LARISA G. CHUVAKHINA,
NIKOLAI A. MOLDENHAUER
and
ANAHITA NASIRBEIK

Strengthening of oil exporters' position within OPEC+ in the world oil market

The current petrodollar system has become a key factor in US economic power by creating external demand for US dollars and treasury bonds, which has allowed accumulation of the state debt without any change in actual credit solvency. The mechanism of this interaction is based on the conclusion of an agreement between the United States and Saudi Arabia, to which joined other OPEC countries subsequently. As a result, OPEC countries pledged to sell oil on the world market exclusively for US dollars. In exchange, the United States granted preferential loans and technology to petroleum exporting countries.

An increase in oil production in the United States alongside growth in exports has neutralized US dependence on oil supplies from OPEC countries, resulting in the transformation of the petrodollar system and a shift in the balance of power in the world oil market. The US had no need to interact with OPEC countries, and the strengthening of sanctions imposed by Western countries against third countries has contributed to the establishment of a new balance of power in the oil market, through coordination between OPEC+ exporters.

A key feature of the change in the position on the world oil market was the new status of the United States, turning from one of the leading oil importers to a world-class exporter. This situation led to a reorientation of OPEC to other markets and to competition with the United States for a share of the world oil market.

As a response, the OPEC+ format was created, which led to an increased influence of exporting countries on the oil market, which is confirmed by the conclusions of the built mathematical model based on the analysis of correlation dependencies of dependent and independent variables used to construct regression equations. The dynamics of world oil market prices and the median values of OPEC countries' currencies against the US dollar were selected as dependent variables. Variables that impact the formation of dependent values are the US dollar index, the level of oil production by OPEC countries and the interest rate on federal funds of the US Federal Reserve. The equations and correlation analysis were based on monthly data from January 2007 to October 2020. To assess the changed nature of the influence of OPEC countries on the global dynamics of oil prices, the time interval was divided into two intervals. The first selected time interval covers the period before the creation of the OPEC+ format: January 2007 - November 2016. Accordingly, the second selected time interval includes the duration of the OPEC+ agreement: December 2016-October 2020. To determine the effective influence of the considering variables on the results obtained at the initial stage, the correlation value was set within - 0.5 d" R e" 0.5, which allowed us to filter out variables with insignificant correlation. After obtaining the correlation dependencies, all pairs of dependent and independent variables were analyzed for approximating functions, which allowed us to study the nature of the dependence in more detail and more accurately construct the regression equations.

1.0 Introduction

The creation of the petrodollar system was made possible when the right to exchange US dollars for their value in gold was revoked in 1971. Alongside the abandonment of the Bretton woods system the United States was preparing an agreement with Saudi Arabia that came into force in 1975, according to which all trading of oil was to be carried out exclusively in US dollars. Under the terms of the agreement, excess oil profits generated by the Saudi Arabia had to be reinvested into US Treasury bonds, which as a result became the leading cause of the growth in US government debt. In return, the United States promised to sell weapons to Saudi Arabia and provide protection against aggression from the outside. The oil producers of the Organization of the Petroleum Exporting Countries – OPEC – followed Saudi Arabia and pledged to sell oil for US dollars. The Sheikhs of countries in the Persian Gulf preferred to keep their dollar savings in American banks. Given this

Messrs. Larisa G. Chuvakhina, Ph.D. in Economics, Associate Professor of the Department of World Economy and International Business, Nikolai A. Moldenhauer and Anahita Nasirbeik, Postgraduate student, Department of World Economy & International Business, Faculty of international economic relations, Financial University under the Government of the Russian Federation, 49, Leningradsky avenue, Moscow, 125993, Russia. E-mail: l-econom@mail.ru / nikolaj.moldenhauer@gmail.com / a.nasirbeik@yandex.ru. Correspondence: a.nasirbeik@yandex.ru

excess cash, the banks issued loans to countries experiencing dollar shortfalls for the purchase of oil and petroleum products. The demand for oil therefore created demand for the dollar and opened the door for the US Federal Reserve System (FRS) to crank up their printing presses to full power. By managing dollar emission, the FRS gained the opportunity to impact oil prices. The 400% increase in the oil price and the subsequent oil shock had extremely negative consequences for the developing countries. Receiving loans from American banks, the developing countries – oil importers became debt hostages of American banks which carried out their settlements in dollars – the currency used in the international oil trade.

The restriction that forced oil exporters to sell their oil for dollars created an artificial demand for US dollars (USD). At the same time, oil has become the source of power and reliability of the US dollar. All oil buyers needed first and foremost to buy US dollars, which led to the growth of the USD within global money turnover. Since the petrodollar system is based on demand for the dollar thanks to oil purchases, we can assert that OPEC overall and the Persian Gulf countries in particular became key elements of the petrodollar system, which provided an opportunity for global economic expansion by the United States.

1.2 THEORETICAL ASPECTS OF THE RESEARCH

Analysts and researchers consider the role of the petrodollar system to be that of a driver of US foreign policy and the foundation of the USD's status as the world's leading reserve currency and the key currency for oil quotes. As noted by researcher B. Gokay, the current petrodollar system represents an attempt by the USA to support the dollar's position as the dominant global currency by linking it with oil prices, while it was the agreement with Saudi Arabia that led to the trading of oil in USD which underlined the US dollar as a global currency (Gokay 2015).

In their research, R. Kaiser and D. Ottaway argue that the agreement with the USA ensured security and stability of the royal house regime in Saudi Arabia (Kaiser, Ottaway 2002). According to M. Klare, as the most influential country in OPEC Saudi Arabia was not among the list of quota-limited oil producing countries, which enabled it to dictate its terms to other oil-exporting countries (Klare 2004).

According to S. Nixon, the sale of such a key commodity in USD placed the United States in a privileged position and forced all oil-importing countries to create dollar reserves that could be used for oil purchases when needed (Nixon 2003).

D.E. Spiro is of the same opinion – believing that the interactions between traders in the oil market allow the USA to dominate as a currency monopoly-holder, as holder of the resource for oil purchasing. As a result, dollar emission was

for a long time mainly based on the oil produced in OPEC countries rather than on goods produced in the United States (Spiro 1999).

According to B. Gokay and D. Whitman, the need to purchase dollars to access the global oil market allowed the USA to develop its national economy and ensure financing of the public debt at the expense of countries interested in buying dollars to be used to purchase oil (Gokay, Whitman 2004).

According to O. Noreng, the accumulation of huge dollar stocks by oil-exporting countries has led to the dollar becoming the main reserve currency, stored in the world's largest banking institutions where OPEC countries have placed their dollar funds (Noreng 2006).

Dr. Mamdouh G. Salameh believed the situation on the oil market began to change after imposing US sanctions against Russia over events in Crimea (Salameh2014).

Purpose of research: to demonstrate the changes arising after formation of OPEC+ on the global oil market.

Hypothesis: the transformation of the petrodollar system through an increased supply of American oil to global markets leads to a change in relations between the leading players in oil trading and a strengthening role for petroleum exporting countries of OPEC+ in the global oil market.

2.0 Research

The peak of growth in oil imports into the United States in 2004 was delivered by strategic OPEC trading partners, – primarily, from the Persian Gulf. From that point, dependence on supplies from OPEC countries began to weaken. The decline in supplies from OPEC countries was offset by growth in oil purchases from Canada and Mexico. This diversification of oil import supply marked the kickoff of policy aimed at the transformation of the global petrodollar system (Fig.1).

In 2014, the USA moved to minimize oil imports from the Persian Gulf and OPEC countries overall, with Canada and Mexico becoming the leading oil suppliers to the USA, with the bulk of oil imports arriving from Canada. The Canadian oil imported into the USA is produced in Canada and is not re-export supply, which makes the USA virtually unaffected by external supply dynamics from other continents[1] (Fig.2).

When the US oil export embargo was lifted in 2015, the USA began to rapidly grow its volume of oil exports. In 2019, the volume of US oil exports amounted to 581,183% when compared to the 1972 baseline. At the same time, oil imports into the USA continued to decline, reaching the 1977 level in 2019. The growth phase of oil production in this country

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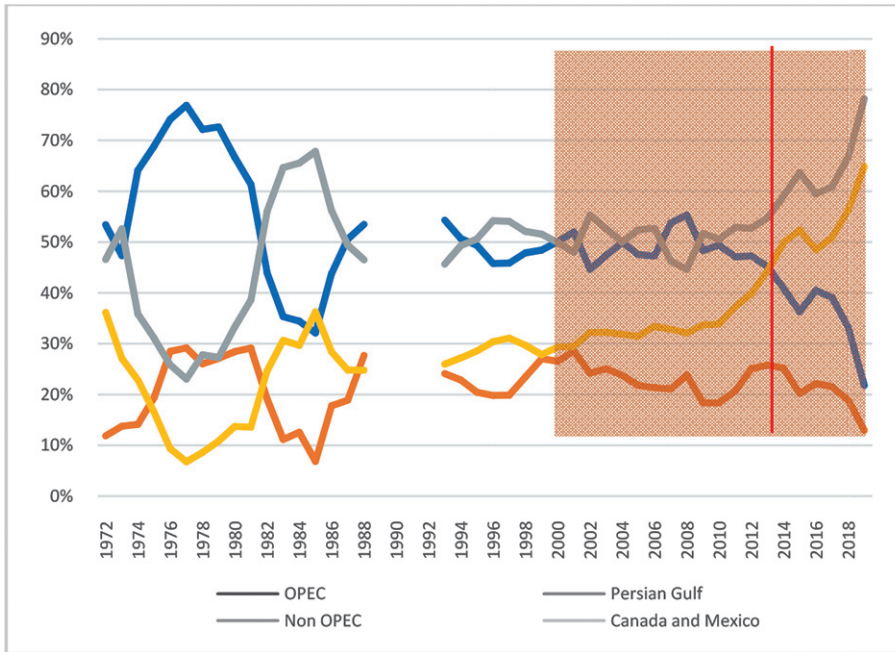[1]Statistics Canada. Table 25-10-0063-01 Supply and disposition of crude oil and equivalent. Retrieved from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510006301(date of request 12.06.2020)

Fig.1 Major oil exporters to the United States

Fig.2 Canadian oil production in barrels

Region (APR) increased significantly. Total oil supplies to the US in 2015-2018 were almost equal to the volume of supplies to the APR countries in 2018. For OPEC, Europe is oil sales market number one[3]. With the expansion of US oil exports, and after the European region was identified as a priority, the oil-producing countries of the Persian Gulf involved in the global interaction petrodollar system established by the US, in recent years have become direct competitors of the US in the European oil market (Fig.4).

The US actions by positioning itself in competition with OPEC while increasing sanctions pressure on third countries, facilitated signing of a new OPEC+ agreement in December 2016 (Нефтяное соглашение ОПЕК$^+$. 2020).

According to the terms of the OPEC[+] agreement, from 2017 to the beginning of 2020 member countries reduced their total production from 32.4 to 30 million barrels per day. As a result, the market share of these countries in the global oil market dropped to 28.5%, with the US occupying the vacant share through increased shale oil production of 4 million barrels per day and an increase in oil exports by five times over the review period.

In early 2020, the new balance established in the oil market has proven its effective role in setting oil prices. According to the signed Declaration of Cooperation (DoC), the participating countries pledged to reduce the aggregate production by 9.7 million barrels per day in May, June, and July after the renewal of agreements on the same volume of production cuts in July 2020. The deal was designed for the
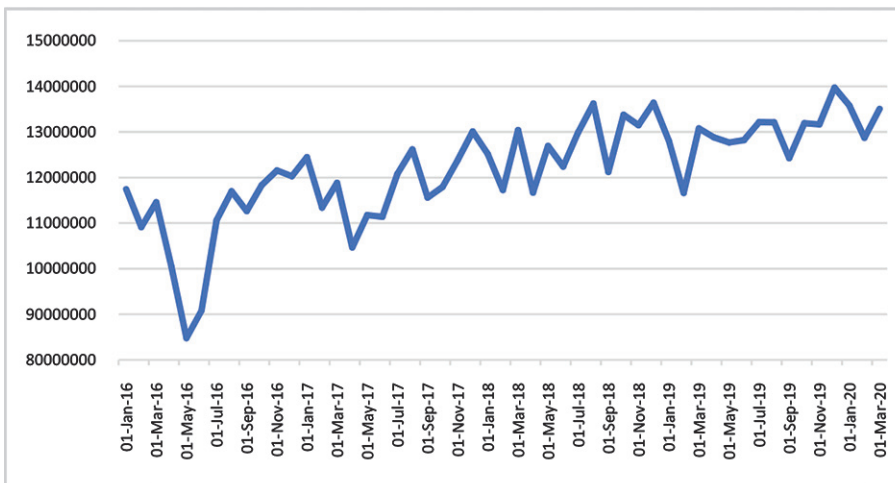
began in 2011 during the shale revolution. In 2019, oil production in the US was up to 129% of the 1972 baseline[2] (Fig.3).

The desire to expand oil exports meant the need to find potential trading partners capable of meeting the demand for American oil, while also supporting the transformation of the petrodollar system in line with US interests. European countries were identified as potential long-term recipients of American oil.

In response to the diversification of US imports, OPEC countries were forced to refocus their exports to other markets. The volume of exports by OPEC countries to the US decreased from 4,734,900 to 2,813,600 barrels per day. During the same period, exports to the countries of the Asia-Pacific

[2]US Energy Information Administration, U.S. Crude Oil Imports. Retrieved from: http://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_epc0_im0_mbbl_m.htm(Date of request 14.06.2020); U.S. Field Production of Crude Oil (Thousand Barrels). Retrieved from: http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPUS1&f=A(Date of request 14.06.2020); Crude Oil Exports by Destination. Retrieved from: http://www.eia.gov/dnav/pet/pet_move_expc_a_epc0_eex_mbbl_a.htm(Date of request 14.06.2020)

[3] OPEC - OPEC Members' crude oil exports by destination. Retrieved from: https://asb.opec.org/index.php/data-download (Date of request 13.06.2020)
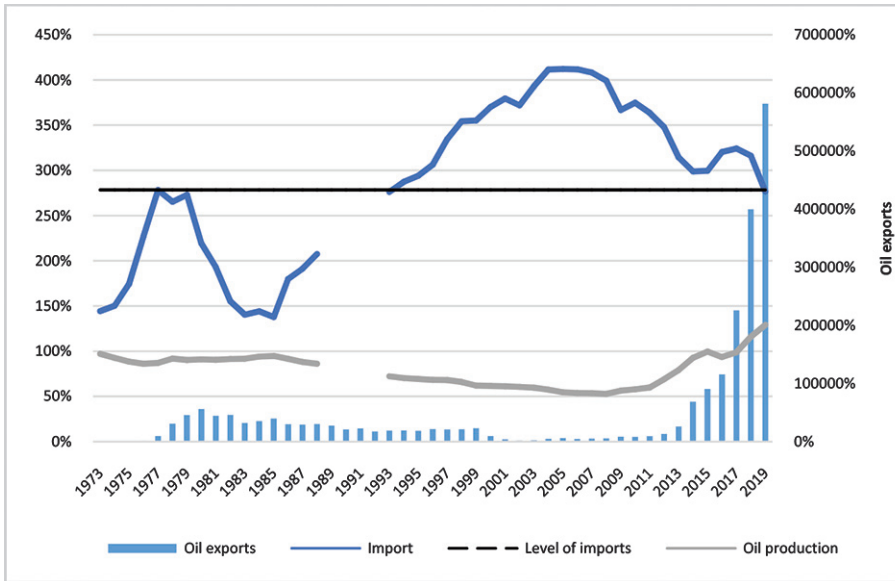
Fig.3 The volume of the oil market in the United States relative to 1972 (%)

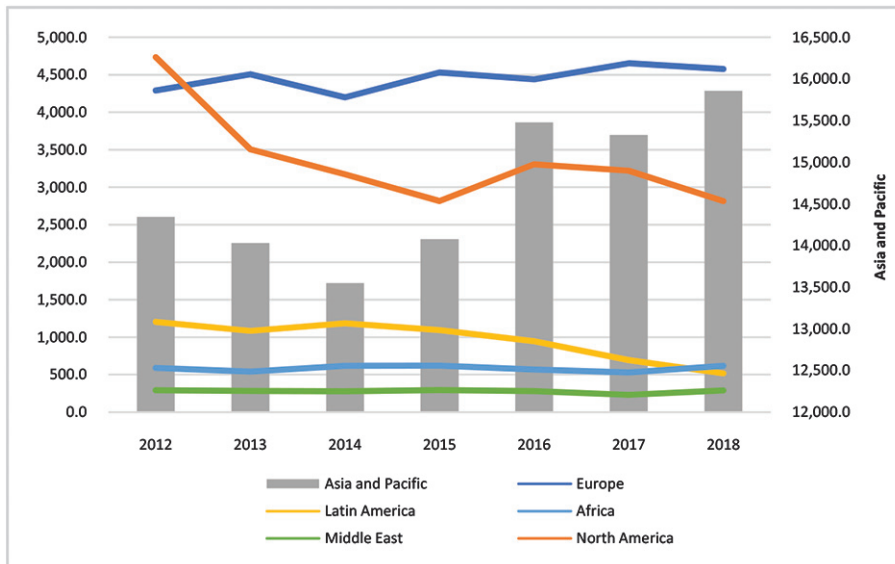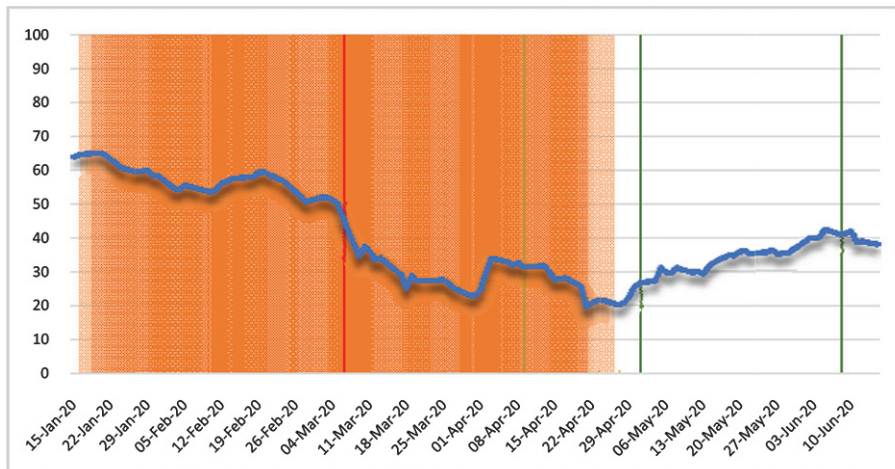Fig.4 OPEC oil exports (1000 bpd)

Fig.5 Impact of COVID19 and OPEC+ on Brent price

period from May 1, 2020 to the beginning of May 2022.After DoC entered into force on May 1, 2020, the price of Brent crude oil grew by 37% as compared to its lowest level (April 27, 2020) over the COVID19 pandemic. Fig.5 (the price decline zone due to COVID19 is shown in the pink on the graph below).

The red vertical line indicates the date of Russia's withdrawal from the OPEC+ deal (06.03.2020), the yellow vertical line - the date of the adoption of new agreements, the green vertical lines – the entry into force and extension of the agreements[4]. As a result of the measures taken, the price of Brent crude oil increased by 98% as compared to April 27, 2020. In addition to the aforementioned countries, the deal involved USA and Canada – which formally were not participants to it. The US pledged to cut production by 1.5 million barrels per day in Q2 of 2020, and Canada – by 1 million b/d in 2020[5]. The OPEC+ agreements imply an increase in oil production by 500 thousand b/d from January 2021 and monthly meetings of the OPEC+ countries in the future (Новак назвал детали соглашения ОПЕК+ для России. 2020).

The role of OPEC+ in the transformed petrodollar system can be evaluated by developing a mathematical model – regression equations showing petroleum exporting countries' impact on the world oil market before and after the OPEC+ agreement was signed. The time periods in question covers the period of January 2007 to November 2016 (first selected time interval); and from December 2016 to October 2020 (second selected time interval). The

[4] Investing.com, Brent Oil Futures. Retrieved from: https://www.investing.com/commodities/brent-oil-historical-data(Date of request 15.06.2020)

[5] OPEC, OPEC Monthly Oil Market Report 13 May 2020.Page 5. Retrieved from: https://www.opec.org/opec_web/en/publications/338.htm (Date of request 12.06.2020)

model is based on monthly data, with the same group of variables for each time interval, namely: the price of Brent crude oil on the futures[6] and spot markets[7]; and the median value of OPEC countries against USD[8]. Selected as independent variables were the price of dollar index futures[9]; the level of oil production by OPEC countries[10]; and the US Federal Reserve's federal funds rate[11].

The variable selection logic is intended to highlight the changing impact on price dynamics on the oil market. The independent variables can be divided into three categories, based on the number of variables. Federal funds rates reflect the impact of the monetary policy of the US financial regulator on the oil market. The dollar index demonstrates the cumulative impact of the foreign exchange market on changes in the oil market. The volume of oil produced by OPEC countries shows the impact of changes in supply on market value and the impact of the cartel on the global oil market. Dependent variables include two categories: the oil market and the OPEC countries currency rates. Brent crude oil reflects price volatility, being a global oil market indicator. The OPEC countries' currency rate shows changes in revenues from oil sales.

The first stage for assessing OPEC's impact on the global oil market is conducting a correlation analysis between the dependent and independent variables across each selected time interval. The significance of the selection of indicators of correlation analysis is determined in the range of $-0.5 < R > 0.5$ (Table 1).

TABLE 1: CORRELATION MATRIX FOR THE FIRST SELECTED TIME INTERVAL

Variables	USD index	OPEC's oil production level	Federal funds rate
Brent futures	−0,769	−0,212	−0,660
Brent spot	−0,754	−0,200	−0,078
OPEC courrencies	0,834	0,606	−0,363

Based on the correlation matrix data for the first interval, we can conclude that the decisions made by OPEC countries do not have a significant impact on global oil price dynamics. On the contrary, the decisions made by the US Federal Reserve on federal funds rates have a significant impact on the oil market. At the same time, the influence of the US financial regulator only impacts the oil futures market and does not affect the spot oil market. The most significant dependent variable is the dollar index, which has the highest value correlation with independent variables. The logic of interaction, reflected in dollar index correlation values, lies in the structure of the global oil market, with trades carried out in US dollars. Consequently, the demand for oil creates demand for the dollar, affecting rates and the dollar index values. This leads to the inverse correlation of the oil price and the dollar index value, and a direct correlation between the currencies of OPEC countries. Dollar deficits due to oil

demand strengthen the US currency, leading to an increase in the dollar index and the currencies of OPEC countries.

While the nature of dollar index dependence with dependent variables is clear, the impact of the US Federal Reserve System has a slightly different relationship. The nature of the interaction between the federal funds rate and Brent futures has a financial rather than commodity dependence, like the dollar index. Naturally, by increasing the interest rate, the US financial regulator reduces the amount of dollars in circulation, which leads to an increase in the oil price, reflecting the inverse relationship of two variables. However, since the impact of the Fed's decisions extends only to the futures market and does not affect the physical supply of oil, it can be concluded that oil paper contracts are used as a speculative tool for profit against the background of changes in the future exchange rate of the US dollar.

On the contrary, the dependence of OPEC and the oil market is expressed not so much by the financial as by the commodity component - the nature of this interaction, however, being indirect. Since, according to the correlation analysis for the first selected time interval, OPEC does not have a significant impact on the dynamics of prices on the world oil market, the dependence is expressed through the OPEC countries' currency rates. This interaction is due to the growth of the dollar. Consequently, the higher the dollar rate, the more income the OPEC countries will receive, which leads to an increase in production.

As a result, the time interval before OPEC+ formation is characterized by an insignificant correlation between the cartel's actions and oil prices. The main agent market is America influencing the oil market through its monetary instruments, i.e. the Federal Reserve's activities and the change in the dollar exchange rate in response to these actions (Table 2)

Based on the values of the correlation matrix of the second time interval, we can note the changed nature of the

[6] Investing.com, Brent Oil Futures. Retrieved from: https://www.investing.com/commodities/brent-oil-historical-data (Date of request 04.12.2020)

[7] US Energy Information Administration, Brent Spot price. Retrieved from: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=M(Date of request 04.12.2020)

[8] Investing.com, currencies. Retrieved from: https://www.investing.com/currencies/(Date of request 04.12.2020)

[9] Investing.com, US Dollar Index. Retrieved from: https://www.investing.com/currencies/us-dollar-index (Date of request 04.12.2020)

[10] US Energy Information Administration, Crude oil production OPEC toatl. Retrieved from: https://www.eia.gov/opendata/qb.php?category=1039874&sdid=STEO.COPR_OPEC.M(Date of request 04.12.2020)

[11] FRED Economic Data, Federal Funds Rate. Retrieved from: https://fred.stlouisfed.org/series/FEDFUNDS(Date of request 04.12.2020)

TABLE 2: CORRELATION MATRIX FOR THE SECOND SELECTED TIME INTERVAL

Variables	USD index	OPEC's oil production level	Federal funds rate
Brent futures	-0,295	0,543	0,743
Brent spot	-0,248	0,508	0,791
OPEC courrencies	0,123	-0,768	-0,024

influence of independent variables on the dependent ones. First, it should be noted that the main factor influencing all dependent variables was the actions of the OPEC countries. This fact suggests that as a result of the OPEC+ formation the influence of participating countries on the world oil market has increased significantly.

The nature of the influence of the US FRS on the dynamics of oil prices has changed. The impact of the federal funds rate applies to both the futures and the spot oil markets. At the same time, there is no significant correlation with the OPEC currency rates. An important element of the correlation analysis of the second time interval is the absence of significant correlation of the dollar index with all dependent variables.

The interaction of OPEC decisions with the dynamics of world oil prices is a direct relationship, which indicates an increase in production in line with oil prices. It follows from this that the actions of OPEC as an integral part of OPEC+ have a direct impact on the oil market. However, OPEC's actions are inversely related to the value of OPEC countries currency rates against USD, which leads to compensation of income in national currencies when the national currency rate falls. The relationship between this dependence is provided by an increase in oil production and an increase in incomes.

There is a direct relationship between the federal funds rate and the oil price, which indicates a non-standard interaction between the two variables. Growth in rates causes the amount of dollars in circulation to decrease and the value of the currency to increase, which increases the cost of goods in dollars. Since this is a direct and not an inverse relationship, we can assume that the rate either does not have time to influence the money supply, or the Federal Reserve resorts to other instruments to impact the dollar exchange rate.

As a result, based on the correlation matrix data for the second time interval, it is possible to identify the general nature of the impact of independent variables on the dependent ones. The level of OPEC production corresponds to global oil demand and inversely increases against dollar rate growth. The federal funds rate does not have a leading effect on global oil price dynamics. At the same time, there is no influence of the US regulator on the OPEC countries' exchange rates to USD either directly through the federal funds rate, or indirectly through the dollar index.

If we compare the correlation dependence of these

variables between the two periods, we can clearly observe the increased impact of OPEC+ on global oil prices. Prior to OPEC+ formation, the cartel had no significant impact on the oil market overall, however through its expansion OPEC was able to influence the price of oil on both the futures and spot markets.

The next step in deriving regression equations is to estimate curvilinear line for each dependent variable and each independent variable for both time intervals, by analyzing nine approximating functions based on the largest square of determination coefficient. This curvilinear analysis includes the study of the linear, logarithmic, inverse, quadratic, cubic, compound, growth, exponential, and logistic functions. The tables below show the best approximation results for all variables for both periods with the values of the squared coefficient of determination (R-squared) (Tables 3&4).

TABLE 3: RESULTS OF APPROXIMATION FOR THE FIRST SELECTED TIME INTERVAL

Dependent variable: Brent futures		
Function	Independent variable	R-squared
Exponential	USD Index	0,638
Cubic	Federal funds rate	0,144
Dependent variable: Brent spot		
Function	Independent variable	R-squared
Exponential	USD Index	0,611
Cubic	Federal funds rate	0,145
Dependent Variable: OPEC countries' currencies		
Function	Independent variable	R-squared
Squared	USD Index	0,745
Cubic	OPEC's oil production level	0,500

TABLE 4: RESULTS OF APPROXIMATION FOR THE SECOND SELECTED TIME INTERVAL

Dependent Variable: Brent Futures		
Function	Independent Variable	R-squared
Cubic	OPEC's oil production level	0,300
Cubic	Federal funds rate	0,654
Dependent Variable: BrentSpot		
Function	Independent variable	R-squared
Cubic	OPEC's oil production level	0,280
Cubic	Federal funds rate	0,725
Dependent Variable: OPEC countries' currencies		
Function	Independent variable	R-squared
Cubic	OPEC's oil production level	0,680

Based on the correlation analysis conducted and the approximation of nine functions for all variables for both periods, six curvilinear regression equations were obtained. These equations reflect the mathematical relationship of each of the dependent variables with significant correlations as

defined above.

For the first time interval, the equations are:

Brent futures $= 451{,}774 - 5{,}154 \times x_1 - 3{,}016\, x_2 - 0{,}53 \times x_3^3$

x_1 - USD Index

x_2 - Federal funds rate

x_3 - Federal funds rate

TABLE 5A THE MODEL PARAMETERS FOR THE DEPENDENT VARIABLE: BRENT FUTURES

Criterions	Result
Coefficient of determination	0,860
Squared coefficient of determination	0,740
Fisher's criterion	29,875

Brent Spot $= 369{,}632 - 3{,}652 \times x_1 - 2{,}246 \times x_2 - 0{,}94 \times x_3^3$

x_1 – USD Index

x_2 – Federal funds rate

x_3 – Federal funds rate

TABLE 5B: THE MODEL PARAMETERS FOR THE DEPENDENT VARIABLE: BRENT SPOT

Criterions	Result
Coefficient of determination	0,888
Squared coefficient of determination	0,789
Fisher's criterion	39,262

OPEC countries' currencies
$= 1829{,}05 - 4{,}112 \times x_1 - 83{,}66 \times x_2 + 0{,}34 \times x_3^2 - 0{,}032 \times x_4^3$

x_1 – USD Index

x_2 – OPEC's oil production level

x_3 – USD Index

x_4 – OPEC's oil production level

TABLE 6: THE MODEL PARAMETERS FOR THE DEPENDENT VARIABLE: OPEC CURRENCIES

Criterions	Result
Coefficient of determination	0,882
Squared coefficient of determination	0,777
Fisher's criterion	99,570

For the second time interval, the equations are:

Brent Futures $= 421{,}067 - 21{,}297 \times x_1 + 27{,}630 \times x_2 + 0{,}009 \times x_3^3 - 1{,}838 \times x_4^3$

x_1 – OPEC's oil production level

x_2 – Federal funds rate

x_3 – OPEC's oil production level

x_4 – Federal funds rate

TABLE 7: THE MODEL PARAMETERS FOR THE DEPENDENT VARIABLE: BRENT FUTURES

Criterions	Result
Coefficient of determination	0,860
Squared coefficient of determination	0,740
Fisher's criterion	29,875

Brent spot $= 377{,}546 - 18{,}745 \times x_1 + 31{,}094 \times x_2 + 0{,}008 \times x_3^3 - 2{,}262 \times x_4^3$

x_1 – OPEC's oil production level

x_2 – Federal funds rate

x_3 – OPEC's oil production level

x_4 – Federal funds rate

TABLE 8 THE MODEL PARAMETERS FOR THE DEPENDENT VARIABLE: BRENT SPOT

Criterions	Result
Coefficient of determination	0,888
Squared coefficient of determination	0,789
Fisher's criterion	39,262

OPEC countries currencies
$= -349{,}465 + 37{,}086 \times x_1 - 0{,}021 \times x_2^3$

x_1 – OPEC's oil production level

x_2 – OPEC's oil production level

TABLE 9: THE MODEL PARAMETERS FOR THE DEPENDENT VARIABLE: OPEC CURRENCIES

Criterions	Result
Coefficient of determination	0,825
Squared coefficient of determination	0,680
Fisher's criterion	46,757

Based on the equations above, we can conclude that the factors affecting oil price dynamics have changed: during the first period, prior to OPEC+ formation, the impact of the cartel on world oil prices was insignificant; during the second period the situation is reversed. The OPEC+ formation subsequently changed the factors impacting upon oil market prices. At the same time, it should be noted that with the growth of OPEC+' influence on the global oil market, the impact made by the US Federal Reserve by leveraging monetary policy instruments decreased. Therefore, the OPEC+ formation has contributed not only to the exporting countries' growing influence on the oil market but has also contributed to a return by the market to a classical supply and demand relationship in the pricing of goods, while remains the influence of US financial regulator's monetary tools to determine the oil quotes.

3.0 Conclusions

With the growth of domestic oil production, sales market diversification and a shifting focus toward oil imports from

Mexico and Canada, the United States set the stage for the transformation of the established petrodollar system, which was in place until 2014, while leading oil exporter Saudi Arabia reinvested excess funds into the US treasury.

Freed from dependence upon the Persian Gulf for its oil imports, the United States was able to directly dictate global oil prices. This monopoly on oil pricing combined with increased sanctions pressure on third countries, led to OPEC+ agreements in response to US actions, leading to restored balance in the oil market.

OPEC countries impact on the oil market increased significantly as a result of the OPEC+ agreement, which made it possible to shift the focus of oil pricing away from the US monetary instruments characteristic of the previous petrodollar system - towards the classic combination of supply and demand factors in the commodity market. The changed nature of the impacts set out in this model demonstrates that the decisions made by OPEC became the primary factor in the dynamics of the oil price, whereas this did not play a significant role prior to the adoption of the OPEC+ agreement. Furthermore, actions by the US Federal Reserve to use monetary stimulation instruments during this stage have weakened the US position on oil pricing, which is a sign of the change to come in the petrodollar system.

Overall, the transformation of the petrodollar system that was largely a result of US policy has led to a greatly strengthened position for petroleum exporting countries within OPEC+ on the oil market.

References

1. Gokay B., Whitman D. (2004): "'Ghost Dance: The U.S. and Illusions of Power in the 21st Century', Alternatives." *Turkish Journal of International Relations* (3(4) Winter): 60-91. Accessed December 05, 2020. https://dergipark.org.tr/tr/download/article-file/19452.

2. Gokay, B. (2015): Two pillars of US global hegemony: Middle Eastern oil and the petrodollar. Accessed December 05, 2020. https://eprints.keele.ac.uk/1086/1/MCI%2BTwo%20pillars%20of%20US%20global%20hegemony.Gokay.pdf.

3. Kaiser, R., Ottaway, D. (2002) Oil for Security Fueled Close Ties. Accessed December 05, 2020. https://www.washingtonpost.com/archive/politics/2002/02/11/oil-for-security-fueled-close-ties/fdf1f123-214f-41b3-a53c-a5e687c648e7/.

4. Klare, M. (2004): Blood and Oil. How America's Thirst for Petrol is Killing US. Edited by Hamish Hamilton. London.

5. Nixon, S. (2003): 'What's that in Euros?' The Spectator. Accessed December 05, 2020. http://archive.spectator.co.uk/article/18th-october-2003/18/whats-that-in-euros.

6. Noreng, O. (2006): 'Oil and Islam - Economic Distress and Political Opposition' The Politics of Oil. London: Routledge.

7. Radiosputnik. (2020): "Новак назвал детали соглашения ОПЕК + для России." December 03. Accessed December 06, 2020. https://radiosputnik.ria.ru/20201203/neft-1587583491.html.

8. RIA Novosti.(2020): "Нефтяное соглашение ОПЕК+." March 31: https://ria.ru/20200331/1569375663.html. Accessed December 06, 2020. https://ria.ru/20200331/1569375663.html.

9. Salameh, Mamdouh G. (2014): "Turning the Gaze Towards Asia: Russia's Grand Strategy to Neutralize Western Sanctions." (United States Association for Energy Economics - USAEE Research Paper Series) (Working Paper No. 14-168). Accessed December 05, 2020. https://ssrn.com/abstract=2467639.

10. Spiro, D.E. (1999): The Hidden Hand of American Hegemony: Petrodollar Recycling and International Markets. Ithaca, NY: Cornell University Press.

Blind peer reviews carried out

SHALE OIL AND ECOLOGY IN AUSTRALIA – THE SEARCH FOR BALANCE

18. Lechtenbohmer, S., Altmann, M., Capito, S., Mat-ra Z., Weindrorf, W., Zittel, W. (2011): Impacts of Shale Gas and Shale Oil Extraction on the Environment and on Human Health. Brussels: European Parliament, 88 p. Available at: URL: https://www.europarl.europa.eu/meetdocs/2009_2014/documents/envi/dv/shale_gas_pe464_425_final_/shale_gas_pe464_425_final_en.pdf

19. Thornhill, J. (2019): Environmentalists Say Tapping Australian Shale Would Worsen Carbon Emissions. World Oil. 28.10.2019. Available at: URL: https://www.worldoil.com/news/2019/10/28/environmentalists-say-tapping-australianshale-would-worsen-carbon-emissions

20. CO_2 Emissions (Metric Tons Per Capita) – Australia. The World Bank. Available at: URL: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC? locations=AU

21. Steffen, W., Vertessy, R., Dean, A., Hughes, L., Bambrick, H., Gergis, J., Rice, M. (2018): Deluge and Drought: Australia's Water Security in a Changing Climate. Sydney: Climate Council of Australia Ltd, 85 p. Available at: URL: https://www.climatecouncil.org. au/wp-content/uploads/2018/11/Climate-Council-Water-Security-Report.pdf

22. McLean, B., Thottam, J. Could Fracking Debt Set off Big Financial Tremors? (2018). The Wharton School of the University of Pennsylvania. 21.09.2018. Available at: URL: https://knowledge.wharton.upenn.edu/article/will-fracking-industrydebts-set-off-financial-tremors

23. Blasi, A., Nobuoka, Y. (2018): Investment Analysis: The Journey of US Light Tight Oil Production towards a Financially Sustainable Business.International Energy Agency (IEA). 26.07.2018. Available at: URL: https://www.iea.org/news/investment-analysis-the-journey-of-us-light-tight-oilproduction-towards-a-financially-sustainable-business

Blind peer reviews carried out

BINAY KUMAR SAMANTA
and
MANISH KUMAR JAIN

Planned redesign of beehive coke ovens for pollution control and power generation

Fossil fuel based thermal power or ovens not only exude greenhouse gases and pollutants but transfer enormous amount of waste heat up in air. Heat gets enveloped in the stratosphere and circulate around the earth; escalating global warming. France, Czech Republic, Slovakia, Austria, Andorra, Luxembourg, Poland and Germany made it the hottest June on record in 2019. Around 50 coke ovens around Dhanbad are losing and facing closure, with fate of employees doomed. Jharkhand State Pollution Control Board, Dhanbad had been issuing letters to the small-scale refractory and beehive hard coke-ovens to bring down stack gas emissions to below 150mg/Nm³ of suspended particulate matter (SPM), equivalent to the standards of large thermal power plants, deploying electrostatic precipitators (ESP). Some locally made pollution control devices were deployed, but these reduced the chimney draft and coking time increased. Installation of wet scrubbing methods would not be economic and slow down production. With experience as the Manager of a by-product coke oven, the chimney detour method with mechanical exhauster suggested for beehive coke oven. Proposed design not only can generate power, but also trap pollutants by a kind of wet scrubbing and produce byproducts like coal tar. Various associations of small-scale hard coke ovens and refractory industries had approached The Institution of Engineers (India), Dhanbad Local Centre. In this paper, the authors briefly present how waste heat can be converted to power, while absorbing pollutants in hydraulic main in the unique chimney detour method and producing coal tar, exuding clean gas.

Keywords: *Flue gases; coke ovens; hydraulic main; chimney detour method; thermodynamics; converting pollutants.*

1.0 Introduction

Non-recovery coke plants are originally referred to as beehive types, and in this project attempt has been made to convert to recovery type in small such ovens. The second law of thermodynamics states that waste heat must be produced when converting a temperature difference into mechanical energy. India loses USD 68 billion, or about Rs 4,14,800 crores of its gross domestic product due to electricity shortage, as per FICCI report on Power Transmission. There is urgent need of generating power at small scale for additional revenue, while converting pollutants to useful products. Some energy is consumed and rest is dissipated into the atmosphere as heat, with great concern across the world (Guang J. Zhang, Ming Cai and Aixue Hu 2013). The future of coal-based thermal power, identified as the biggest emitter of greenhouse gases and heat is threatened. Power generation with waste heat and absorption of GHG and converting pollutants can be panacea for coal utilization industry.

Many types of new technologies (Colak I, Sagiroglu S, Fulli G et al 2016) for minimizing CO_2 emissions are evolving like carbon sequestration, storage, CO_2 capture etc. In this method raw coal feed of roughly 20% VM, coal gas available would be $200 \times 36 = 7200$ m³ per day = 300 m³ per hour and at chimney temperature around 900ºC. Even small hard coke ovens can generate 500-1000 kW power, for their ancillary industries or sell to State Electricity Board grid. Waste heat dissipation in air should be minimized as up to 3 MW generation is permitted by Indian Electricity Rules 2003.

2.0 Investigations

According to Air (pollution and control) Act and Rules 1981, permissible limits of air pollution, SPM (suspended particulate matter) in micro-gm/m³ and gases in ppm (parts per million), as followed in environmental monitoring have to be followed. Industry & Commerce Association, Dhanbad allowed projects and environment consultants for preliminary inspection of the Jealgora-Gobindpur coke oven plant of M/S Industrial Engineering Co. Discussions were held at site with plant officials and it was found amenable for the project. This was discussed with Environment Department of ISM (Venkatesh A., Singh G, Reddy DV and Jain MK 2010) and confirmation for joint inspection was received. Joint inspection was made of the Jealgora-Gobindpur plant with ISM professors and provisional layout of different components like temporary chimney, exhaust gas boiler, steam turbine, generator, control panel, hydraulic main, exhauster, coal-tar and ammonia liquor

Messrs. Binay Kumar Samanta, Department of Mining Engineering and Manish Kumar Jain, Department of Environment Science and Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad 826004. Email: iitism.bks@outlook.com, manish@iitism.ac.in