A. (2012) 'The Economic Cycle in Russia in the Years 1998-2008: the Emergence of Internal Mechanisms for Cyclic Development or Importation of the Global Turmoil?', *Higher school of economics economic journal*, 16(1), pp. 31–57. Available at: https://elibrary.ru/item.asp?id=17720108.

Cochrane, J. H. (1991) 'A critique of the application of unit root tests', *Journal of Economic Dynamics and Control*, 15(2), pp. 275–284. doi: 10.1016/0165-1889(91)90013-Q.

Dickey, D. A. and Fuller, W. A. (1981) 'Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root', *Econometrica*, 49(4), p. 1057. doi: 10.2307/1912517.

Elder, J. and Serletis, A. (2010) 'Oil Price Uncertainty', *Journal of Money, Credit, and Banking*, 42(6), pp. 1137–1159. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=908675.

Eliseeva, I. (2011) 'Russian Statistics Today', *Voprosy Ekonomiki*, (2), pp. 75–92. doi: 10.32609/0042-8736-2011-2-75-92.

Elliott, G., Rothenberg, T. J. and Stock, J. H. (1996) 'Efficient Tests for an Autoregressive Unit Root', *Econometrica*. [Wiley, Econometric Society], 64(4), pp. 813–836. doi: 10.2307/2171846.

Greene, W. H. (2008) *Econometric Analysis*. 6th edn. Pearson Prentice Hall.

Hamilton, J. D. (2018) 'Why You Should Never Use the Hodrick-Prescott Filter', *Review of Economics and Statistics*, 100(5), pp. 831–843. Available at: http://www.nber.org/papers/w23429%0Ahttp://www.nber.org/data-appendix/w23429.

Hayo, B. and Kutan, A. M. (2005) ‘The impact of news, oil prices, and global market developments on Russian financial markets’, *Economics of Transition*, 13(2), pp. 373–393. doi: 10.1111/j.1468-0351.2005.00214.x.

Ito, K. (2008) ‘Oil prices and macro-economy in Russia: The co-integrated VAR model approach’, *International Applied Economics and Management Letters*, 1(1), pp. 37–40. Available at: http://econ.upm.edu.my/iaeml/vol1no1/bab07.pdf.

Jahan, S. and Serletis, A. (2019) ‘Business cycles and hydrocarbon gas liquids prices’, *The Journal of Economic Asymmetries*. Elsevier Ltd, 19(January), p. e00115. doi: 10.1016/j.jeca.2019.e00115.

Kilian, L. and Vigfusson, R. J. (2011) ‘Are the responses of the U . S . economy asymmetric in energy price increases and decreases ?’, 2, pp. 419–453. doi: 10.3982/QE99.

Korhonen, I. and Peresetsky, A. (2016) ‘What Influences Stock Market Behavior in Russia and Other Emerging Countries?’, *Emerging Markets Finance and Trade*, 52(5), pp. 1210–1225. doi: 10.1080/1540496X.2015.1037200.

Kwiatkowski, D. *et al.* (1992) ‘Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?’, *Journal of Econometrics*. North-Holland, 54(1–3), pp. 159–178. doi: 10.1016/0304-4076(92)90104-Y.

Lescaroux, F. and Mignon, V. (2008) ‘On the influence of oil prices on economic activity and other macroeconomic and financial variables’, *OPEC Energy Review*, 32(4), pp. 343–380. doi: 10.1111/j.1753-0237.2009.00157.x.

Lütkepohl, H. (2005) ‘VAR Order Selection and Checking the Model Adequacy’, in *New Introduction to Multiple Time Series Analysis*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 135–192. doi: 10.1007/978-3-540-27752-1_4.

Melnikov, R. (2010) ‘The impact of oil price dynamics on the macroeconomic indicators of the Russian economy’, *Applied Econometrics*, 17(1), pp. 20–29. Available at: https://ideas.repec.org/a/ris/apltrx/0043.html.

Ozmen M.U., Akcelik F. (2017) ‘Asymmetric exchange rate and oil price pass-through in motor fuel market: A microeconometric approach’, *The Journal of Economic Asymmetries*. Elsevier Ltd, 15 (June), pp. 64-75. https://doi.org/10.1016/j.jeca.2017.02.002

Pavlova, E. V. *et al.* (2017) ‘Dependence of the Russian Economy on Oil Prices in the Context of Volatility of the Global oil Market : Articulation of Issue’, 7(3), pp. 225–230.

Peresetsky, A. (2011) *What determines the behavior of the Russian stock market*. Munich. doi: 10.5897/JAERD12.088.

Phillips, P. C. B. and Perron, P. (1988) ‘Testing for a Unit Root in Time Series Regression’, *Biometrika*. [Oxford University Press, Biometrika Trust], 75(2), pp. 335–346. doi: 10.2307/2336182.

Sergi, B. S. and Berezin, A. (2018) ‘Oil and Gas Industry’s Technological and Sustainable Development: Where Does Russia Stand?’, in *Exploring the Future of Russia’s Economy and Markets*. Emerald Publishing Limited, pp. 161–182. doi: 10.1108/978-1-78769-397-520181009.

Serletis, A. and Kemp, T. (1998) ‘The cyclical behavior of monthly NYMEX energy prices’, *Energy Economics*. North-Holland, 20(3), pp. 265–271. doi: 10.1016/S0140-9883(97)00007-8.

Sims, C. A. (1980) ‘Macroeconomics and Reality’, *Econometrica*. JSTOR, 48(1), pp. 1–48. doi: 10.2307/1912017.

Smirnov, S. (2015) ‘Economic Growth and Economic crises in Russia: The End of the 1920s - 2014’, *Voprosy Ekonomiki*, 5(5), pp. 28–47. doi: 10.32609/0042-8736-2015-5-28-47.

Smirnov, S., Kondrashov, N. and Petronevich, A. V (2017) ‘Dating cyclical turning points for Russia:

formal methods and informal choices', *Journal of business cycle research*, 13(1), pp. 53–73. Available at: https://link.springer.com/article/10.1007/s41549-017-0014-9.

Ruble I.(2019) 'The U.S. crude oil refining industry: Recent developments, upcoming challenges and prospects for exports', *The Journal of Economic Asymmetries,* 20, e00132. https://doi.org/10.1016/j.jeca.2019.e00132.