# Economic Growth and Oil Industry Development: Assessment of the Interaction of National Economy Indicators

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## Abstract

The results of the national economy functioning determined by the huge complex of factors: structure of the national economic complex, the share of leading industries, the effectiveness of their development and the impact on socio-economic indicators of the country and regions of oil extraction complex. The purpose of the paper is to investigate the scientific approaches to the impact of oil price fluctuations on the economic growth of exporting countries and assessing the interaction of economic growth of the national economy and factors of the oil industry. To study the cointegration and causal relationships of the development of national economy the paper proposed a two-tier approach: on the basis of the heterogeneous modified OLS (FMOLS) model, a linear relationship is established between the indicators of economic development (GDP, capital and labor costs) and indicators of the functioning of the national economy (volumes of oil production and rent payments for oil); the causal links between the economic growth of national economy, the volume of oil production and rent payments are determined by the Granger method based on the developed time series model (VECM), which allows you to adjust the short-term dynamics of parameters depending on the identified long-term relationships between variables and their deviations. The results of the study of cointegration and causal links between the development of the oil industry and the national economy showed that the growth of oil production and the level of rent payments for oil increase GDP for OPEC countries, high and middle-income countries. For countries with low and below average income levels, a 10% increase in oil production leads to a 0.2% increase in GDP. Insignificant economic benefits for this configuration of countries are associated with the lack of systematic modernization of the industry and necessitate a change in the system of state regulation of exploration and use of oil fields, the transition from extensive to intensive development of oil production complex for high value added products.

**Keywords:** national economy, assessment, oil production, oil prices, oil rent

## Introduction

The efficiency of the national economy of any state is determined by the structure of the economic complex, the share of leading industries, the effectiveness of their development and the impact on socio-economic indicators of the country and regions of oil production (Dzwigol, 2020). The relevant assessment becomes especially relevant for the countries - leaders in oil production, where the oil industry is the dominant industry, which largely determines the vectors of development of countries, socio-economic policies, the level of innovation and more. Estimation and econometric modelling of macroeconomic growth models includes a variety of approach methods, ranging from

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production functions and vector autoregressions to nonparametric modelling (Klymenko, 2016; Czyżewski, 2019; Hasan, 2019).

## Literature Review

Considerable attention of domestic and foreign scientists is focused primarily on the study of the impact of oil price fluctuations on the economic growth of exporting countries (Bhowmik, 2019; Bilan, 2019c; Brychko, 2019; Mishchuk et al, 2020; Kostiukevych et al, 2020). The oil factors of the countries selected for the study have an impact on both political and economic processes, which in turn leads to price fluctuations, investment uncertainty, inflation, changes in the stock market and economic growth of the national economy (Dźwigoł, 2018; Naser, 2019; Vasilieva, 2017; Kalyayev et al., 2019; Akimov et al., 2020). In turn, the works (Bogachov et al., 2020; Boiko et al., 2019; Chygryn et al., 2020; Dalevska et al., 2019; Dementyev & Kwilinski, 2020; Dzwigol, 2019a; 2019b; 2020a; 2020b; Dzwigol & Dzwigol-Barosz, 2018; 2020; Dzwigol et al., 2019a; 2019b; 2019c; 2020a; 2020b; Furmaniak, et al., 2018; 2019a; 2019b; Kharazishvili et al., 2020; Kondratenko et al., 2020; Kwilinski, 2018a; 2018b; 2019; Kwilinski et al., 2019a; 2019b; 2019c; 2019d; 2019e; 2019f; 2019g; Kwilinski & Kuzior, 2020; Kwilinski et al., 2020a; 2020b; 2020d; Lakhno et al., 2018; Miskiewicz, 2018; 2019; 2020a; 2020b; Miskiewicz & Wolniak, 2020; Pająk et al., 2016; 2017; Ponomarenko et al., 2018a; 2018b; 2018c; 2019; Prokopenko et al., 2015; 2018; 2019a; 2019b; Prokopenko & Miskiewicz, 2020; Saluga et al., 2020; Savchenko et al., 2019; Tkachenko et al., 2019a; 2019b; 2019c; 2019d; 2019e) are devoted to sustainability in economic development at various levels of activity, allowing us to analyze the relationship in energy consumption more deeply.

Thus, the first study of the impact of oil prices on macroeconomic indicators of the country was conducted in 1983 by G. Hamilton in "Oil and the Macroeconomy since World War II". The researcher proved that the increase in oil prices has a more significant impact on changes in macroeconomic indicators than its fall (Hamilton, 2009; Abaas, 2018; Augbaka, 2019; Akimova et al., 2020).

R. Jimenez-Rodriguez and M. Sanchez (Jiménez-Rodríguez, 2005) in their work "Oil Price Shocks and Real GDP Growth - Empirical Evidence for Some OECD Countries" based on the use of multivariate VAR-analysis of panel data (formula1), for both linear and nonlinear models , found a significant relationship between oil prices and macroeconomic indicators of OECD countries. At the same time, the authors note different effects on changes in macroeconomic indicators due to lower and higher oil prices for different types of OECD countries: exporting and importing countries (Yevdokimov, 2018; Singh, 2019; Mlaabdal, 2017; Lyulyov, 2019a; Panasiuk et al., 2020). In particular, for importing countries, rising oil prices negatively affect their economic growth, and for exporting countries (UK and Norway) there is a diametrically different nature of the impact: rising oil prices have a significant negative impact on UK GDP growth, while Norway receives benefit from rising oil prices.

$$y_t = c + \sum_{i=1}^{p} \Phi_i \, y_{t-i} + \varepsilon_t \qquad (1)$$

where $y_t$ – vector (n × 1) of endogenous variables (real GDP, effective exchange rate, oil price, wage level, inflation rate, short- and long-term interest rates).

A similar conclusion is reached by scientists (Haque, 2019; He, 2019) studying the relationship between oil prices and macroeconomic aggregates (gross domestic product, consumer prices and unemployment) for 26 OECD countries during 1980-2011 on the basis of econometric methods:

- cross-sectional dependence test:

$$CDLM1 = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \widehat{\rho_{ij}^2} \sim \chi_{\frac{N(N-1)}{2}}, \qquad (2)$$

- root tests:

$$\Delta y_{it} = a_i + \beta_i y_{i,t-1} + \gamma_i f_t + \varepsilon_{it}, \qquad (3)$$

H0: βi=0
H0: βi<0 i=1,2…N1, i= N1+1, N1+2,…N,

- panel integration tests.

The tests confirmed the existence of a long-term relationship between oil prices and macroeconomic aggregates. At the same time, the scientists (Kasztelnik, 2019; Kuzior, 2019) are indicating a statistically significant and negative impact of oil prices on gross domestic product, consumer prices and unemployment.

Omojolaibi J. (Omojolaibi, 2015) conducts his research on the impact of oil prices on the macroeconomic indicators of the oil-dependent country Nigeria for 1985-2010 years:

$$\begin{cases} CPI_t = \sum_{k=0}^{\infty} S_{11}(k)V_{1t-k} + \sum_{k=0}^{\infty} S_{12}(k)V_{2t-k} + \sum_{k=0}^{\infty} S_{13}(k)V_{3t-k} + \sum_{k=0}^{\infty} S_{14}(k)V_{4t-k}, \\ GDP_t = \sum_{k=0}^{\infty} S_{21}(k)V_{1t-k} + \sum_{k=0}^{\infty} S_{22}(k)V_{2t-k} + \sum_{k=0}^{\infty} S_{23}(k)V_{3t-k} + \sum_{k=0}^{\infty} S_{24}(k)V_{4t-k}, \\ M_{2t} = \sum_{k=0}^{\infty} S_{31}(k)V_{1t-k} + \sum_{k=0}^{\infty} S_{32}(k)V_{3t-k} + \sum_{k=0}^{\infty} S_{33}(k)V_{3t-k} + \sum_{k=0}^{\infty} S_{34}(k)V_{4t-k}, \\ OP_t = \sum_{k=0}^{\infty} S_{41}(k)V_{1t-k} + \sum_{k=0}^{\infty} S_{42}(k)V_{2t-k} + \sum_{k=0}^{\infty} S_{43}(k)V_{3t-k} + \sum_{k=0}^{\infty} S_{44}(k)V_{4t-k}, \end{cases} \quad (4)$$

where CRI -inflation, $M_2$ -money supply, GDP -gross domestic production, $V_{it-k}$ – uncorrelated white noise values, $S_{ij}(L)$ – polynomials of the lag operator.

Structural equation (4) can be transformed into a vector equation:

$$X_t = [\ CPI_t\ GDP_t M_{2t} OP_t] \text{ та } V_t = [V_{1t}\ \ V_{2t}\ \ V_{3t}\ \ V_{4t}] \quad (5)$$

In a study (Cheng, 2017) on the impact of oil prices on Singapore's macroeconomic indicators, the authors found that changes in oil prices have little negative impact on gross domestic product, inflation and unemployment in the country. Another important conclusion is the establishment of a tendency to reduce the intensity of the impact of oil factors in Singapore since 1989 on economic growth (Bilan, 2019a; Kwilinski, 2018).

Ghalayini L. (Ghalayini, 2011) in order to investigate the impact of oil prices on economic growth uses tests on the causality of Granger:

$$GDP_t = C_0 + \sum a_i\, GDP_{t-i} + + \sum \beta_i\, P_{t-i} + \varepsilon \quad (6)$$

$$P_t = C_0 + \sum a_i\, P_{t-i} + + \sum \beta_i\, GDP_{t-i} + \varepsilon \quad (7)$$

where $GDP_t$ – gross domestic product of the study country in the t-th period, $P_t$ – the price of oil of the studied country in the t-th period.

The G-7 and OPEC countries were selected as the objects of Galaini's research (OPEC, (2018). Based on the analysis, the scientist concludes that for most countries there is no interaction between changes in oil prices and economic growth.

The significant influence of these oil factors on economic growth was reflected in the work of M. Mohammed (Mohammed, 2018) using a lag autoregressive model (3.8) based on Angola data for the period 1985-2015, the author concludes about the integrated processes of increasing oil production and economic growth. At the same time, the lack of inverse causality of economic growth to oil production, according to the author, indicates the dependence of Angola on external demand for its oil. Thus, the government needs to pursue a policy of economic diversification in order to minimize adverse global economic shocks associated with a sharp decline in global oil demand (Levchenko, 2018; Lyulyov, 2019b; Pimonenko, 2018; Teletov et al., 2020).

$$\begin{cases} \Delta Y_t = a_0 + \sum_{i=1}^{m} \beta \Delta Y_{t-i} + \sum_{i=1}^{n} \varphi \Delta OP_{t-i} + \theta_1 Y_{t-1} + \theta_2 P_{t-1} + \varepsilon_{1t} \\ \Delta OP_t = a_0 + \sum_{i=1}^{m} \beta \Delta OP_{t-i} + \sum_{i=1}^{n} \varphi \Delta Y_{t-i} + \theta_1 OP_{t-1} + \theta_2 Y_{t-1} + \varepsilon_{1t} \end{cases} \quad (8)$$

where $Y$ – logarithm of the country's GDP, OP – the level of oil production in the country.

However, this result is the opposite of the conclusions of (Tamba, 2017). Based on the annual data for the period 1977–2010, J. Tamba investigated the causal relationship between oil production and economic growth. The results obtained using the vector autoregressive model (VAR) and the Wald test indicate that there is no causal relationship between the variables. In addition, an additional conclusion of the study is the need to introduce a transparent system of oil revenue management in the state, which, accordingly, will contribute to the economic growth of the state in the future (Vasilyeva, 2019; Miśkiewicz, 2020). Another group of scientists concluded that development of the oil complex produces significant environmental damage. To decrease the greenhouse gas emission could be realized through providing renewable energy and implementation the sustainable development principals in the oil industry (Cebula, 2018; Mentel, 2018). In this, case the authors (Chygryn, 2018; Chygryn, 2014; Bilan, 2019b) proved the positive impact of green investment on decreasing GHG emissions and increasing the share of renewable energy.

H. Choi and S. Yoo (Choi, 2016) concluded that the relationship between oil consumption and economic growth in Brazil has a two-way causality. Researchers note that Brazil's economic growth is driven by oil consumption, so reforms to overcome oil consumption restrictions should be implemented to minimize possible reductions in GDP. According to Pakistani scholars (Awan, 2018), such a reform should also be followed by the Government of Pakistan.

Because the results obtained from single-root tests, the joint integration and Granger causality based on error correction models (ECMs) have shown that there is a bilateral causality between oil consumption and economic growth in Pakistan. This means that increasing oil consumption directly affects economic growth (Marcel, 2019).

Alhatlan K. (Alkhathlan, K. A. (2013) conducted a thorough study of the relationship between oil production and economic growth in Saudi Arabia from 1971 to 2010. The paper emphasizes the presence, both in the short and long term, of a statistically significant impact of rent payments from oil production on the real gross domestic product of the country. This study is based on the solution of a system of equations:

$$\begin{cases} y_t = \beta_0 + \beta_1 or_t + \beta_2 inf_t + \beta_3 dco_t + \varepsilon_t \\ y_t = \beta_0 + \beta_1 or_t + \beta_2 inf_t + \beta_3 dco_t + \beta_4 tot_t + \varepsilon_t \\ y_t = \beta_0 + \beta_1 or_t + \beta_2 inf_t + \beta_3 dco_t + \beta_4 tot_t + \beta_5 wr_t + \varepsilon_t \\ y_t = \beta_0 + \beta_1 or_t + \beta_2 inf_t + \beta_3 dco_t + \beta_4 wr_t + \varepsilon_t \end{cases} \quad (9)$$

where $y_t$ – real GDP per capita, $or_t$ – the amount of rent payments from oil, $inf_t$ – inflation, $dco_t$ – the level of domestic oil consumption used in the industrial sector, $tot_t$ – trade openness.

## Methodology

To study the impact of the oil industry on the socio-ecological and economic development of the national economy, Ukraine is the object of study, and for comparison - 20 countries that have signed a cooperation agreement for economic, energy, financial and cultural cooperation under the initiative "One Belt and One way "and according to the World Bank are divided into three subgroups:

- high-income and above-average countries (Belgium, Italy, Kazakhstan, the Netherlands, Germany, Poland, Russia, Romania, Turkey, France),
- OPEC countries (Algeria, Indonesia, Iran, Qatar, Kuwait, United Arab Emirates, Saudi Arabia),
- countries with low and below average income (Ukraine, Uzbekistan).

To study the cointegration and causal relationships of the development of national economy in general, the paper proposes a two-tier approach:

1) on the basis of the heterogeneous modified OLS (FMOLS) model, a linear relationship is established between the indicators of economic development (GDP, capital and labor costs) and indicators of the functioning of the national economy (volumes of oil production and rent payments for oil);

2) the causal links between the economic growth of national economy, the volume of oil production and rent payments are determined by the Granger method based on the developed time series model (VECM), which allows you to adjust the short-term dynamics of parameters depending on the identified long-term relationships between variables and their deviations.

$$\text{FMOLS-model: GDP} = F(K, L, OP) \rightarrow GDP_{it} = \alpha + \beta_1 K_{it} + \beta_2 L_{it} + \beta_3 OP_{it} + \varepsilon_{it} \quad (10)$$

where $GDP_{it}$ – GDP of the i-th country per capita in period t; $K_{it}$ - capital costs of the i-th in the period t (gross fixed capital formation); $L_{it}$ - labor costs of the i-th country in the period t (economically active population aged 15 years and older); $OP_1$ - volumes of oil production, $OP_2$ - volumes of rent payments for oil; $\beta_1$, $\beta_2$, $\beta_3$ - coefficients of elasticity, respectively, capital, labor, oil production; $\alpha$ - the level of technological development of national economy, which is determined by establishing the coefficients of elasticity of capital, labor, oil production, rent payments; $\varepsilon$ - statistical error; t - research period; i - country of study.

$$\text{VECM-model: } \begin{cases} GDP_{it} = \alpha_0 + \sum_{i=1}^{m} \beta_{ik} \Delta GDP_{i,t-1} + \sum_{i=1}^{n} \eta_{ik} \Delta OP_{i,t-1} + e_{1t,} \\ OP_{it} = \alpha_0 + \sum_{i=1}^{m} \theta_{ik} \Delta OP_{i,t-1} + \sum_{i=1}^{n} \mu_{ik} \Delta OP_{i,t-1} + e_{1t,} \end{cases} \quad (11)$$

where $\alpha_0$ – equation constant; $\beta_{ik}$, $\eta_{ik}$, $\theta_{ik}$, $\mu_{ik}$ – calculated system parameters; $\Delta GDP_{i,t-1}$ – change in GDP of the i-th country in the t-th period compared to the previous year; $OP_{i,t-1}$ – change parameters; $e$ – statistical error.

## Results

The traditional factors of change in demand and supply of oil on the world market, which forms the level of oil prices include: the scale of oil production; geopolitical position of the main oil-exporting regions; information on the depletion of oil reserves on the planet; oil and oil reserves in oil-importing countries and the level of reserves of oil-

exporting countries; statements by OPEC members on production quotas and price targets; oil infrastructure; environmental problems, etc.

The table 1 and 2 show the results of the regression analysis of the impact of the price per barrel of Texas oil on the economic growth of the European Union and the World during 1986-2019.

**Table 1: Determining the Impact of the Price per Barrel of Texas Oil on the Economic Growth of The European Union during 1986-2019.**

```
      Source |       SS           df       MS      Number of obs   =        30
-------------+----------------------------------   F(1, 28)        =     62.63
       Model |  3.8601e+26         1  3.8601e+26   Prob > F        =    0.0000
    Residual |  1.7257e+26        28  6.1632e+24   R-squared       =    0.6911
-------------+----------------------------------   Adj R-squared   =    0.6800
       Total |  5.5858e+26        29  1.9261e+25   Root MSE        =    2.5e+12

ВВП  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
Ціна |   1.33e+11   1.68e+10     7.91   0.000     9.83e+10    1.67e+11
cons |   7.13e+12   8.70e+11     8.19   0.000     5.35e+12    8.91e+12
------------------------------------------------------------------------------
```

*Source: created by the author*

The results of the regression analysis of the impact of the price per barrel of Texas oil on the economic growth of the European Union and the World during 1986-2019 showed its positive and statistically significant impact at the level of 1%.

**Table 2: Determining the Impact of the Price per Barrel of Texas Oil on World Economic Growth during 1986-2019**

```
      Source |       SS           df       MS      Number of obs   =        30
-------------+----------------------------------   F(1, 28)        =     40.49
       Model |  7.9973e+27         1  7.9973e+27   Prob > F        =    0.0000
    Residual |  5.5304e+27        28  1.9751e+26   R-squared       =    0.5912
-------------+----------------------------------   Adj R-squared   =    0.5766
       Total |  1.3528e+28        29  4.6647e+26   Root MSE        =    1.4e+13

ВВП  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
Ціна |   6.03e+11   9.48e+10     6.36   0.000     4.09e+11    7.98e+11
cons |   2.18e+13   4.93e+12     4.43   0.000     1.17e+13    3.19e+13
------------------------------------------------------------------------------
```

*Source: created by the author*

The results of cointegration and causation of oil production, rent payments for oil (key parameters of the oil industry) and economic growth of the national economy are presented in table 3, 4.

**Table 3: The Results of Cointegration and Causation of Oil Production and Rent Payments for Oil and Economic Growth of the National Economy**

| The values of the constants β for the corresponding variables in the FMOLS model | FMOLS model configurations | | | | | |
|---|---|---|---|---|---|---|
| | Configuration A (high- and middle-income countries | | Configuration C (OPEC countries) | | Configuration E (low- and middle-income countries) | |
| | Stat. | Prob. | Stat. | Prob. | Stat. | Prob. |
| $\beta_1$ (K) | 0.1994 | 0.011** | 0.223 | 0.000* | 0.681 | 0,000** |
| $\beta_2$ (L) | –16.946 | 0.759 | 0.069 | 0.443 | –7.665 | 0,867 |
| $\beta_3$ ($OP_1$) | 0.073 | 0.000* | 0.099 | 0.000* | 0.023 | 0,000* |
| $\beta_3$ ($OP_2$) | 0.014 | 0.000* | 0.117 | 0.000* | –0.037 | 0,018** |
| $R^2$ ($OP_1$/$OP_2$) | 0.79/0.92 | | 0.82/0.93 | | 0.97/0.86 | |

Note: *, ** and *** – statistical significance at the level 1 %, 5 % and 10 %; $R^2$ – coefficient of model determination; Stat. – direction and strength of influence; Prob. – level of significance

*Sources: created by the authors*

The simulation results showed that the growth of oil production positively increases GDP for OPEC countries and countries with high and above-average incomes, which is primarily due to increased demand for oil, according to the foresee of International Energy Agency.

For low- and below-average-income countries, a 10% increase in oil production leads to a corresponding GDP growth of 0.2% on average.

**Table 4: The Results of Cointegration and Causation of Oil Production and Rent Payments for Oil and Economic Growth of the National Economy**

| Hypotheses | VECM model configurations | | | | | |
|---|---|---|---|---|---|---|
| | Configuration A (high- and middle-income countries | | Configuration C (OPEC countries) | | Configuration E (low- and middle-income countries) | |
| | Prob. | Explanation | Prob. | Explanation | Prob. | Explanation |
| **GDP → $OP_1$** | 0.045** | Lack of causality | 0.046** | Bilateral causality | 0.033** | Bilateral causality |
| **$OP_1$ → GDP** | 0.036** | Unidirectional causality | 0.053*** | | 0.001* | |
| **GDP → $OP_2$** | 0.042** | Lack of causality | 0.063*** | Bilateral causality | 0.002* | Bilateral causality |
| **$OP_2$ → GDP** | 0.033** | Unidirectional causality | 0.068*** | | 0.000* | |
| Note: *, ** and *** - statistical significance at the level 1 %, 5 % and 10 % | | | | | | |

*Sources: created by the authors*

Insignificant economic benefits for this type of country are associated with the lack of modernization of the industry and require a change in the paradigm of subsoil development, the transition from extensive to intensive development (strengthening technological development for high value-added products).

Positive values of parameters $\beta_1$ and $\beta_3$ for countries with high and above-average income and OPEC, their high statistical significance at the level of 1-5% suggest that countries with high and above-average income, OPEC use the amount of rent payments for oil for development technological progress contributing to increased economic development. With an increase in oil rents by 10% for low- and below-average-income countries, GDP will shrink by 0.3%, and the two-sided causality between these parameters indicates, on the one hand, the ineffectiveness of policies to support the development of those sectors of the economy. related to the extractive industry, and on the other hand about the inefficiency of market reforms carried out in the oil industry due to the instability of state institutions.

## Conclusion

Conducted investigation gave the opportunity to concluded according the main features of the global energy market. 1. The world oil market is a recipient of the influence of global objective manifestations of the world economy, its social and political processes. Therefore, his study necessitates the study of relevant trends, institutions, market elements and features of their impact on pricing processes.

2. The level of consumption of oil and related products of its refining is determined by the level of development of each country.

3. Global trends in the development of innovative technologies, the development of alternative energy, the slowdown in the global economy cause certain changes in the growth of oil consumption.

4. Global objective and subjective development trends: uneven geographical location of fields, the creation of oil cartels that defend the interests of certain stakeholders and global institutions, in general, largely determine the monopoly position in the oil market.

5. The world oil market is constantly affected by the effects of various contradictions that arise between major stakeholders and market players and that have different economic, political, social and environmental interests.

6. The development of the world oil market is not stable; its development trends are determined from time to time in relation to the world leaders in oil production.

7. International policy in the field of environmental protection, the introduction of measures by countries to combat global climate change, the implementation of commitments by countries in the field of low-carbon development change the trends in the consumption of petroleum products.

The results of the study of cointegration and causal links between the development of the oil industry and the national economy showed that the growth of oil production and the level of rent payments for oil increase GDP for OPEC countries, high and middle-income countries. For countries with low and below average income levels, a 10% increase in oil production leads to a 0.2% increase in GDP. Insignificant economic benefits for this configuration of countries are associated with the lack of systematic modernization of the industry and necessitate a change in the system of

state regulation of exploration and use of oil fields, the transition from extensive to intensive development of oil production complex for high value added products.

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