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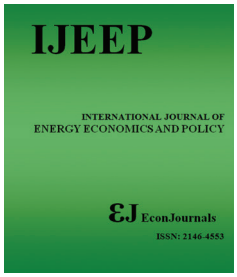

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The Effect of US Shale Oil Production on Local and International Oil Markets

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ABSTRACT

US shale oil has created dramatic changes in international oil markets. The United States became the world's biggest producer of crude oil after it overtook Saudi Arabia and Russia and then returned to exporting crude oil after a stop that lasted more than four decades. Its imports of crude oil decreased significantly. US shale oil had a remarkable impact on the structure of international crude oil trade; Other producers, including OPEC, were affected by the decline in their shares in the global oil market and the decline in their financial revenues. Technological development has played an essential role in the success of US shale oil by reducing costs and increasing economic feasibility. Therefore, US shale oil is no longer highly sensitive to lower oil prices, as it was before. Furthermore, the continuous increase in crude oil prices from $24.4/barrel in 2001 to $97 and $111.6 in 2008 and 2012, respectively, was enough to make shale oil production economically profitable. Now, the United States plays an essential role in the global oil market, as the largest consumer and producer and, behind China, the second largest importer. Shale oil is expected to play a growing role in the US oil sector and the global oil industry in the future.

Keywords: US Shale Oil, Crude Oil Price, International Oil Markets, OPEC, Fiscal and External Break-even Price.
JEL Classifications: L12, Q 41, Q43, Q33

1. INTRODUCTION

Energy markets, in general, and the crude oil market, in particular, have not seen fierce controversy throughout their long history, such as the controversy related to US shale oil. This controversy revolves around several issues, including the economic feasibility of US shale oil production with its high break-even price and adverse effects on the environment compared to other types of crude oil. What is the extent of the contribution of shale oil to the production of US and global crude oil? What is the impact of US shale oil on international crude oil trade, crude oil prices, and OPEC? Can OPEC disrupt the US shale oil boom? Why have other countries with reserves exceeding those of the United States of shale oil not achieved similar success in this field? And what are the challenges facing US shale oil? Although this controversy has lasted for many years, the answers to the above questions were contradictory. Therefore, this study will discuss these questions in more detail and depth to find clear answers supported by accurate numbers and rational economic analysis.

The interest of economic analysts in the US shale oil revolution began in 2008 due to the high growth rates of shale oil production achieved this year, which exceeded 79%. This production continued to increase at high growth rates throughout the following years, where the amount of production increased between 2007 and 2019 more than 25 times, and the annual growth rate reached 58%. In 2019, US shale oil production represented nearly two-thirds of US crude oil production and more than 11% of global crude oil production. The success of the American shale oil revolution is due to two main reasons: the first is the gradual and escalating rise in

crude oil prices beginning in 2000 (Abadie and Chamorro, 2017). And the second is the technique known as hydraulic fracturing, a method of breaking up an oil shale formation by pumping water, sand and chemicals at high pressure, which has improved dramatically, and this has led to a reduction in production costs (Bahgat, 2014; Ansari, 2017).

Salameh (2013) concluded that American shale oil will not affect global oil supplies and that oil production in the United States will peak in 2019 and begin to decline. As a result, the United States will never surpass Russia or Saudi Arabia. He also believes that one barrier to increased shale oil is high production costs and that without prices above $100/barrel, no one would be interested in shale oil. While Platts (2013) expected that if prices fall below $50, this will lead to shut-in Eagle Ford wells.

Manescu and Nuño (2015) predicted that in 2020 US shale oil production will reach 4.8 Mb/d, making up approximately a third of US crude oil production. In reality, production reached 7.35 Mb/d in 2020, accounting for more than two-thirds of US crude oil production. They also highlighted the weak relationship between the US shale oil revolution and the 2014 oil price crash. In contrast, the European Central Bank (2016) confirmed that a rise in oil supply, particularly US shale oil, could explain 60% of the drop in oil prices in 2014. According to Baumeister and Kilian (2016), the US economy still responds to oil price shocks as an oil importer. There is no evidence that US shale oil has changed the response of the US economy to oil price fluctuations. Therefore, when oil prices reduce, US economic activity increases and vice versa. Kilian (2016) highlighted the uncertainties surrounding the future of shale oil's future; therefore, he warned against the assumption that the United States will become the largest oil producer in the world and will overtake Saudi Arabia. Furthermore, he noted that the improved horizontal drilling and fracking technology that drove the US shale oil revolution might prolong the boom, but it will likely not last forever.

Álvarez and Nino (2017) emphasized that since 2014, US shale oil has affected oil prices by increasing global crude oil supply and influencing OPEC policies. With the increase in production, OPEC initially moved to maintain its market share. Still, it could not compete enough, so it preferred to follow a policy of price stability. They indicated that shale oil will play a decisive role in international oil markets, at least for the next 15 years. While Bjornland and Julia (2018) demonstrated that the US had increased its reliance on oil, not as a consumer, but as a producer; therefore, the United States did not experience a boom when crude oil prices fell between 2014 and 2016. The increase in oil prices may now positively affect economic activity in the United States rather than negatively. Nathan et al. (2020) found that without the shale oil revolution, oil prices would have risen by 36% in 2018 and that US shale oil has reduced current volatility in oil prices by about 25% and will reduce volatility by more than 50% in the long term. Gundersen (2020) shows that US shale oil negatively affected oil prices after 2013 but not before. He indicated that US crude oil explains 13% of the volatility in oil prices during 2003–2015. While the OPEC and US together explain a third of the volatility.

From a review of the previous literature, we can clearly say that the US shale oil revolution is a controversial issue. This study focuses on the critical issues related to US shale oil and discusses contentious issues to better understand the impact of US shale oil locally and globally.

2. METHODOLOGY AND DATA

In this study, the statistical analysis methodology was used, as research questions were answered using descriptive tables and graphs, which study the trends of the causal relationship between the increase in US shale oil and other variables such as the break-even price of shale oil, US crude oil production, the number of drilling rigs, OPEC shares in global oil trade, global crude oil production, crude oil prices, global crude oil trade structure, US crude oil trade structure, fiscal break-even oil price, and external break-even oil price for OPEC members. The data used in this study were obtained from international institutions and organizations such as OPEC, the US Energy Information Administration (EIA), and the International Monetary Fund, which are reliable sources that are very concerned with oil, energy, and the economy.

3. GLOBAL RESERVES OF SHALE OIL

The US EIA estimated the recoverable shale oil reserves worldwide at 345 billion barrels, distributed in 42 countries. Geographically, 92% of the global recoverable shale oil reserves are located in four regions. North America has 80 billion barrels, the former Soviet Union has 77.2 billion barrels, Asia and the Pacific have 61 billion barrels, and South America has 59.7 billion barrels. As countries, more than 63% of the global reserves of technically recoverable shale oil are concentrated in five countries. Russia has 21.7%, the United States 16.8%, China 9.3%, Argentina 7.8% and Libya 7.5% (Table 1).

3.1. US Shale Oil Production Progress

The United States ranks first in shale oil production and represents 80% of total global production. Canada came second with 0.45 Mb/d in December 2014, while other countries with large technically recoverable reserves, such as Argentina, Russia, Mexico, Colombia and Australia, have not yet reached commercial shale oil production. Argentina produced no more than 50 thousand barrels/day in 2015 (Aloulou, 2016), and Russia did not exceed its shale oil production in 2013, more than 120 thousand barrels/day (OGJ, 2014).US shale oil production increased so dramatically during the period 2007–2019. Therefore, some oil industry experts called it the US shale oil revolution; it increased from 0.34 Mb/d in 2007 to 1.31 Mb/d in 2011 and then increased to 5.8 Mb/d in 2015 and 8.60 Mb/d in 2019, representing 11.43% of global crude oil production. Production increased between 2007 and 2019 by more than 25 times, with an annual growth rate of 58%, a very high rate that the global oil industry has never seen before. The increase in production rates is attributable to two major factors that contributed significantly to the success of the shale oil boom, namely the development of production techniques that decreased the break-even price of production and the increases in oil prices,

which increased from $24.4 a barrel in 2001 to $111.6 in 2012 (BP, 2022); These two reasons were sufficient to make shale oil production profitable from an economic point of view.

As a result, US crude oil production increased from 5.07 Mb/d in 2007 to 12.23 Mb/d in 2019, the highest production in US history (Figure 1), of which shale oil represented more than 70%. Meanwhile, the contribution of US shale oil production to global crude oil production increased from 0.48% in 2007 to 11.43% in 2019. As shown in Table 2, US shale oil production increased during the period 2007–2019 almost double compared to global crude oil production. As global crude oil increased by 4.2 Mb/d, while US shale oil production increased by 8.3 Mb/d, this increase in US shale oil production was one of the important reasons that led to a surplus in world oil supply. It ultimately resulted in a price collapse in the fourth quarter of 2014. Although the turmoil in the Middle East, such as the turmoil in Iraq, Libya, and the sanctions imposed on Iran, has reduced the surplus in oil supply, prices have not resisted these production increases and have tended to decline (World Bank, 2018).US shale oil production in 2019 exceeded

Table 1: Distribution of technically recoverable shale oil by regions and countries, 2013 (billion barrels, %)

Region	Reserves	Percentage	Countries	Reserves	Percentage
North America	80	23.2	Russia	75	21.7
Former Soviet Union	77.2	22.4	United States	58	16.8
Asia and Pacific	61	17.6	China	32	9.3
South America	59.7	17.3	Argentina	27	7.8
Others	67.1	19.5	Libya	26	7.5
Total	345	100	Others	127	36.8
			Total	345	100

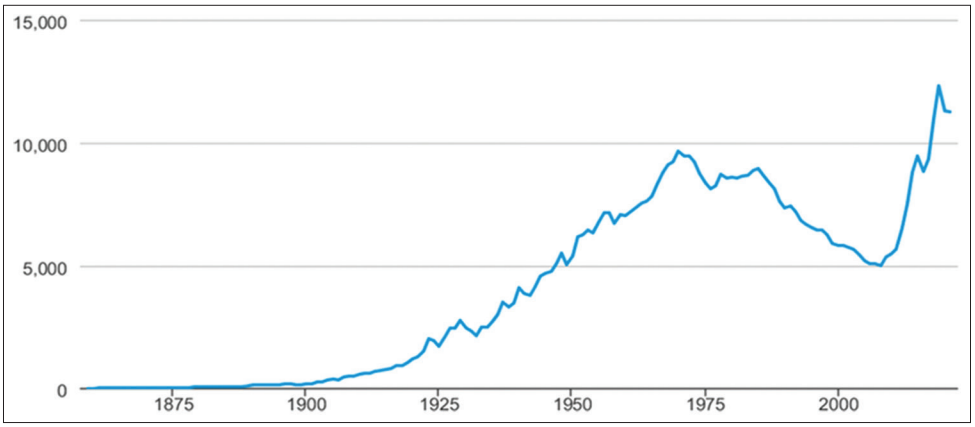
Source: Author's computation, based on EIA, 2013. EIA: Energy information administration

Table 2: US shale oil production and its percentage from US and global crude oil production (2007–January 2023) (Mb/d, %)

Years	US shale oil		US crude oil			Global crude oil		
	Production Mb/d	Annual growth rate (%)	Production Mb/d	Annual growth rate (%)	US shale oil (%)	Production Mb/d	Annual growth rate (%)	US shale oil (%)
2007	0.34		5.07		6.7	71.1		0.5
2008	0.61	79.4	5.00	−1.4	12.2	71.7	0.8	0.9
2009	0.69	13.1	5.36	7.2	12.9	68.8	−4.0	1.0
2010	0.87	26.1	5.48	2.2	15.9	69.7	1.3	1.3
2011	1.31	50.6	5.67	3.4	23.1	70.2	0.7	1.9
2012	2.25	71.8	6.52	15.0	34.5	72.7	3.6	3.1
2013	3.48	54.7	7.49	14.9	46.4	72.8	0.1	4.8
2014	4.10	17.8	8.79	17.4	46.7	73.4	0.8	5.6
2015	4.50	9.8	9.44	7.4	47.7	75.1	2.3	6.0
2016	4.30	−4.4	8.84	−6.4	48.6	75.3	0.3	5.7
2017	5.80	34.9	9.35	5.8	62.0	74.6	−0.9	7.8
2018	7.40	27.6	10.99	17.6	67.3	75.8	1.6	9.8
2019	8.60	16.2	12.23	11.3	70.3	75.3	−0.7	11.4
2020	7.35	−14.5	11.31	−7.6	65.0	69.2	−8.1	10.6
2021	7.33	−0.3	11.25	−0.5	65.2	69.7	0.7	10.2
2022	7.90	7.7	11.70	4.0	67.5	72.2	3.6	10.9
2023-January	8.20	3.8	12.40	6.0	66.1	73.4	1.7	11.2

Source: Author's computation, based on EIA, 2021, OPEC, 2022; EIA, 2023a. EIA: Energy information administration

Figure 1: US crude oil (1860–2022) (thousand b/d)



Source: EIA, 2023b

crude oil production in eight OPEC member states combined. Algeria, Libya, Venezuela, Nigeria, Angola, Gabon, Congo and Equatorial Guinea, as the production of these eight countries did not exceed 7.7 Mb/d. It also exceeded the production of two of the largest OPEC member producers. Iraq and the United Arab Emirates, since their production reached 7.63 Mb/d (OPEC, 2020).

In 2020, due to the consequences of COVID-19, the global demand for crude oil decreased from 75.1 in 2019 Mb/d to 69.1 Mb/d in 2020, and oil prices fell to their lowest level in two decades, reaching $ 16.55 in April. It resulted in a 14.8% fall in US shale oil production, compared to 8.1% for global crude oil production. However, this did not last long. In 2022, due to the recovery of the global economy from the effects of Covid-19 (Rodhan and Jaaz, 2022), along with the onset of the Ukrainian crisis, crude oil prices rose again to $ 110 in February 2022 (World Economic Forum, 2022), resulting in a rise of 7.7% in US shale oil production compared to 3.59% for global crude oil production. In January 2023, US shale oil production increased by 3.8%, while global crude oil production increased by 1.6%. In the same month, US shale oil represented 11.17% of global crude oil production, the highest since 2019 (Table 2).

Since 2018, the US has become the world's biggest producer of crude oil. The increase in US crude oil production, driven by shale oil, exceeded all expectations. The US EIA predicted in June 2012 that the US would surpass Russia and Saudi Arabia in crude oil production in 2020 (EIA, 2012). Some oil economists described that such rosy expectations are not supported by the realities of the international oil market and that the expected US production by 2020 will not reach more than 7.40 Mb/d, which is much less than the anticipated production of Saudi Arabia and Russia in the same year (Salameh, 2013). The United States surpassed Saudi Arabia and Russia faster than expected, which was achieved in 2018 (Dunn and Hess, 2018). This is the first time that the United States has exceeded Saudi Arabia in crude oil in 27 years and Russia in 20 years (Figure 2). The United States plays an essential role in the global crude oil market as the second largest importer of crude oil after China and as the largest consumer and producer after surpassing Russia and Saudi Arabia in 2018 (OPEC, 2022). These accelerated increases in US shale oil production had significant impacts domestically and internationally. Locally, it affected oil imports and exports, the gross domestic product, and the creation of new jobs. At the international level, it significantly increased oil supply, directly affecting the price of crude oil, which affected other producers, especially OPEC, which took several steps to counteract the US shale oil and maintain its market share.

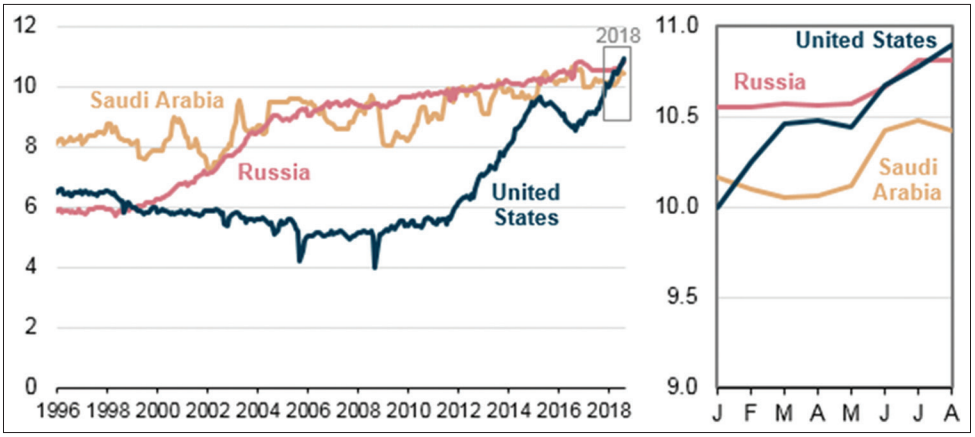
3.2. Shale Oil Impact on US Crude Oil Trade

The rapid development of shale oil production during 2007–2019 has reduced US crude oil imports and improved crude oil exports, leading to a marked improvement in net crude oil imports. With US shale oil production increasing from 0.34 Mb/d in 2007 to 8.6 Mb/d in 2019, US crude oil imports decreased from 10.03 Mb/d in 2007 to 6.49 Mb/d in 2019. In other words, US crude oil imports fell during this period by an annual rate of 2.5%. Unlike the declining path of US crude oil imports, exports have taken an upward path. However, this increase was not significantly noticeable until 2016, when the US Congress lifted restrictions on crude oil exports. As is known, after the OAPEC's 1973 oil embargo, Congress passed the Energy Policy 1975, which imposed restrictions on the export of crude oil. This restriction continued until 1985, when President Reagan allowed crude oil to be exported only to Canada, following Canada's decision to lift some restrictions on exports to the United States (Greenley, 2019).

With US shale oil production increasing and because US shale oil is light oil and most refineries in the United States are designed to deal with heavy and medium oil, its supply increased and its prices decreased locally compared to international prices. As crude oil production moved towards higher levels, the policies instituted during the 1970s became inadequate. Consequently, in 2016, Congress passed the Consolidated Appropriations Act, which removed restrictions on crude oil exports (Melek and Ojeda, 2017).

As a result, US exports increased from 0.03 Mb/d in 2007 to 3.21 Mb/d in 2020. In contrast, US crude oil imports decreased from 10.03 Mb/d in 2007 to 5.88 in 2020. This decreased net crude oil imports from 10 Mb/d in 2007 to 2.67 in 2020. In 2021, the US imported approximately 6.11 Mb/d of crude oil and exported about 2.96 Mb/d. However, some of the crude oil that the US imports is refined by US refineries into petroleum products that the

Figure 2: US crude oil production (1996–2018) (Mb/d)



Source: Dunn and Hess, 2018

US subsequently exports. However, US net imports of petroleum products and crude oil decreased from 12.04 Mb/d in 2007 to 0.67 Mb/d in 2019 (Figure 3). In 2020, net US imports of petroleum products and crude oil were negative, the 1st year since 1949. In 2021, the United States exported approximately 8.54 Mb/d and imported about 8.47 Mb/d of petroleum products and crude oil, making the US a net exporter of petroleum products and crude oil for the 2nd year since 1949 (EIA, 2022).

It is clear from the above analyses that increases in shale oil production have allowed the United States to reduce the chronic deficit in net crude oil imports by reducing imports and increasing crude oil exports. After more than four decades of stopping oil exports, it also allowed the US to become a crude oil exporter. These increases in shale oil helped the United States achieve self-sufficiency and become a net exporter of petroleum products and crude oil starting in 2021. Shale oil production affected both sides of the international oil trade in opposite directions; both directions were not in the interest of other oil-producing countries, especially OPEC.

3.3. Why Did Shale Oil Succeed in the US and Not in Elsewhere?

The shale oil revolution was successful in the United States for the following reasons:

1. Individuals and companies have mineral resource property rights in the United States, although, in most of the world these rights belong exclusively to governments. This fact provides a substantial incentive for landowners to lease or sell their property rights to oil companies. The wide availability and adaptability of the market for drilling rigs and other critical equipment, such as exploration and production tools, is another distinctive characteristic. For instance, the US and Canada possess more than 65% of the world's drilling rigs. These characteristics, which are not present in other regions of the globe, make the United States a unique player in terms of invention and experimentation. (Maugeri, 2012).
2. The continuous increase in crude oil prices from $24.4 a barrel in 2000 to $111.6 in 2012 was sufficient to make shale oil production profitable from an economic point of view (BP, 2022).
3. Low-interest rates in banks and financial institutions: This constituted a strong incentive for oil companies to borrow, as the total loans granted to companies operating in shale oil extraction reached nearly $250 billion in 2014 (Amadeo, 2021).
4. The distinguished application of hydraulic fracturing technologies in shale gas reservoirs has made it possible to repeat the application of experience in extracting hydrocarbons in unconventional oil-rock fields. This has been encouraged by the widening differences between natural gas prices and crude oil prices, especially after the collapse of gas prices in the United States and its decline to low levels, while oil prices maintained high levels until the last quarter of 2014.
5. Tax exemptions, legal and institutional frameworks, availability of active service industries, advanced infrastructure in the oil industry, and a trained workforce have all contributed to the rapid expansion of US shale oil (Ragab, 2015).

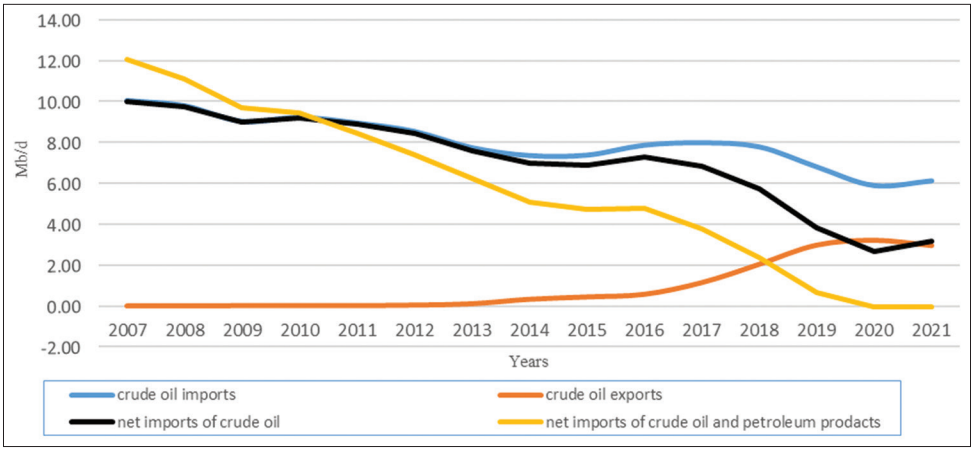
Until now, only a limited number of countries have successfully produced shale oil; Canada produces about 0.4 Mb/d of shale oil. In Argentina, geological information indicates that the resources could be substantial. However, production in Argentina is about 50 thousand barrels/day. For example, elsewhere, such as in China, South Africa and Ukraine, exploration has begun, but production targets have been reduced, or exploration has been abandoned. Long-term, some successes can be achieved in shale oil production in Argentina, Canada, Russia, Mexico, Australia, China and the United Arab Emirates. By 2040, shale oil production will exceed 3.5 Mb/d from regions outside the United States (Gould and Glade, 2019). Conditions that existed for US shale oil are not available, for the most part, in other countries that contain reasonable shale oil reserves. Therefore, there are doubts that the success of the US Shale oil would easily replicate in other regions, at least within the next few years.

3.4. Breakeven Price[1] of US Shale Oil Production

Rising oil prices were a significant factor in the prosperity of the US shale oil revolution, especially during the period from 2011 to 2014, in which crude oil prices exceeded the break-even price of

1 Breakeven prices relate to the lowest oil price required for profitability.

Figure 3: US crude oil exports, imports, net imports, and net imports of petroleum products and crude oil (2007–2021) (Mb/d)



Source: Authors' computation, based on OPEC, 2023; EIA, 2022

US shale oil production, which was more than $ 90/barrel, with the increase in prices from 79.5 dollars/barrel 2010 to more than $ 111 a barrel in 2012, US shale oil production increased from 0.87 in 2010 to 2.25 Mb/d in 2012, that is, the annual growth rate of production is close to 80%.US shale oil has been very sensitive to fluctuations in international oil markets due to its high break-even price. Competitors often relied on the collapse of the US shale oil industry when prices fell below the 90th level, which did not occur despite constant price fluctuations. During 2015–2019, the break-even price decreased to $ 73 a barrel in 2014, then to $ 60 in 2015 (Kapustin and Grushevenko, 2018), and between 48 and 52 on average after 2017 (Plante and Patel, 2019).

This continuous decrease in the break-even price of shale oil made the US shale oil industry more flexible to face fluctuations in oil prices, and the results were the opposite. Despite the drop in prices from about 100 dollars a barrel in 2014 to 64 dollars in 2019, shale oil production has doubled by 100% during this period. The main reason for the drop in US shale oil break-even is due to the growing experience of US companies operating in the field of shale oil during the previous period and the tremendous technological development that the US shale oil industry witnessed, which led to improved efficiency and then productivity. Initial production rates have increased due to the development of drilling techniques; in recent years, the average production of new wells has been higher compared to previous years. Therefore, the first month of crude oil production per new well for the five most significant fields in the United States, Niobrara, Permian, Eagle Ford, Anadarko, and Bakken, improved significantly during 2007–2019 (Figure 4). Furthermore, despite the significant decrease in the number of active rigs, which decreased from 1370 in 2013 to 860 in 2019, crude oil production did not fall. On the contrary, crude oil production increased from 7.5 Mb/d in 2013 to 12.1 Mb/d in 2019 (Figure 5).

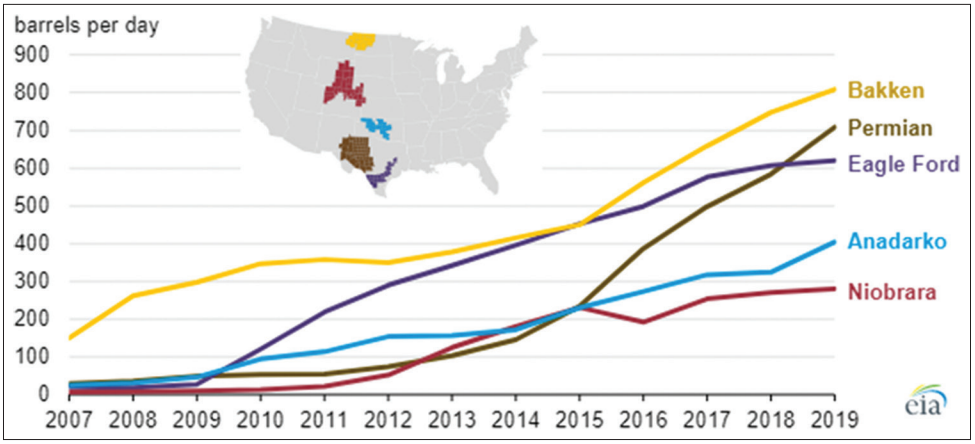
With all these developments, US shale oil has become an essential player in the international market. It cannot be ignored in any way. All bets have fallen on its collapse with the drop in prices; this indicates the failure of the policies of the major producers in the international oil markets, whose policies led to the crude oil prices reaching record levels during the period 2011–2014, because of which the start of the US shale oil industry succeeded. It is not possible for them now to take US shale oil from the crude oil markets despite the multiple attempts by significant producers to flood the oil markets by increasing the oil supply to reduce prices and cause losses to US shale oil and then push it outside the international oil markets, as happened in 2015 and 2019.

3.5. Can OPEC Curb the Shale Oil Revolution?

OPEC has many rational reasons to confront the US shale oil revolution, as it has been dramatically affected by the increases in US shale oil production; OPEC crude oil exports to the US decreased from 5.1 Mb/d in 2010 to 0.96 Mb/d in 2021. In other words, its share decreased from 55% to 11% in the US crude oil market (OPEC, 2022). The decline in OPEC crude oil exports to the US was not at the same rate between its countries; Light oil producers were the most affected, such as Nigeria, whose exports decreased from 1.623 Mb/d in 2010 to 0.174 Mb/d in 2021 and Angola, which reduced its exports from 0.6 Mb/d to 0.017 Mb/d in 2021. The reason for this is that US shale oil is light and because of its high production, which led to a lack of need to import it, as well as because most US refineries are technically designed to deal with heavy oil (OPEC, 2022). As for the producers of heavy crude oil from OPEC members, their exports decreased, but in smaller proportions. Saudi Arabia, for example, although it has significant shares in US refineries (Al-Darwish et al., 2015), its exports to the United States fell from 1.21 Mb/d in 2010 to 0.42 Mb/d in 2021.

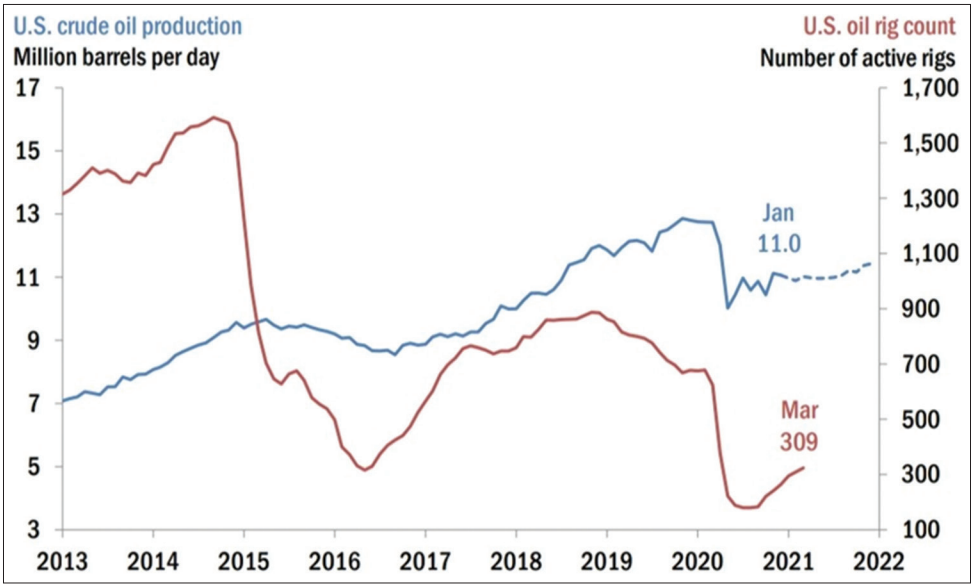
Furthermore, OPEC's share of global crude oil production decreased from 41.1% to 37.9% between 2010 and 2021, Although OPEC was able to find other consumers to buy its crude oil in Asia and Pacific, led by China and India, whose imports from OPEC increased from 11.56 to 14.17 Mb/d during the same period (OPEC, 2022), OPEC was forced to reduce production to maintain prices after the US shale oil production increase. However, the increase in US shale oil caused a supply glut in oil markets and greatly affected crude oil prices in international markets, as happened in the last quarter of 2014, when prices collapsed; approximately 60% of the price decline was due to the increase in supply, especially the supply of shale oil (European Central Bank, 2016), which was reflected in the oil revenues achieved by OPEC members. For example, the OPEC members' oil revenues for 2019 decreased to nearly 50% of revenues in 2012 (Table 3).

Figure 4: First-month crude oil production per new well (2007–2019)



Source: EIA, 2020a

Figure 5: Oil production and number of rigs in the US (2013–2021)



Source: Federal Reserve Bank of Dallas, 2021

Table 3: Oil revenues for OPEC members (billion dollars)

OPEC countries	2012	2019
Iran	101.5	19.4
Iraq	94.1	80.1
Kuwait	108.5	52.5
Saudi	337.5	202.4
United Arab Emirates	86.1	49.636
Algeria	48.3	22.67
Libya	60.2	24.2
Nigeria	95.7	45.1
Angola	69.9	32.3
Venezuela	93.5	22.5
OPEC	1182.9	564.9

Source: OPEC, 2020; OPEC, 2017

The same is repeated with the other producers who share OPEC's concerns about US shale, including Russia, which has cooperated with OPEC since 2015 and collectively is called OPEC +.

Therefore, the motivations to preserve its market share and oil revenues are an acceptable justification for its attempt to obstruct US shale oil production. OPEC may have achieved some successes by flooding the oil market by increasing production to reduce prices, causing losses to companies operating in the US shale oil field and removing them outside the oil markets, as happened in 2015. Despite the losses that OPEC incurs when it pursues the policy of dumping oil markets due to lower prices, it can suffer some losses in the short term to achieve higher prices in the long term. OPEC was able to do this previously due to the high break-even price of shale oil production when it was above $ 90 a barrel. Still, the big question is whether it can repeat this after the significant drop in the US shale oil break-even price, which is approaching $ 50. The answer to this question is complex and has more than one aspect. The break-even price for OPEC+ crude oil production is lower than for shale oil. For example, the break-even price, in dollars per barrel, is 9.1 in Iran, Saudi Arabia 10, Iraq 10.6, UAE 12.3, Venezuela 27 and Russia 19.2. Therefore, the crude oil break-even price supports OPEC+ in pursuing the policy of dumping, but what about the fiscal break-even Oil Price[2] and the external break-even Oil Price[3]?

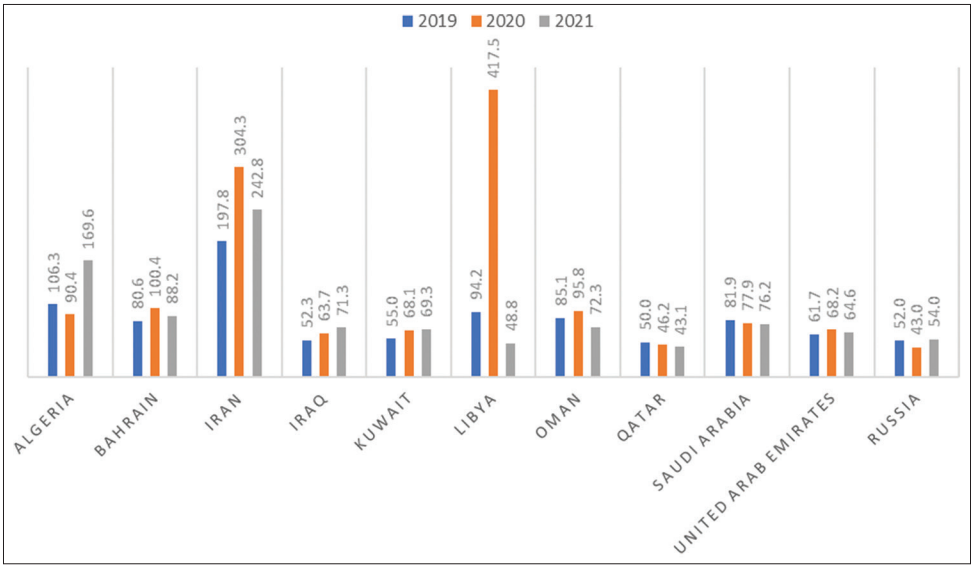
One of the financial restrictions that OPEC+ members faces is the break-even crude oil prices at which an economy (regarding an external break-even) or a government (regarding a fiscal break-even) needs to balance its spending. At the national level, the most commonly used is the fiscal break-even price, which is the lowest price per barrel that a government must receive to cover its spending (Setser and Frank, 2017). If the fiscal break-even price is higher than the crude oil price, OPEC+ members have four options: reducing spending, borrowing, drawing down existing financial reserves, or devaluing the currency; all of these options, although they can be implemented in the short term, will have a major long-term influence and can lead to serious social and economic impact, and if the crude oil price is less than the external break-even price, the economy is expected to adjust spending outflows to meet expenditure inflows. In other words, the government has to cut spending or let the value of its currency fall, which also has economic and social repercussions that many OPEC + members may not bear (EIA, 2020b).

Fiscal break-even has varied considerably for most OPEC+ members during 2019–2021, ranging from $ 43 to $ 417.5. On average, it was $ 95.26. Regarding external break-even, it ranged between 29.4 and 97.4 dollars. On average, it was $ 54 (Figures 6 and 7). Based on current fiscal and external breakeven prices for OPEC + members compared to the current breakeven price for US shale oil, which ranges between 48 and 52 dollars/barrel, it becomes clear that it is not easy for OPEC members and other producers allied with them to follow the policy of flooding the oil markets to reduce prices and then displace US shale oil out

2 Oil Fiscal Breakeven Price is the price at which there is no budget deficit or surplus (U.S. dollars per barrel).

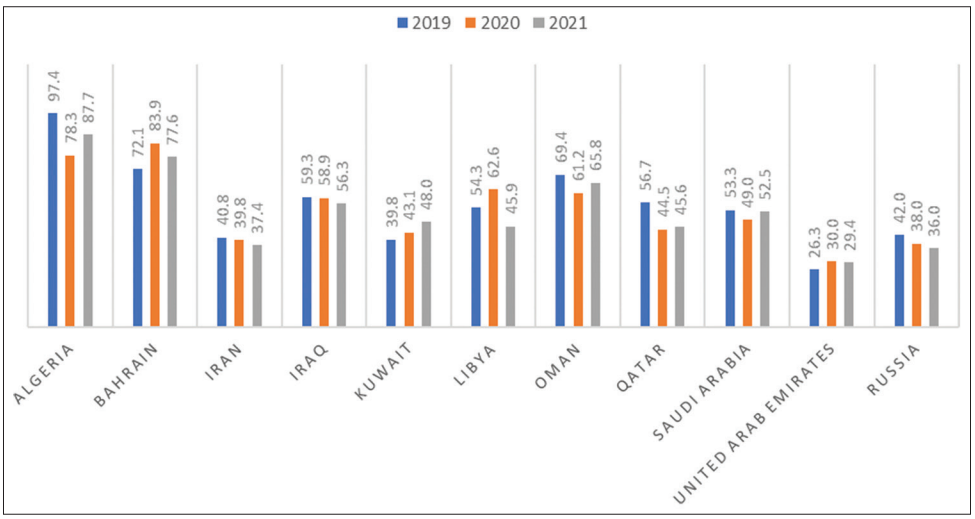
3 Oil External Breakeven is the price at which the trade deficit will be eliminated (U.S. dollars per barrel).

Figure 6: Fiscal break-even oil price for OPEC+ (2019–2021) (USD/barrels)



Source: Authors' computation, based on IMF, 2020

Figure 7: External break-even oil price for OPEC+ (2019–2021) (USD/barrels)



Source: Authors' computation, based on: IMF, 2020

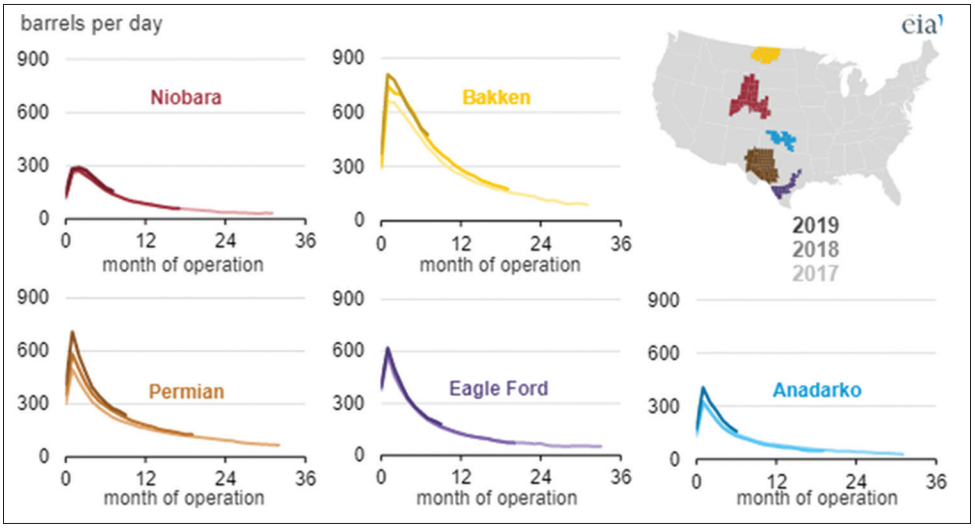
of the international oil markets. If they can do so in the short term by following the options we mentioned earlier when the external and fiscal break-even prices fall below the crude oil prices, then they cannot bear the consequences of that in the long term. Now, we can clearly say that US shale oil is out of the grip of OPEC and the other producers cooperating with it and that they can no longer significantly influence it regarding the price war. This means that US shale oil production will continue to rise unless it faces other problems outside of this area.

Finally, we can briefly present the OPEC position towards the US shale oil revolution. In 2012, Abdalla Salem Al-Badri, the secretary general of OPEC, asserted that OPEC would not be impacted by US shale oil production. Al-Badri believed that shale oil suffers from high production costs, estimated at $90 a barrel, making it very sensitive to low oil prices. He thought shale oil would be completely out of the market if prices fell to $50-70 a barrel. Al-Badri was also sceptical of estimates that US shale production could reach 3 million barrels in 20 years and estimated that in 2018 production could begin to decline rapidly (Salameh, 2013). The events that took place proved the opposite, as the costs of producing shale oil fell much below the level of $90 a barrel, shale oil did not go out of the market when prices fell to the level of $60-70 a barrel, and shale oil did not need 20 years to reach a level of 3 Mb/d. Production increased to a higher level than this level in 2013, that is, after 1 year. Finally, shale oil did not decrease significantly in 2018, as production increased from 2.25 Mb/d in 2012 to 8.6 Mb/d in 2019. Despite the decrease in production in 2020 due to the consequences of Coved 19, production gradually recovered until it reached 8.2 Mb/d in January 2023.

4. CHALLENGES FACING US SHALE OIL

Despite the significant expansion that the shale oil industry has seen, it faces some challenges. One of the main problems

Figure 8: Average crude oil production per new well (2017–2019)



Source: EIA, 2020a

associated with shale oil is the large number of wells needed to maintain existing production levels, as the production of shale oil wells decreases very quickly after the beginning of production (Figure 8). In 2017, for example, about 8500 wells were drilled, almost 70% of which were to fill the decline in the production wells. Without these new wells, shale oil production would have been expected to decrease by approximately 1.8 Mb/d in 1 year (Gould and Glade, 2019). Shale oil is extracted by pouring water, sand, and chemicals into the earth at high pressure. This mechanism exacerbates water and land contamination. (Salameh, 2013). Therefore, the shale oil industry should develop technological solutions to reduce the use of water and chemicals, reduce pollution, and reduce water depletion.

The annual energy forecast for 2020 issued by the US EIA sets out three scenarios for the future path of US shale oil production, as follows (EIA, 2020c):

- First: The Reference Scenario. This scenario indicates that US shale oil production will continue to increase until it reaches 11 Mb/d in 2035 and remains close to this level until 2045. Then production begins to decline, and investment moves to more expensive and less productive areas. The EIA expects that the increase in production growth will result from improving the efficiency of drilling operations and reducing costs, making the development of oil shale resources less sensitive to oil prices compared to the past.
- Second: The Optimistic Scenario, in which more advanced technology is used, and the recoverable reserves rise, compared to the reference scenario. In this scenario, shale oil is expected to continuously increase to approximately 14 Mb/d during the mid-2050s as the new advanced technology reduces production costs and improves productivity, stimulating the development of additional resources. Then, shale oil production slowly decreases toward the end of 2050.
- Third: The Pessimistic Scenario assumes that no change will have occurred in the technology used, in addition to the assumption that there will be a rapid decline in the recoverable reserve resources. Therefore, shale oil production is expected to reach about 8 Mb/d in 2023 and then begin to decline.

It is observed from the scenarios of US shale oil production that it is difficult to accurately predict the production volume. An apparent discrepancy between the pessimistic and optimistic scenarios can range from 8 to 14 Mb/d. The assumptions related to technological developments and recoverable reserves represent the essential aspects on which future expectations of shale oil production are based, in addition to the expected assumptions about oil prices.

5. CONCLUSION

Progress in US shale oil production has exceeded all expectations, as it increased from 0.34 Mb/d in 2007 to 5.8 Mb/d in 2015 and 8.60 Mb/d in 2019, representing 11.43% of global crude oil production. Production increased between 2007 and 2019 more than 25 times, with an annual growth rate of 58%, a very high rate that the global oil industry has never seen before. With these increases in shale oil, US crude oil production reached its highest level in its long history, exceeding 12 Mb/d in 2019. This made the United States play an essential role in the global oil market, as the second largest importer after China, as well as the largest consumer and producer, after exceeding Russia and Saudi Arabia in 2018. This led to fundamental changes in the structure of international oil trade. With the increase in US shale oil production, US crude oil imports decreased and exports increased, as net imports fell by 7.34 Mb/d between 2007 and 2020, a considerable amount in the international oil markets. As a result of this increase, many producers lost part of their market shares, especially OPEC, whose share of global production decreased and also its share of exports to the United States, which fell by 3.8 Mb/d during the period 2010–2019, in addition to the losses that producers suffered as a result of the price collapse in the last quarter of 2014, the essential part of which is due to the increase in shale oil production.

The high break-even price has been an obstacle to the development of shale oil. However, significant technological development

in hydraulic fracturing has helped reduce production costs. Consequently, the break-even price decreased from $ 90/barrel in 2010 to between $ 48-52/barrel after 2017, and US shale oil became less sensitive to crude oil prices compared to the previous period. OPEC has a strong tool to control shale oil, which is the low break-even price for its oil compared to the US shale oil break-even price, but at the same time, it is facing strong pressures as a result of the high fiscal and external break-even price. Consequently, it can no longer control shale oil and there are no longer fears of the collapse of the US shale oil industry under the pressure of a price war. The shale oil industry still faces some environmental challenges, such as pollution and excessive water use. However, technological development in the future can reduce these environmental impacts and water use. Therefore, Shale oil is expected to play a growing role in the US oil sector and the global oil industry in the future, in 2045, shale oil production is predicted to increase between 11 and 14 Mb/d.

The United States was distinguished by the presence of unique legal, legislative, geological, economic, and financial characteristics, and these unique characteristics supported the success of the US shale oil. Therefore, we do not expect this experience to be repeated in other countries, given that it does not have the same characteristics and advantages.

REFERENCES

Abadie, L.M., Chamorro, J.M. (2017), Valuation of real options in crude oil production. Energies, 10(8), 1218.

Al-Darwish, A.I., Alghaith, N., Behar, A., Callen, T., Deb, P., Hegazy, A., Khandelwal, P., Pant, M., Qu, H. (2015), Saudi Arabia: Tackling Emerging Economic Challenges to Sustain Strong Growth. In: IMF Departmental Papers. United States: International Monetary Fund, Middle East and Central Asia Department.

Aloulou, F. (2016), World Tight Oil Production to More than Double from 2015 to 2040. Available from: https://www.eia.gov/todayinenergy/detail.php?id=27492 [Last accessed on 2022 Sep 13].

Álvarez, I.A., Di Nino, V. (2017), The oil market in the age of shale oil. ECB Economic Bulletin, 8, 57-74.

Amadeo, K. (2021), The US Shale Oil Boom and Bust. Available from: https://www.thebalance.com/us-shale-oil-boom-and-bust-3305553 [Last accessed on 2022 Oct 27].

Ansari, D. (2017), OPEC, Saudi Arabia, and the shale revolution: Insights from equilibrium modelling and oil politics. Energy Policy, 111(C), 166-178.

Bahgat, G. (2014), The shale gas and oil "revolution": Strategic implications for United States policy in the middle east. The Journal of Social, Political and Economic Studies, 39(2), 219-230.

Baumeister, C., Kilian, L. (2016). Lower Oil Prices and the US Economy: Is this Time Different? Brookings Papers on Economic Activity, FALL. p287-357.

Bjornland, H.C., Julia, Z. (2018), The Shale Oil Boom and the US Economy: Spillovers and Time-varying Effects, CAMA Working Paper, 59. Norway: BI Norwegian Business School.

BP. (2022), BP Statistical Review of World Energy 2022. 71st ed. London: BP.

Dunn, C., Hess, T. (2018), The United States is now the Largest Global Crude Oil Producer. Available from: https://www.eia.gov/todayinenergy/detail.php?id=37053 [Last accessed on 2022 July 23].

EIA. (2012), Annual Energy Outlook 2012. Available from: https://www.nrc.gov/docs/ml1409/ml14093a265.pdf [Last accessed on 2022 Aug 23].

EIA. (2013), Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States. Available from: https://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf [Last accessed on 2023 Jan 09].

EIA. (2020a), US Crude Oil Production Efficiency Continues Year-over-year Improvements. Available from: https://www.eia.gov/todayinenergy/detail.php?id=42595 [Last accessed on 2022 Oct 22].

EIA. (2020b), Break-even Crude Oil Prices are One Metric of the Economic Constraints Facing OPEC+ Members. Available from: https://www.eia.gov/petroleum/weekly/archive/2020/200617/includes/analysis_print.php [Last accessed on 2022 Dec 13].

EIA. (2020c), Annual Energy Outlook 2020. Available from: https://www.eia.gov/outlooks/aeo/pdf/aeo2020%20full%20report.pdf [Last accessed on 2023 Jan 19].

EIA. (2021), Crude Oil Production. Available from: https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm [Last accessed on 2022 Dec 07].

EIA. (2022), Monthly Energy Review. Available from: https://www.eia.gov/totalenergy/data/monthly/archive/00352210.pdf [Last accessed on 2022 Nov 03].

EIA. (2023a), Tight Oil Production Estimates by Play. Available from: https://www.eia.gov/petroleum/data.php#crude [Last accessed on 2023 Feb 07].

EIA. (2023b), US Field Production of Crude Oil. Available from: https://www.eia.gov/dnav/pet/hist/leafhandler.ashx?n=pet&s=mcrfpus2&f=a [Last accessed on 2023 Feb 07].

European Central Bank. (2016), ECB Economic Bulletin, Issue 4 2016. Frankfurt Am Main, Germany: European Central Bank.

Federal Reserve Bank of Dallas. (2021), US Oil Production and Rig Count, Energy Slideshow. Dallas: Federal Reserve Bank of Dallas.

Gould, T., Glade, C. (2019), Could Tight Oil go Global? Available from: https://www.iea.org/commentaries/could-tight-oil-go-global [Last accessed on 2022 Dec 05].

Greenley, H. (2019), The World Oil Market and US Policy: Background and Select Issues for Congress. Washington, D.C: Congressional Research Service.

Gundersen, T.S. (2020), The Impact of U.S. Supply Shocks on the Global Oil Price. Energy Journal, 41(1), 151-174.

IMF. (2020), Statistical Appendix: Middle East and Central Asia. Washington, D.C: International Monetary Fund.

Kapustin, N.O., Grushevenko, D.A. (2018), Global prospects of unconventional oil in the turbulent market: A long term outlook to 2040. Oil and Gas Science and Technology, 73(67), 1-13.

Kilian, L. (2016), The impact of the shale oil revolution on U.S. oil and gasoline prices. Review of Environmental Economics and Policy, 10(2), 194-205.

Manescu, C.B., Nuño, G. (2015), "Quantitative Effects of the Shale Oil Revolution," European Central Bank Working Paper 1855. Frankfurt Am Main, Germany: European Central Bank.

Maugeri, L. (2012), Oil: The Next Revolution. United States: Harvard Kennedy School, President and Fellows of Harvard College.

Melek, N.C., Ojeda, E. (2017), Lifting the U.S. crude oil export ban: Prospects for increasing oil market efficiency. Economic Review, 102(2), 51-74.

Nathan, S.B., Jin, X., Yücel, M.K. (2020), The Shale Revolution and the Dynamics of the Oil Market, Working Paper 2021. Dallas: Federal Reserve Bank of Dallas.

OGJ. (2014), Tight Oil Production Pushes US Supply to More than 10% of the Total in the World. Available from: https://www.ogj.com/general-interest/article/17270346/eia-tight-oil-production-pushes-us-supply-to-more-than-10-of-worlds-total [Last accessed on 2022 Jun 28].

OPEC. (2017), Annual Statistical Bulletin. 54th ed. Vienna, Austria: OPEC.

OPEC. (2020), Annual Statistical Bulletin 57th ed. Vienna, Austria: OPEC.

OPEC. (2022), Annual Statistical Bulletin 59th ed. Vienna, Austria: OPEC.
OPEC. (2023), Data. Available from: https://asb.opec.org/data/asb_data.php [Last accessed on 2023 Feb 28].
Plante, M.D., Patel, K. (2019), Break-even Oil Prices Underscore Shale's Impact on the Market. Federal Reserve Bank of Dallas. Available from: https://www.dallasfed.org/research/economics/2019/0521. [Last accessed on 2022 Dec 18].
Platts. (2013), Special Report: New Crudes, New Markets, Price Group/Oil Division. Plattsburgh: McGraw-Hill Companies, Inc.
Ragab, A. (2015), The reality and prospects of the unconventional oil and natural gas industry in North America and its implications for the member states. Journal of Oil and Arab Cooperation, 41(152), 9-98.
Rodhan, M.A., Jaaz, A.H. (2022), Box-Jenkins Modelling and Forecasting of the WTI Crude Oil. In: Abd-Alhameed, R., Al-Hussaibi, W., Rana, Z., editors. Proceedings of 2nd International Multi-disciplinary Conference Theme: Integrated Sciences and Technologies, IMDC-IST 2021, 7-9 September 2021, Sakarya, Turkey. Ghent, Belgium: European Alliance for Innovation (EAI). p1-13.
Salameh, M.G. (2013), Impact of the US Shale Oil Revolution on the Global Oil Market, the Price of Oil and Peak Oil. Vol. 3. Cleveland: International Association for Energy Economics. p27-31.
Setser, B.W., Frank, C.V. (2017), Using External Breakeven Prices to Track Vulnerabilities in Oil-exporting Countries. Council on Foreign Relations. Available from: https://www.cfr.org/report/using-external-breakeven-prices-track-vulnerabilities-oil-exporting-countries [Last accessed on 2023 Jan 14].
World Bank. (2018), Global Economic Prospects, Broad-based Upturn, But for How Long? Washington, D.C: World Bank.
World Economic Forum. (2022), How does the War in Ukraine Affect Oil Prices? Available from: https://www.weforum.org/agenda/2022/03/how-does-the-war-in-ukraine-affect-oil-prices [Last accessed on 2023 Feb 01].