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Predictive Scenarios of the Russian Oil Industry; with a Discussion on Macro and Micro Dynamics of Open Innovation in the COVID 19 Pandemic

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Abstract: The decrease in the economic activity level around the world due to the COVID-19 pandemic spread has led to a sharp decrease in the crude oil price and provoked an oil war outbreak in the global energy market. The current situation has provoked the need for a total decrease in the crude oil production in the world. Considering that Russia is one of the main oil exporters on the world market, the need to determine the supply and demand levels for Russian oil is becoming relevant. The aim of the paper is to model predictive scenarios of Russian oil industry development, considering the specifics of the current economic environment given the COVID-19 pandemic. The multifactor correlation modeling method was used to form the system of indicators determining the level of demand and supply for Russian oil used and the total level of their influence. The functions determine the probability of implementing various scenarios of oil industry development depending on the predicted values of demand and supply. The three-sigma rule and the fuzzy sets method were used to estimate three scenarios of oil industry development for 2020–2021. Changes in revenues of the industry under the influence of forecast indicators of supply and demand for oil have been assessed and the probability of implementation of each of the scenarios has been reasoned. The results obtained are of a practical nature and can be used by government agencies, financial intermediaries, and scientists to diagnose Russian oil industry development. The results will be useful for oil companies to develop a strategy of open innovations for further design of the scientific information field for the effective functioning of the industry in complete uncertainty conditions.

Keywords: oil wars; Russia; crude oil; oil industry; COVID-19 pandemic; open innovations

1. Introduction

Russia is a major producer of crude oil, accounting for 13% of global production [1]. At the same time, the Russian economy is largely determined by oil prices, since about 14% of GDP comes from the base material sector [2]. Russia's oil production volume remains almost constant, while oil prices are highly volatile [3,4]. This means that the volatility of super profits for Russia is determined not by the production volume, but by the oil market, which does not depend on Russia. The introduction of quarantine in almost all countries and regions of the world due to the COVID-19 pandemic has triggered significant changes in energy markets. These changes are very significant in the short term and may have equally important consequences in the long term for all sectors of the fuel and energy industry as well as for the so-called energy transition process.

Crude oil is one of the main drivers of economic activity that contributes most to global energy production and consumption [5,6]. Global demand for petroleum products, in particular Brent, is on an upward trend mainly due to growing and developing economies. With the rapid spread of the COVID-19 pandemic, demand for oil fell in the first and second quarters of 2020 due to a decline in economic activity around the world. The drop in demand was triggered primarily by a slowdown in the Chinese economy, which completely reformatted the global energy supply and demand scenario [7,8]. Experts believe that this situation will cause the global demand for oil to drop by a record 9.3 mln barrels to 90.5 mln barrels per day in 2020, compared to 2019, even if countries lift quarantine restrictions on the movement of people in the second half of this year [9]. Lower demand for crude oil has triggered a steady decline in the price of energy resources [10]. As a solution, OPEC suggested a production cut in oil in response to falling oil demand. Crude oil prices for many producers were below operating costs [11]. On the other hand, countries such as Saudi Arabia and Russia did not at first consciously slow down the rate of resource production fearing that their share of the common market would be taken by the rest of the participants. This led to the outbreak of the "oil war" [12,13]. These countries are among the leaders in oil production, so lowering oil prices over a longer period of time will only harm their economies in the long run. In addition to economic interests, political interests are also beginning to come into play, as each country's government is interested in increasing or maintaining the welfare of its own citizens, and the currencies of some countries, particularly Russia, are tied either to the value of a barrel of oil or to the oil reserves, so that declining production involves too much risk to the oil-dependent national economy. All things considered, oil producing nations have agreed to a 10 million barrel reduction in May and June 2020 followed by cuts of 6 million barrels a day until April 2022, with Russia and Saudi Arabia contributing to half of those cuts [14]. All oil producing countries agreed to cut supply by 23% [15]. The oil price war, which started in March after the collapse of previous OPEC+ talks, lasted exactly 31 days. The situation has changed with the price of crude oil on the energy market gradually recovering, but the question of how fast and complete the recovery of demand for oil in the second half of 2020 will be remains open.

High crude oil prices kept the Russian economy growing, while in the current situation of complete uncertainty experts predict the end of the era of fossil fuels due to the coronavirus recession [16]. Some analysts even believe that the peak of demand for it was passed back in 2019, that is 15 years earlier than expected [16]. Nowadays there exists a great mass of academic literature focusing on the economic properties of oil, its impact on the aggregate world economy and specifically on economies of different types (say, net exporters or net importers of oil, emerging or developed ones, etc.) [17–21].

Most modern studies consider changes in the oil industry in terms of certain economic variables, such as the exchange rate [22–26], inflation rate [27–30], unemployment rate [31–35], innovations [36,37] and others. Researchers use different econometric methods, analyzing the nature of the relationship between the internal and the external variables [38–47].

Some scientists determined the impulsive responses to the oil's leaps [48–51], while others estimated its significance, volume, and time rate, as well as the disappearances of the response [51,52]. Oil industry development modeling is quite widespread in this block of studies. The modeling uses the fuzzy sets method, allowing the determination of the influence of not only quantitative factors but also qualitative variables on industry development to operate with linguistic criteria. This enables researchers to significantly improve forecast accuracy and economic phenomenon assessment objectivity [53].

A third block of works also deals with the problems of oil industry influence on economic transformations, environment [54], and modernization in the raw materials economy [55].

Another set of scientific studies reflects an asymmetrical relationship between economic activity in the country and the level of oil prices on the world energy market, depending on changes in the main economic indicators. In particular, several papers dwell on the role of oil price and the real exchange rate fluctuations of the ruble on Russian fiscal policy and economic performance [56–58]. One more worthwhile example concentrates on four large energy producers and addresses the issue of the effects of oil price shocks on the real exchange rate, output and inflation level via SVAR methodology [59,60]. It should be noted, however, that previous studies have mainly examined the influence of economic factors on changes in demand, the application of energy resources, and the price range. These factors can be explained from the point of view of economic laws, which makes it possible to identify and substantiate certain regularities of change in the impact of the price on oil or other energy resources. Yet in the current environment, the subsequent economic recovery after the COVID-19 recession will be the main factor determining the trajectory of oil prices, which is characterized by complete uncertainty. It is already clear that the global economic crisis is about to start (although its severity and duration are not yet known); strict quarantine has been imposed in many countries, including Russia, accompanied by lower oil prices. It is difficult to say what the impact of oil prices will be, precisely because it is now combined with a number of other factors, including sanctions, which have not yet been lifted. Nevertheless, the shocking decline in oil prices had a negative impact on the Russian economy. Therefore, this study is intended to determine a prognostic scenario for the development of the Russian oil industry, taking into account the specifics of the modern economic situation in the conditions of the COVID-19 pandemic. This research is aimed at substantiation of oil industry development scenarios in the context of the humanitarian crisis, rather than financial one, which slightly expands the research scope regarding the determination of the industry development uncertainty condition. Humanitarian crisis cannot be considered as the usual mismatch of supply and demand; it causes the society to have problems functioning as a whole. Under these conditions the development of the oil industry or the economy as a whole is difficult to predict, even in the short term. This uncertainty requires non-standard synthetic tools development. The use of open innovation products by industry enterprises is especially important, which allow for non-standard solutions to be found in the current difficult circumstances of the oil industry; that is what this research is aimed at. In the course of the research the system of main indicators and factors determining the peculiarities of supply and demand for Russian crude oil was formed and the aggregate nature of their influence on the profitability of the industry was described. The probabilities of three scenarios for Russian oil industry development depending on the oil production volumes of the main producing countries and the COVID-19 pandemic trend were statistically calculated and justified. The most probable nature of Russian oil industry development at the end of 2020–2021 under unchanged economic conditions has been determined.

This paper is divided into several sections as follows: Section 1 includes relevant research topics, reviews the literature, and provides an outline of the factors and hypotheses of this study. Section 2 describes the research methodology, data collection, and data analysis. Results are discussed in Section 3. Lastly, Section 4 summarizes the conclusions of this study, with recommendations outlined in Section 5.

2. Materials and Methods

2.1. Determining Supply and Demand Indicators in the World Oil Market Affecting the Development of the Russian Oil Industry

Factors that determine the state of the oil industry are supply and demand at the world oil market, as their ratio determines the equilibrium price, sales volume, and proceeds from oil sales.

Proceeds from oil sales is the resulting indicator (Y) with its dynamics characterizing the state of the industry and determining the development scenarios. The most significant factor affecting the demand for oil at this stage of development is the COVID-19 pandemic.

Statistical data on the value of oil sales in Russia are very limited, because the highest level of specification is a monthly one, while the duration of the COVID-19 pandemic is four months (January–April 2020). This data set does not allow for statistical analysis aimed at identifying factors that affect the industry. In this regard, the article investigates the influence of factors on the state of the Russian oil industry through the indicator of dynamics of world prices (P) for Urals oil (which is produced in Russia), expressed in dollars per barrel. The analysis is based on the daily data for the period January-April 2020. The change in demand for oil as a result of the COVID-19 pandemic affected the level of world oil prices, which in its turn affected the volume of revenues of the Russian oil industry. OPEC+ is also aimed at regulating the price level. Therefore, the use of index P as a result of the modeling allowed us to ensure the sufficiency of the sample and to reflect the influence of supply and demand factors on the world oil market in the conditions of the pandemic on the condition of the Russian oil industry.

The results of the correlation analysis based on the daily data for the period January–April 2020 showed that the most significant influence on the oil price level, among the factors describing the spread of the COVID-19 virus, is produced by the ratio of the number of those who got ill with COVID-19 to the number of those who recovered during the period ti-1—ti (Z index). The correlation coefficient was r = −0.79, which is statistically significant by the Student's criterion with the number of degrees of freedom df = (81; 0.05). The correlation coefficient values were calculated using the Statistica 12.0 software. The analysis of relevant literature [61–65] allowed us to identify the following additional indicators:

(i) rate of increase in the number of infected people in the world at a given time t_i
(ii) duration of the pandemic (duration is understood as the period of time from the moment of mass infection in China - 22.01.2020 to the analyzed point of time t_i)
(iii) number of people falling ill in the world at a time t_i
(iv) the number of countries in the world where COVID-19 infections have been recorded at a given time t_i
(v) number of countries in the world where quarantine has been implemented at a given time t_i
(vi) number of countries with prevalence > 0.001% of the population at the time of infection t_i
(vii) number of countries with prevalence > 0.01% of the population at the time of infection t_i
(viii) number of countries with prevalence > 0.1% of the population at the time of infection t_i
(ix) the number and rate of increase in the number of infected in the world's main oil consumers (USA, China, India, Japan) [66]
(x) the duration of the pandemic in these countries at a given time t_i, in days

The values of the correlation coefficients of these indicators with P do not exceed |0.21|. The January to April 2020 time period reflects the duration of the COVID-19 pandemic.

On the supply side, the factors affecting the price level are the oil production and export volumes of OPEC countries with the share of 33–38% of the world oil production for the last 5 years [5], as well as the production and export volumes of the USA (providing 15.8% of the world oil market at the beginning of 2020 and ranking 1st in the world in oil production and 8th in export), Russia (13.5% of the market, 2nd place by production and export), Canada (5.7% of the market, 4th place by production and export), China (4.8% of the market, 6th place by production) [66]. Other prominent representatives of the world oil market (from the top 10 countries by production and export volumes: Saudi Arabia, Iraq, UAE, Kuwait, Iran) are OPEC members and their influence on the oil market in Russia is studied as part of OPEC. The correlation coefficients between the indicators that determine the supply on the world oil market and the price level, calculated on the basis of daily data for the period January-April 2020, are presented in Table 1.

Table 1. Values of paired correlation coefficients between indicators that determine supply at the world oil market and price level.

	P	*X1*	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*	*X9*	*X10*
P	1										
X1	−0.81 *	1									
X2	−0.74 *	0.76 *	1								
X3	−0.76 *	−0.04	−0.11	1							
X4	−0.50 *	−0.19	−0.12	0.61 *	1						
X5	−0.71 *	−0.13	−0.14	−0.09	−0.12	1					
X6	−0.70 *	−0.18	−0.09	−0.10	−0.13	0.75 *	1				
X7	−0.20	−0.11	−0.20	−0.08	−0.14	−0.10	−0.12	1			
X8	−0.17	−0.19	−0.11	−0.12	−0.16	−0.16	−0.15	0.48 *	1		
X9	−0.79 *	−0.20	−0.11	−0.16	−0.17	−0.20	−0.12	−0.16	−0.13	1	
X10	−0.75 *	−0.19	−0.20	−0.08	−0.20	−0.11	−0.07	−0.11	−0.17	0.86 *	1

Legend keys: P—Urals oil global price, US $ per barr.; *X1*—oil production volume in OPEC countries, mln. barr./day; *X2*—export volume from OPEC countries, mln. barr./day; *X3*—oil production volume in USA, mln. barr./day; *X4*—export volume from USA, mln. barr./day; *X5*—oil production volume in Canada, mln. barr./day; *X6*—export volume from Canada, mln. barr./day; *X7*—oil production volume in China, mln. barr./day; *X8*—export volume from China, mln. barr./day; X9—oil production volume in Russia, mln. barr./day; *X10*—export volume from Russia, mln. barr./day; *—correlation coefficients that are significant according to Student criterion with $p = 0.05$.

Significant correlation coefficients between indicators *P-X1*, *P-X2*, *P-X3, P-X4, P-X5, P-X6, P-X9,* and *P-X10* show that the supply side has a significant impact on the price level of production and exports of OPEC countries, the USA, Canada, and Russia. The value of correlation coefficients between the indicator *P* and *X1* is −0.81, between the indicator *P* and *X2* is −0.74, between the indicator *P* and *X3* is 0.76, between the indicator *P* and *X4* is −0.50, between the indicator *P* and *X5* is −0.71, between the indicator *P* and *X6* is −0.70, between the indicator *P* and *X9* is −0.79, and between the indicator *P* and *X10* is 0.75. There are also significant links between production and export performance within countries (between the indicators *X1-X2*, *X3-X4*, *X5-X6*, *X7-X8, X9-X10*), which is why the use of all these indicators in the future to model scenarios of the Russian oil industry development will lead to multicollinearity and decrease the reliability of the results. Of the pairs of correlated indicators (*X1-X2*, *X3-X4*, *X5-X6*, *X7-X8, X9-X10*) stronger impact on P is due to *X1*, *X3*, *X5,* and *X9*. These indicators will be used in the study as indicators that determine supply on the world oil market and influence the development of the Russian oil industry.

The cumulative effect of independent variables *Z, X1*, *X3*, *X5,* and *X9* on the resulting index *P* is estimated using the constructed linear multifactor regression model, the adequacy of which is evidenced by the values of the F-criterion on the model and the t-criteria on independent variables. Statistica 12.0 software was used to build the model.

2.2. Predictive Scenarios of Russian Oil Industry Development

Scenarios of economic processes can usually be described with the help of three development scenarios: L-shaped, implying that the level of indicators characterizing the development of the economy (of an industry or an individual entity) and their growth rates in the post-crisis period over a long period of time are at a lower level than in the pre-crisis period; U-shaped, implying that the level of indicators in the post-crisis period is at a lower level than in the pre-crisis period, but with pre-crisis growth rates; V-shaped, implying a rapid recovery [67–69]. These scenarios are the basis for predicting the development of the Russian oil industry during the COVID-19 pandemic and the recovery period. The probability of L-scenario is described by *p1* indicator, U-scenario by *p2*, and V-scenario by *p3*. The basis for measuring the probabilities of *p1*, *p2*, *p3* depending on the influence of indicators *Z*, *X1*, *X3*, *X5*, and *X9* is the method of fuzzy sets that was chosen due to the low degree of theoretical and practical determinacy of these scenarios of development.

Taking into account the fact that the world oil market is in a situation where the reserves are filled, and therefore all the volumes of Russian production are for sale (domestic consumption and export), then, $Y_i = (P \times X9)_i = f(Z_i, X1_i, X3_i, X5_i, X9_i) \times X9_i$, with Y_i being Russian oil revenues within i-th period.

Y levels correspond to the development scenarios: L scenario is a low level, U scenario is a medium level, V scenario is a high level.

L-shaped scenario of oil industry development comes into force with $Y_{TPi} \ll \bar{Y}_{TPi}$, U-shaped comes into force with $Y_{TPi} \approx \bar{Y}_{TPi}$, V-shaped comes into force with $Y_{TPi} >> \bar{Y}_{TPi}$, with Y_{TPi} being the chain growth rate of the indicator Y within i-th period, and $\bar{Y}_{TP}$ being average pre-crisis revenue growth rates in the Russian oil industry. As a pre-crisis period, the time range of 2016–2019 with monthly details is taken. The three-sygma rule was used to determine the level of the Y_{TP} indicator. The rule was used because it allows for the determination of the confidence interval: in this case it is the range of values which characterizes the average level of the indicator with a probability (0; 100%). Y_{Tp} values that are below the confidence interval with 100% confidence will be at a low level, while those that are above the confidence interval will be at a high level. The Y_{Tp} indicator is characterized by the normal law of distribution, and therefore it became possible to use this rule.

Variation range median deviation of the Y_{TPi} indicator between 2016 and 2019 from the average deviation did not exceed 50% of the standard deviation, indicating no asymmetry. With this in mind, the low level of the indicator (L-scenario) out of 100% confidence formed the values $Y_{TPi} < Y_{TP1i}$, with $Y_{TP1i} = (\bar{Y}_{TP} - 3 \times \sigma)$; for V-scenario—$Y_{TPi} > Y_{TP3i}$, $Y_{TP3i} = (\bar{Y}_{TP} + 3 \times \sigma)$; for U-scenario—$Y_{TPi} = Y_{TP2i} = \bar{Y}_{TP}$, with σ being standard deviation of the Y_{TP} indicator. For Y_{TPi} values that are out of the range probability of scenario implementation was in the range [0; 1] and determined in the Matlab 7.0.1 software using the following formulas:

$$
\begin{aligned}
p_1 &= \begin{cases} 1, Y_{TPi} < Y_{TP1i} \\ \frac{Y_{TP2i} - Y_{TPi}}{Y_{TP2i} - Y_{TP1i}}, Y_{TP1i} \le Y_{TPi} < Y_{TP2i} \\ 0, Y_{TPi} \ge Y_{TP2i} \end{cases} \\
p_2 &= \begin{cases} 0, Y_{TPi} < Y_{TP1i} \\ \frac{Y_{TPi} - Y_{TP1i}}{Y_{TP2i} - Y_{TP1i}}, Y_{TP1i} \le Y_{TPi} < Y_{TP2i} \\ 1, Y_{TPi} = \bar{Y}_{TP} \\ \frac{Y_{TP3i} - Y_{TPi}}{Y_{TP3i} - Y_{TP2i}}, Y_{TP2i} < Y_{TPi} \le Y_{TP3i} \\ 0, Y_{TPi} > Y_{TP3i} \end{cases} \\
p_3 &= \begin{cases} 0, Y_{TPi} \le Y_{TP2i} \\ \frac{Y_{TPi} - Y_{TP2i}}{Y_{TP3i} - Y_{TP2i}}, Y_{TP2i} < Y_{TPi} \le Y_{TP3i} \\ 1, Y_{TPi} > Y_{TP3i} \end{cases}
\end{aligned}
\quad (1)
$$

In determining the scenario of industry development in the period of COVID-19 Y_{Tpi} designated basic growth rates of indicator Y as compared to 31.12.2019. The use of basic growth rates allowed us to estimate the possibility of the Russian oil industry reaching the pre-crisis level.

The prediction of industry development is based on: (1) dynamics of COVID-19 spread in the world (forecast of Z indicator change); (2) OPEC+ actions aimed at stabilization of the world price by means of oil production decrease (change of X1, X3, X5, X9 indicators). The forecast is based on the short- (until the end of 2020) and medium-term period (for 2021). To predict the dynamics of COVID-19 spread in the world, the extrapolation method and Chow test were used to study the presence of structural shifts in the dynamics of the indicator. For the prediction of supply on the world oil market, OPEC+ actions in relation to the decrease in production of the world's leading oil exporters were analyzed.

As a basis for the prediction of supply on the world oil market and its impact on the Russian oil industry, the terms of the OPEC+ agreement providing for the reduction of oil production volumes were used [70,71]. According to the existing OPEC+ agreements, the OPEC countries and Russia agree to reduce their oil production by a total of 9.7 mln barrels per day by the end of June 2020, compared to the 2019 average. The volume of OPEC+ oil decline in the following periods (until the end of 2021) is less deterministic. Additional OPEC and Russia production cuts to 31.12.2020 will be 7.7 mln barrels per day and 5.8 mln barrels per day in 2021 [70]. Due to the lack of distribution of production cuts between OPEC and Russia, this study adopts the ratio of basic terms of the OPEC+ agreement (April 2020): OPEC countries account for 74.2% of the total reduction, while Russia accounts for 25.8% [70]. In physical terms, this is: for OPEC countries 5.7 mln barrels per day until 31.12.2020, 4.3 mln barrels per day until 31.12.2021; for Russia 2 mln barrels per day until 31.12.2020, 1.5 mln barrels per day until 31.12.2021. Of the non-OPEC countries, the largest oil producers US and Canada have committed to reducing production by 5 mb/d, but these agreements are declarative in nature. The countries have not committed to reducing production [72]. Therefore, the EIA forecast is a more informative one. According to the EIA forecasts of 12 May 2020 [73], U.S. oil production by the end of 2020 is 10.9 mln barrels per day, and by the end of 2021 it is 10.3 mln barrels per day. The most significant forecast is that the decrease in production in the second quarter of 2020 will be about half of the annual decline in 2020. Canadian oil production in 2020 will decrease by 0.4 mln barrels per day compared to 2019, and at the end of 2021 will reach the 2019 level [73].

3. Results

3.1. Modeling the State of the Russian Oil Industry under the Influence of Supply and Demand Factors Amidst COVID-19 Pandemic

Correlation analysis confirmed the opposite effect of OPEC, USA, Canada and Russia oil production volumes, as well as the ratio of the number of COVID-19 diseases to the number of recoveries to the level of world prices for Urals oil. The function of dependence of these indicators $P_i = f$ (Z, $X1$, $X3$, $X5$, $X9$), obtained by using a linear multifactor regression model is as follows:

$$P = -5.57 \times Z - 1.77 \times X_1 - 1.13 \times X_3 - 1.04 \times X_5 - 2.78 \times X_9 + 148.83 \quad (2)$$

With regard to the oil production indices, throughout the whole period under study (January-April 2020) the inverse character of the influence on the price level is observed. As for the Z index, the stable reverse influence has been observed since the end of February, which is conditioned by its dynamics (Figure 1).

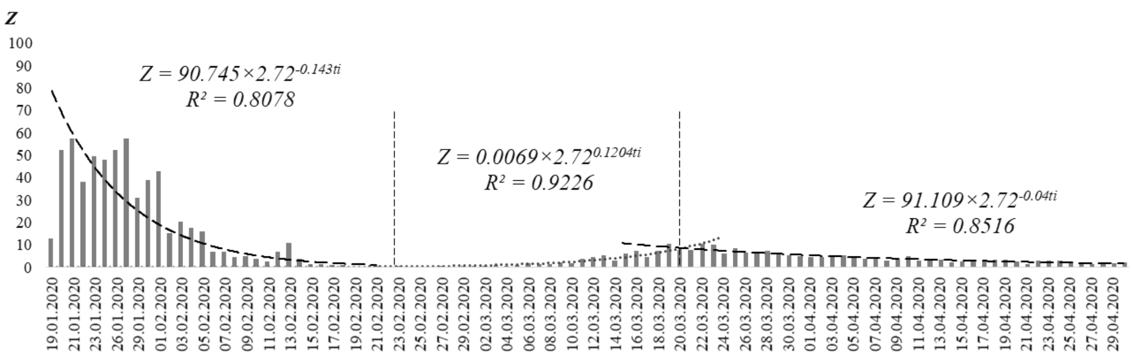

Figure 1. Disease to recovery ratio in the world during the period of COVID-19 spread.

To assess the dynamics of the indicator Z presented in Figure 1, we took the values of the variation series for the 19.01.2020–30.04.2020 period with the extremes being excluded (nine determined by the Dixon criterion). The dynamics of the Z indicator demonstrates three stages of its development. Statistically, the significance of the differences in the regularities of the Z indicator change at these three stages was confirmed by the Chow's test. Application of this test proved the presence of two structural shifts in the dynamics of the indicator: (1) in the 21.02.2020–24.02.2020 period; (2) in the 19.03.2020–21.03.2020 period. Checking model residue with F-statistics showed that $F_1 > F_{tabl}$ (10.37 > 4.12), $F_2 > F_{tabl}$ (9.84 > 4.03), with F_1 being the empirical value of statistics calculated on the basis of the difference between the sum of deviation squares of the model built on the intervals [t_0; t_2] and the models built on the intervals [t_0; t_1], [t_1; t_2]; with F_2 being the empirical value of statistics calculated on the basis of the difference between the sum of deviation squares of the model built on the intervals [t1; t3] and the models built on the intervals [t_1; t_2], [t_2; t_3]; and with F_{tabl} being tabular Chow statistics with $p = 0.05$; t_0 = 19.01.2020, t_1 = 22.02.2020, t_2 = 20.03.2020, and t_3 = 30.04.2020.

At the first stage, the ratio of the number of patients to those who have recovered decreases exponentially. During this period, infection with the virus occurred in China and in Australia and Asia (South Korea, Singapore, Japan, Thailand) [74]. The sharp decline is due to severe quarantine measures in China (closure of schools, universities, international communication, banning of mass events, state of emergency in selected provinces) [75] and the high quality of the health system [76]. Against the background of the decline in the indicator, the price level of Urals oil continues to decline, which is caused by the decline in production in China, as the main consumer of oil in the world after the U.S., and the pessimistic mood about the spread of COVID-19 in the world, associated with the detection of the virus in Europe.

The second stage is characterized by an increase in morbidity on all continents, in all countries except China. The declaration of COVID-19 as a pandemic (11.03.2020), quarantine by a number of countries, closure of international communication, restriction of mobility on the territory of countries led to a slowdown in the rate of the disease incidence. Phase 3 is characterized by an exponential decrease in Z. The values of Z indicator at the 2nd and 3rd stages closely correlate with the level of world oil prices. Therefore, in order to build the model (2) the time range of the study was narrowed by the period [20.03.2020; 30.04.2020]. It is this period that reflects current trends of the virus development in the world and provides a balanced assessment of the impact of the pandemic on the Russian oil market (not only the impact of the epidemic in China).

The appropriateness of the model (2) is confirmed by the *F*-criterion, the calculated value of which (19.43) exceeds the Table 2.53 (with the number of the freedom degrees df = (5; 30) and the significance level 0.05); the t-criterion, the calculated values of which |18.43| by Z indicator, |12.11| by X1, |8.16| by X3, |7.98| by X5, |16.43| by X9 exceed the Table 2.04 (with the number of the freedom degrees df = 30 and the significance level 0.05). The excess of the calculated t-criterion values on the module over the tabular one indicates the statistical significance of the impact of indicators Z, X1, X3, X5, X9 on the level of the world prices for Urals oil. The excess of the calculated F-criterion values over the tabular one signifies the adequacy of the constructed model as a whole and the possibility of its use for prognostic development scenario construction for Russia's oil industry in the COVID-19 context.

Over the period 2016–2019, the average growth rate of revenues of the Russian oil industry is 1.01, i.e., $\bar{Y}_{TP} = 1.01$. With this in mind, the functions of determining the probability of development of L, U, V-scenarios take the form of:

$$p_1 = \begin{cases} 1, Y_{TPi} < 0.83 \\ \frac{1.01 - Y_{TPi}}{0.18}, 0.83 \le Y_{TPi} < 1.01 \\ 0, Y_{TPi} \ge 1.01 \end{cases}$$
$$p_2 = \begin{cases} 0, Y_{TPi} < 0.83 \\ \frac{Y_{TPi} - 0.83}{0.18}, 0.83 \le Y_{TPi} < 1.01 \\ 1, Y_{TPi} = 1.01 \\ \frac{1.19 - Y_{TPi}}{0.18}, 1.01 < Y_{TPi} \le 1.19 \\ 0, Y_{TPi} > 1.19 \end{cases} \quad (3)$$
$$p_3 = \begin{cases} 0, Y_{TPi} \le 1.01 \\ \frac{Y_{TPi} - 1.01}{0.18}, 1.01 < Y_{TPi} \le 1.19 \\ 1, Y_{TPi} > 1.19 \end{cases}$$

Model (3) is the basis for forecasting scenarios of Russian oil industry development under the influence of supply and demand factors.

3.2. Predicting Supply and Demand in the Global Oil Market and Modeling Its Impact on the Russian Oil Industry

The dynamics (Figure 1) show the exponential law of the development of the indicator of the ratio of the number of diseased to the recovered: exponential growth and exponential decrease at certain time intervals depending on the administrative measures introduced by the states. At the time of the study, there was a steady decline in the indicator, which is described by the function $Z = 91.109 \times e^{-0.04 \times ti}$, approximation coefficient of this trend line 0.85 indicates the adequacy of the forecast obtained using this function.

The predicted value of the COVID-19 disease ratio as of 30.06.2020 is 0.1924, as of 30.09.2020 is 0.0049, and as of 31.12.2020 is 0.0001. The predicted probabilities of the industry development scenarios implementation under the influence of the demand factor as of 30.06.2020 are as follows: $p1 = 1$, $p2 = 0$, $p3 = 0$; as of 31.12.2020: $p1 = 1$, $p2 = 0$, $p3 = 0$; as of 31.12.2021: $p1 = 1$, $p2 = 0$, $p3 = 0$. With $Z = 0$ the indicator Y does not reach its pre-crisis level (the value of the indicator is 27% lower than the pre-crisis level), which indicates that it is impossible for the industry to enter the U and V-scenarios without settlement of supply volumes. The estimation of influence of Z on Y is received by substitution in the model (2) of forecast values of Z at fixed values of other indicators, at a fixed level of 30.04.2020.

Taking into account the forecast volumes of oil production among OPEC countries, Russia, the USA, Canada, as well as the forecast of COVID-19 distribution in the world, the forecast of scenarios of the Russian oil industry development for the period of 2020–2021 was obtained (Table 2).

Table 2. Determination of predictive scenarios of the Russian oil industry development in 2020–2021 perspective.

Indicator	Predicted Values		
	Q2 2020	Q4 2020	2021
Z	0.1924	0.0001	0
$X1$	27.5	21.8	17.5
$X3$	15.1	10.9	10.3
$X5$	5.3	5.1	5.5
$X9$	3.9	1.9	2.4
Y_{TP} (Z)	0.71	0.73	0.73
Y_{TP} $(X1)$	0.62	0.78	0.9
Y_{TP} $(X3)$	0.52	0.59	0.61
Y_{TP} $(X5)$	0.44	0.44	0.43
Y_{TP} $(X9)$	0.34	0.19	0.23
Y_{TP}	0.66	0.42	0.57
$p1$	1	1	1
$p2$	0	0	0
$p3$	0	0	0

Legend keys: Y_{TP} (Z)—basic rate of growth of the Y indicator against 31.12.2019 г., driven by the change of Z indicator; Y_{TP} $(X1)$—basic rate of growth of the Y indicator, driven by the change of $X1$ indicator; Y_{TP} $(X3)$—basic rate of growth of the Y indicator, driven by the change of $X3$ indicator; Y_{TP} $(X5)$—basic rate of growth of the Y indicator, driven by the change of $X5$ indicator; Y_{TP} $(X9)$—basic rate of growth of the Y indicator, driven by the change of $X9$ indicator; Y_{TP}—overall basic rate of growth of the Y indicator, driven by the change of Z, $X1$, $X3$, $X5$, $X9$ indicators; Y_{TP} (Z), Y_{TP} $(X1)$, Y_{TP} $(X3)$, Y_{TP} $(X5)$, Y_{TP} $(X9)$ are calculated using the formula (2) using predicted values of the corresponding independent variable at a constant level of others; Y_{TP} is calculated using the formula (2) using predicted values of all independent variables.

In 2020–2021, there is no probability of U and V scenarios for Russian oil industry development (100% probable is L scenario that implies the level of industry revenues and growth rates being lower than the pre-crisis ones). According to this scenario, the most positive impact on the development of the Russian oil industry is a presumed decrease in oil production by OPEC countries. Due to this factor (with other factors remaining unchanged), by the end of 2021 there is a 39% probability of U scenario, with revenues of the Russian oil industry being 10% below the pre-crisis level. The decrease in US production also has a positive impact. However, due to the fact that oil production in Russia will decline at a higher rate than in the USA and against the background of increased production in

Canada, by the end of the second quarter of 2020 the industry revenues are predicted to reach 66% as compared to 2019. By the end of 2020 it will be 42%, while by the end of 2021 it will be 57%.

4. Discussions: Macro and Micro Dynamics of Open Innovation in the Covid 19 Pandemic

This study presents an approach to modeling scenario development using the example of the oil industry of the Russian Federation, taking into account the conditions of general quarantine and the trends of the COVID-19 pandemic, which lead to a significant decrease in global economic activity and demand for crude oil. An approach to determining the factors of changes in crude oil price levels [23,25,38,39,52,60] and econometric approaches to estimating the strategic development of the industry [41–44,48] have significant methodological differences from existing research. The presented forecast methodology is based on the current approved agreement between OPEC countries and Russia on the reduction of oil production in order to balance the level of oil prices on the world energy market. That is, on the basis of the developed approach it is possible to determine the scenario of development of the Russian oil industry depending on the current conditions, as well as to vary the data depending on their changes over time. Yet they may change depending on the trends of coronavirus proliferation in the world and changes in the level of economic activity, restoration of supply chains, etc. The modeling of the predictive scenario is based on reliable data and reflects the short- and medium-term trend of oil industry development using Russia as an example. It allows researchers, under conditions of high uncertainty, to significantly reduce to two or three of the most likely alternatives for the development of the industry in the short and medium term. This, in turn, allows for analysis and monitoring of the complex and uncertain environment of the oil industry and energy market, changes in crude oil prices, which are subject to many significant and influential trends, and events characterized by probabilistic and high levels of uncertainty in the current conditions [77]. Justification of forecast values of supply and demand for crude oil makes it possible to increase readiness of Russian oil companies and the government, and provides them with various options of future events and allows them to react to those events adequately, helping them to develop an effective strategy of preventive measures to reduce the impact of oil price volatility on the Russian economy [78,79].

As the research has shown, the Russian oil industry profitability level in the humanitarian crisis context should decrease to 60% of the pre-crisis period by the end of 2021, and this trend may continue for a long time period. In the context of demand stagnation in the domestic and foreign markets, the development does not imply output growth, but rather quality improvement and product range expansion, which makes it necessary to implement the open innovations strategy to ensure industry competitiveness. Numerous studies have proven that industries are constantly applying open innovation platforms for the creation, sharing and commercialization of knowledge, which not only provide profitability and innovative development to the industry [80–83], but also improve strategic management efficiency [84].

The most important task of scientific and technological development of the industry in the near future is to improve the existing fields development efficiency. In many cases, this is economically more acceptable than new fields development (especially with difficult production conditions), as the existing fields have their established infrastructure. Oil companies should initiate relevant innovation projects and involve the Russian Academy of Sciences institutes, the scientific base of universities and industry research centers having the necessary scientific and technological groundwork.

It should be noted that the presented method of scenario development modeling, given the universality of its use, has several limitations. When calculating the predicted revenues of the Russian oil industry (Y), prices at the world market (P) are used (both when calculating revenues from domestic consumption and when calculating revenues from export). But this drawback is leveled out, since the dynamics of the world price determines the dynamics of domestic and export prices. Also, when predicting the dynamics of COVID-19, the possible wave-like nature of the virus development due to seasonal changes in weather conditions is not taken into account by the method due to its inability to make a reliable prediction. There is no possibility to establish reliable data on the real level of testing and coronavirus incidence in countries. Determined scenarios of oil industry development can be adequate only within Russia and cannot be applied to the peculiarities of the industry development in modern conditions of other oil-producing countries. In addition, the prediction was based on a limited statistical sample due to the short period of the COVID-19 pandemic (since January 2020). However, the proposed method of modeling the prediction of the scenario of oil industry development allows the data to vary depending on changes in economic activity conditions and the trend of the pandemic. The proposed approach can be used to predict scenarios for the oil industry development in other countries, provided that the values of the levels of indicators of the growth rates of income from the oil industry used in the model for determining the probability of the development scenarios implementation are adjusted. When adjusting, the change dynamics in the indicator of income from the oil industry for the country under study should be taken into account (the arithmetic mean, standard deviation, and the indicator levels are determined, the differences of which are statistically significant according to the t-criterion). These features will be considered in future studies.

5. Conclusions

The main findings of the econometric study were as follows: the conducted correlation analysis made it possible to determine the negative influence of the growth of oil production in OPEC countries, the USA, Canada, and Russia, as well as the growth of the ratio of the number of COVID-19 diseases to the number of recovering ones on the level of world prices of Urals oil. The developed model for determining the prognostic scenario of Russian oil industry development has testified that under the current conditions of the COVID-19 pandemic, dynamics and oil volume level, according to the agreement between Russia and OPEC+ countries during 2020–2021, completely level out the possibility of the development of U and V scenarios, which under the given conditions allow for the pre-crisis level of oil industry profitability and growth rates to be reached in the short term. Under current conditions, the Russian oil industry will with 100% likelihood follow L-scenario, implying that the level of industry revenues and growth rates are significantly lower than the pre-crisis level; this level of development will remain for a fairly long period of time. The existing terms and conditions of the agreement between OPEC+ countries and Russia on oil reduction will entail a significant decrease in the profitability of the Russian oil industry (up to 60% of the pre-crisis level of 2019 in the nearest year and a half by the end of 2021). This poses a threat to Russia's economic growth under unchanged conditions. Lifting of restrictions in many countries supports the oil market, forming hopes for an early resumption of demand, but the situation still remains undistributed in anticipation of the next wave of the COVID-19 pandemic. If the country does not adapt to the changed situation, its budget revenues and annual growth rates could fall sharply. There is a need for a strategy to significantly increase the share of renewable energy production, and at least to continuously adjust oil prices to dollar inflation (the open innovation strategy implementation) to increase the oil fields productivity. These issues, as well as many others, form the scientific priority for our future research.

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