Articles

1 The oil market in the age of shale oil

Prepared by Irma Alonso Álvarez and Virginia Di Nino

US shale oil production has expanded greatly since 2011, and now rivals that of Russia and Saudi Arabia in terms of market share. However, major producers of conventional oil, and members of the Organization of Petroleum Exporting Countries (OPEC) in particular, have been slow to adapt their production policies. This article investigates the reasons for this delayed reaction and provides an assessment of the relative importance of supply and demand factors in driving oil price developments in the wake of the shale oil "revolution". Shale oil is the key novel factor affecting the structure of the oil market and influencing OPEC's decisions whether to target price stabilisation or market share. The prolonged period of oversupply and low oil prices between the end of 2014 and the third quarter of 2016 was a result of the interplay of these factors; the partial recovery in prices, which occurred in 2017, reflects a gradual rebalancing of the market following the global supply restraint agreed by OPEC and major non-OPEC producers. Analysts expect oil prices to remain in a range consistent with the production costs of the major marginal producers – currently assessed to be around USD 50 per barrel over the short term. However, according to their projections, and given current extraction technology, prices must rise to around USD 65-70 per barrel over the medium term if shale oil production is to continue expanding profitably at a robust pace.

1 Introduction

Commodities, and oil in particular, remain the most important source of volatility in consumer price inflation. This poses a challenge for projections, as oil prices account for most of the prediction errors in inflation rates. Understanding the drivers of oil price movements is fundamental to an assessment of their persistence and of the implications for inflation expectations, as well as, ultimately, to the ability to tailor the monetary policy response. The surge in shale oil production since 2011 is generally considered to have created a structural transformation of the oil market, however several questions remain open: to what extent has that transformation so far affected the supply and demand factors which drive the oil price; and what is its relevance over the longer term?

The shale oil revolution has attracted significant interest because it marks a historical and unexpected turning point in US energy production trends. After three decades of steady decline, US oil production provided the largest contribution to global supply growth in the period from 2012 to 2014, and today rivals that of Saudi Arabia and Russia in terms of its share of global oil production. Initially, shale oil was essentially a US phenomenon, as both technical and legislative issues limited its global impact. In particular, the oil streams in the US, Canadian and Mexican

pipeline systems were only able to absorb flows from the periphery into the internal US states, and exports of US crude oil were banned by a law which had been introduced for national security reasons. Both of these factors led to an extraordinary build-up of inventory, depressing oil prices within the United States. Quality differentials for delivery in landlocked stocking points, such as the West Texas Intermediate (WTI) benchmark[32] (the main benchmark used in the United States) were priced at an increasing discount. Prices for energy products became cheaper in the United States than in the rest of the world. However, the subsequent inversion of the oil streams in the pipelines and the creation of additional rail capacity in 2014, combined with the repeal of the export ban a year later, served to close the gap between US and international oil prices and bring US shale oil into the global arena. By this point, the US Energy Information Administration (US EIA) had made several positive reassessments of shale oil, in terms of both future quantities and life span, suggesting that permanent changes were occurring in the global oil market.

OPEC's production decisions during the shale oil age – which began around 2011 – have been particularly influenced by the evolving supply conditions in the United States. In November 2014 production targets were abandoned in an attempt to regain market share; this aim was achieved, but at the cost of a drop in oil prices of more than half. Persistently low prices and producer nations' impaired public finances prompted OPEC's decision in November 2016 to change its policy again and restrain production, in an effort to rebalance the oil market which had been swamped with inventory. Had OPEC accepted the fact that in its role as swing supplier it was now competing with shale oil producers?

This article describes the evolution of the oil market during the shale oil age, the shifts in OPEC's production strategies and the effects of both of these developments on oil prices. It is structured as follows: Sections 2 and 3 review oil price dynamics and market fundamentals both before and during the shale oil age, with a particular focus on the market shares of major oil producing countries (notably the United States) following the revolution set in motion by the shale oil industry. Box 1 provides details of the structural VAR (SVAR) model of the global oil market used to assess the relevance of supply and demand factors, in which two types of strategies are distinguished, depending on whether OPEC acts to protect its market share (the "strategic" approach) or to stabilise oil prices around a target value (the "accommodative" approach). Box 2 discusses the historical decomposition of the oil price, focusing on the period of shale oil production. Section 4 assesses the potential implications of shale oil for the global supply curve and the equilibrium price, based on micro-level evidence. Section 5 summarises the main themes of the article and concludes with perspectives over the medium and the long term.

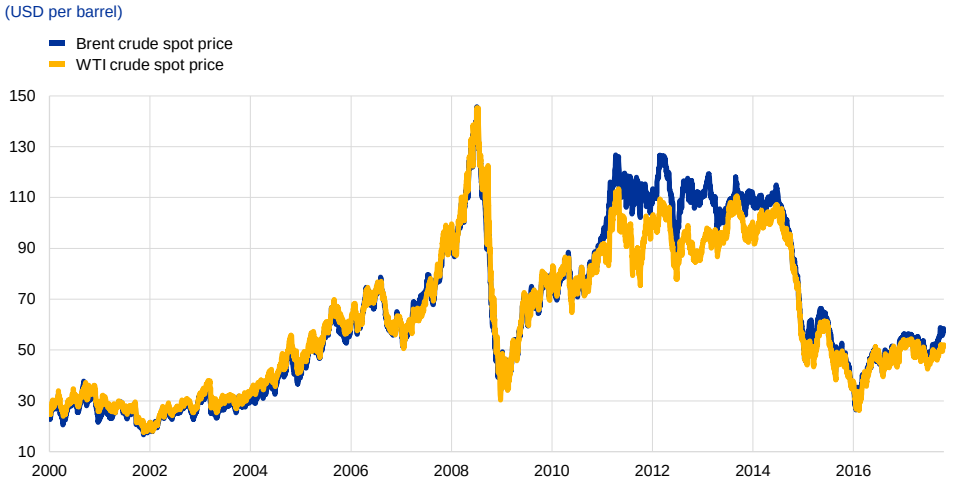
[32] The delivery point under the WTI contract is Cushing in Oklahoma.

2 A narrative of pre-shale oil price dynamics

Developments in the oil price in the years preceding the global financial crisis sowed the seeds for the shale oil revolution. The steep rise in price from USD 23 per barrel in 2003 to an all-time high of USD 145 per barrel on the eve of the global financial crisis was primarily a reflection of surging demand in major emerging economies such as China (see Charts 1 and 4). On the supply side, while non-OPEC producers were struggling to keep up with expanding consumption, OPEC's preference – according to the empirical analysis – was to maintain a relatively tight market and exploit its renewed power to influence market equilibrium (see Chart 3).

Chart 1

Brent and WTI crude spot prices since 2000



Sources: Bloomberg, Datastream and ECB staff calculations.
Note: The latest observations are for 19 October 2017.

Chart 2

Changes in the price differential between Brent crude and WTI since 2000

Sources: Bloomberg, Datastream and ECB staff calculations.
Note: The chart plots the difference (spread) between Brent crude and WTI prices. The latest observations are for 19 October 2017.

Against this background, capital flowed to the shale oil industry to finance investments in research and development. Medium-sized energy companies, generally more financially constrained than the multinationals, took advantage of these capital inflows to further develop horizontal drilling and hydraulic fracturing techniques in the United States, making shale oil production viable and profitable. The development of shale oil production also benefited from the fact that resources were located in sparsely populated areas, and that in the United States land ownership rights include rights to sub-surface minerals and environmental regulation is less strict than in, for example, Europe.[33] The extraction of oil and natural gas from shale rock formations has had a lasting effect on the US energy mix and markedly reduced the United States' dependency on external energy; this has, in turn, helped reduce the perennial US trade deficit.

Over the same period (2003-2007), OPEC regained influence on the oil market by addressing increasing demand from fast-developing emerging economies and stepping in to compensate for significant and protracted disruptions in production. In particular, new lows in prices in the aftermath of the Asian financial crisis of 1997 had restrained field investments for years, and conventional production, which lacked spare capacity, was unable to expand and respond to the growing demand from China and other emerging economies. The gap between global demand and supply was exacerbated by two major disruptions: a drop of 60% in Venezuelan oil production[34] caused by a protracted strike which took place at the national oil company, Petróleos de Venezuela, in late 2002 in an attempt to force the then-president to call early elections; and the Second Gulf War in 2003. Given the general market conditions, OPEC was able to maintain a relatively tight market balance in order to support high oil prices during this period prior to the global financial crisis (see Box 1).

The global financial crisis dramatically reduced economic activity and demand for crude oil and pushed prices below USD 40 per barrel in early 2009 (see Charts 3 and 4). The decline in annual consumption was particularly severe in the United States and more than offset the growth in demand in some emerging economies. However, prices rebounded ahead of firming improvements in global economic conditions, as a result of a very substantial production cut by OPEC of almost three million barrels per day that was not fully reversed until 2012. It can be seen that OPEC's policies are motivated by a series of macro and micro factors as market conditions change; Box 1 details a possible empirical framework which may be established to partially evaluate these factors.

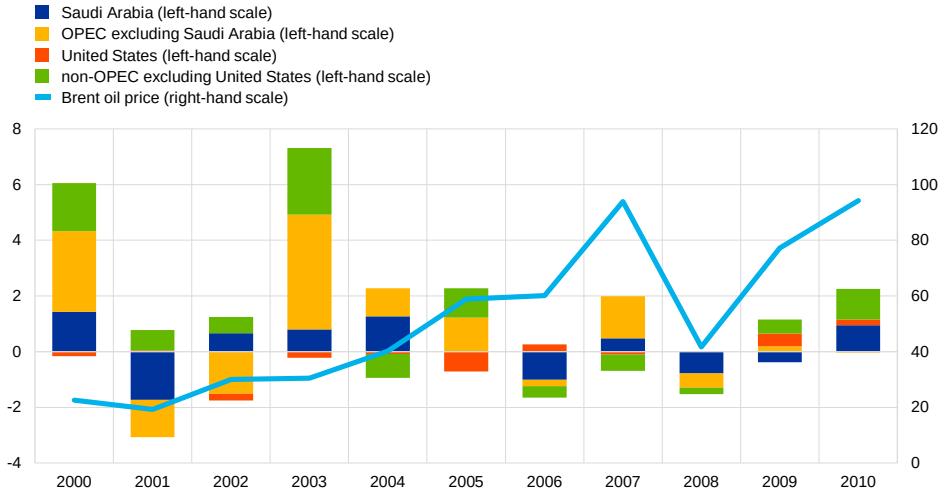
33 See Di Nino V. and Faiella I., "Shale Fuels: The Solution to the Energy Conundrum?", *European Energy and Climate Security,* September 2015, pp.133-153.

34 From its highest point, in January 1997, to its lowest, in January 2003.

Chart 3

Contribution to annual crude oil supply growth (2000-2010)

(percentage points, left-hand scale; USD per barrel, right-hand scale)

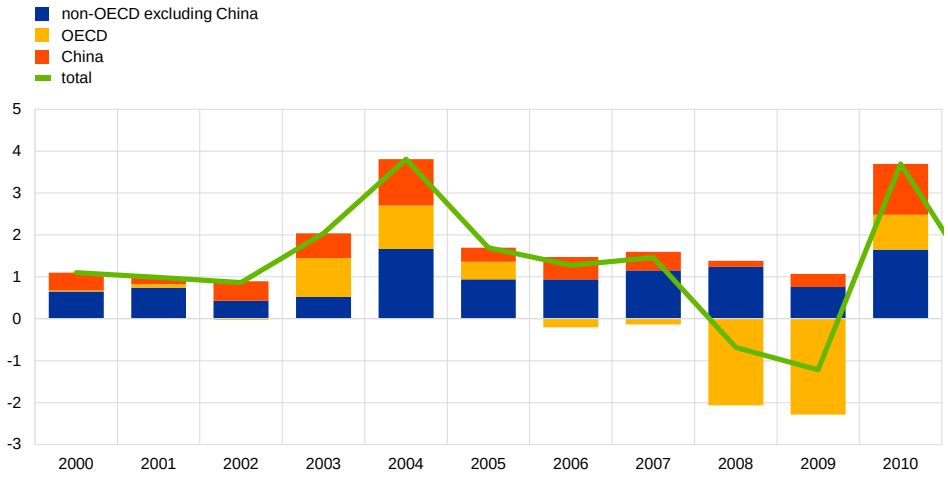


Sources: US EIA, Bloomberg and ECB staff calculations.
Notes: The value for the final month of a year is taken as the value for that year.

Chart 4

Contribution to annual oil demand growth (2000-2010)

(percentage points)



Sources: International Energy Agency (IEA) and ECB staff calculations.

Box 1

A Bayesian structural VAR model incorporating different supply shocks

Prepared by Irma Alonso Álvarez and Virginia Di Nino

This box presents an overview of a structural VAR (SVAR) model of the global oil market used to assess the relevance of supply and demand factors and provides certain insights regarding the debate about which factors dominate oil market dynamics. According to early literature published in the aftermath of the two oil crises of the 1970s, supply factors were the major drivers of price, and the macroeconomic effects of oil market shocks were unrelated to the nature of

the underlying shock.[35] This view persisted in the literature until the end of the second half of 2000, when an increasing consensus identified global demand conditions as the key factor in explaining oil price movements in certain episodes, such as in the run-up to the 2008 crisis[36]. In particular, Kilian and Murphy[37] show that both current and forward-looking demand for oil are driven by expectations about future activity (that is, by speculative demand).

By analogy with Kilian and Murphy, a SVAR model can be used to identify global and speculative demand shocks and, specifically, to distinguish between two supply shocks – "strategic" and "accommodative" – depending on how OPEC reacts to non-OPEC production changes. In the framework of this model, OPEC can decide to protect its market share (the strategic approach), target a desired oil price level (the accommodative approach), or adopt any combination of the two.[38] Using the strategic approach, OPEC production follows the same dynamics as that of non-OPEC producers, amplifying the impact of the shock on oil prices; whereas using the accommodative approach, OPEC tends to offset non-OPEC changes in production, attenuating oil price fluctuations. Shifts between approaches depend, among other factors, on the production capacity of competitors. The rapid rise of shale oil production is therefore likely to have brought about changes in OPEC's production plans[39]. The model contains 24 lags and employs monthly data from February 1973 to April 2017 with the following reduced form representation:

$$Y_t = c + A(L)Y_{t-1} + u_t$$

Y_t is a vector of five endogenous variables including (1) the monthly percentage change in OPEC crude oil production, (2) the monthly percentage change in non-OPEC crude oil production, (3) the growth rate of the interpolated global GDP, (4) the log-real price of oil (Brent crude deflated by the US consumer price index), and (5) the monthly changes in global oil inventories measured as changes in OECD crude oil stocks and in US crude oil inventories. The vector c contains the intercepts, A(L) is a matrix polynomial in the lag operator and u_t is a vector of reduced form error terms.

The key identifying assumptions are sign restrictions imposed on the impact responses of the five variables to the structural shocks; no magnitude restriction is added.[40] This model

35 See Nakov, A. and Pescatori, A., "Inflation-output gap trade-off with a dominant oil supplier", *Federal Reserve Bank of Cleveland Working Paper,* 2007; and Yergin, D., "The Prize: The Epic Quest for Oil", in *Money and Power*, Simon & Schuster, New York, 1992.

36 See Kilian, L., "Exogenous oil supply shocks: how big are they and how much do they matter for the US economy?", *The Review of Economics and Statistics,* Vol. 90, No 2, 2008, pp. 216-240; Baumeister, C. and Peersman, G., "Time-varying effects of oil supply shocks on the US economy", *American Economic Journal: Macroeconomics,* Vol. 5. No 4, 2013, pp. 1-28; and Baumeister, C. and Hamilton, J., "Sign restrictions, structural vector autoregressions, and useful prior information", *Econometrica,* Vol. 83, No 5, 2015, pp. 1963-1999.

37 See Kilian, L. and Murphy, D., "The role of inventories and speculative trading in the global market for crude oil", *Journal of Applied Econometrics,* Vol. 29, No 3, 2014, pp. 454-478.

38 For theoretical underpinnings of OPEC production strategies see Behar, A. and Ritz R., "An Analysis of OPEC's Strategic Actions, US Shale Growth and the 2014 Oil Price Crash", *IMF Working Papers*, No 131, 2016.

39 A number of micro and macro factors seem to influence OPEC decisions. These include global demand, the internal cohesiveness of OPEC, the fiscal needs of oil-producing countries and, most importantly, the production capacity of non-OPEC producers and the marginal cost of high-cost producers.

40 Recent works establish that the historical decomposition of the oil price into fundamental shocks is strongly influenced by the imposition of magnitude restrictions on elasticities of demand and supply curves. See Caldara, D., Cavallo, M. and Iacoviello, M., "Oil Price Elasticities and Oil Price Fluctuations", *International Finance Discussion Papers*, Board of Governors of the Federal Reserve System, No 1173, 2016.

set -up rests on the ability to pin down “strategic” and “accommodative” OPEC behaviour in reaction to non-OPEC supply shocks. If OPEC seeks to maintain its market share (the strategic approach), it will react to expansions in non-OPEC production by also increasing its supply. In this case, both productions have the same sign, leading to a decrease in oil prices and an increase in oil demand. On the other hand, if OPEC aims to stabilise oil prices around a target (for given global demand conditions) it must drain the eventual excess supply by reducing its own supply to support prices. In this case, no sign restrictions are imposed on price and global activity, as they could increase or decrease depending on the net impact on production.[41] Aggregate demand shocks are identified by simultaneous increases in supply and price. In the case of a speculative demand shock, market players purchase oil ahead of expected future shortages in the oil market and, as a result, the real price of oil, inventories and oil production will go up while aggregate demand will decrease (see Table A for a summary of sign restrictions).

Table A

Sign restrictions imposed

(shocks)

Variables	Strategic supply	Accommodative supply	Aggregate demand	Speculative demand	Residual
OPEC supply	-	+	+	+	
NON-OPEC supply	-	-	+	+	
Real activity	-		+	-	
Real price of oil	+		+	+	
Inventories				+	

Source: ECB calculations.

Three major conclusions can be drawn from the results of this analysis: (i) there is no clear dominance of demand and supply factors – each play a relevant role in explaining oil price dynamics, depending on the historical period analysed; (ii) OPEC policies have contributed to maintaining a high oil price in certain specific episodes; and (iii) speculative demand is never a relevant factor. In particular, the contribution of global economic activity to the evolution of the oil price is reduced in this framework, especially during the period from early 2005 until 2015, although it remains the major driver in the late 1970s and early 1980s (see Chart Ab). With regard to supply factors, the model identifies two specific episodes when OPEC acted to keep the market tight. One of these, the period between 1979 and 1985, is generally characterised by less buoyant demand, increasing non-OPEC supply and declining prices. During that time OPEC (namely Saudi Arabia) attempted to support prices by restricting production, thereby preventing prices from dropping further. The second episode was between the end of 2004 and the beginning of 2008, that is, in the run-up to the global financial crisis, when OPEC actively worked to maintain a relatively tight market balance and elevated prices (see Chart Aa).

More generally, this framework has two major advantages over standard models of the oil market which do not differentiate between OPEC and non-OPEC production. First, it is able to identify with more precision the turning points related to specific events in the oil market by distinguishing between different types of supply policies. Second, it reduces the residual shock,

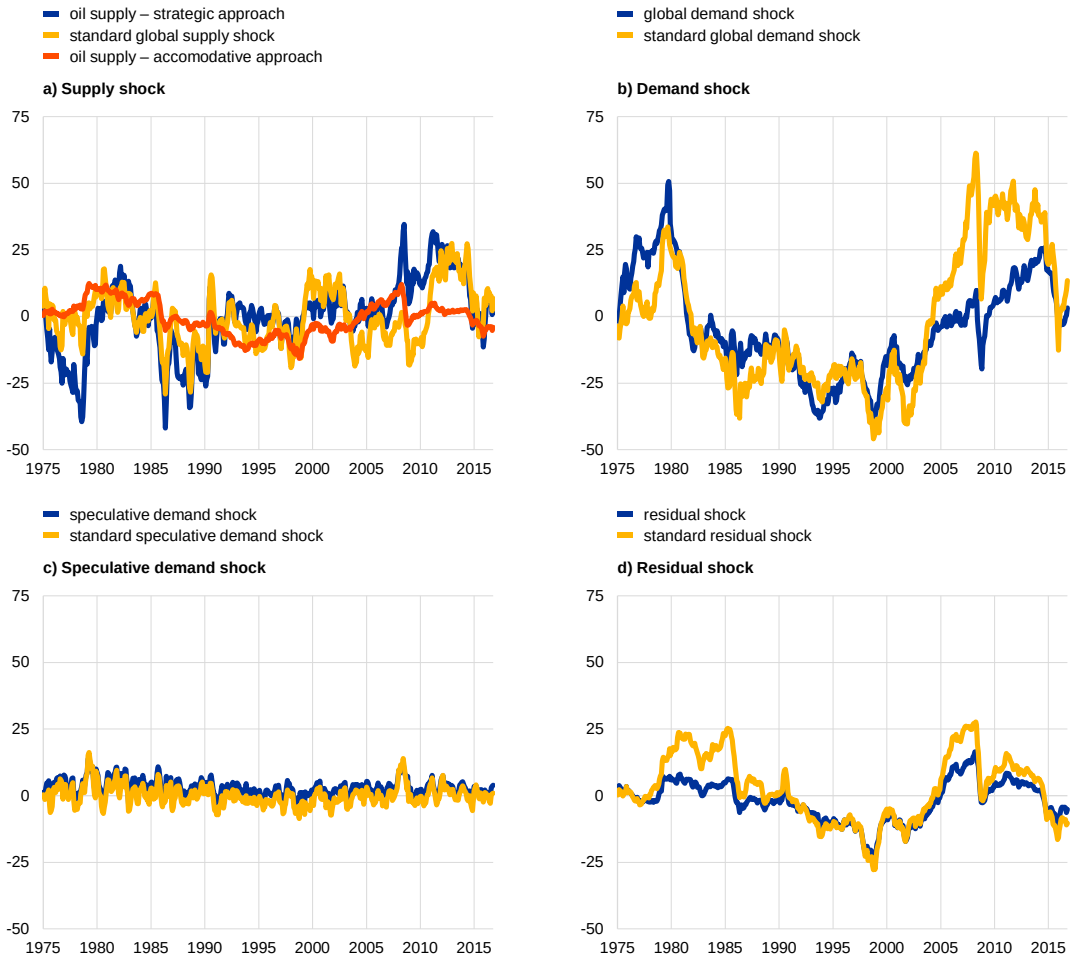
41 To select only those supply shocks which have some persistent effect, a further restriction is imposed, i.e. that the oil price reaction persists for at least 12 periods in the case of a strategic supply shock.

which represents the unexplained part of oil price dynamics particularly in the early 1980s and in the run-up to the global financial crisis (see Chart Ad).

Chart A

Historical decomposition of oil prices (1975-2016)

(percentage monthly contributions)



Sources: US EIA, IEA, World Economic Outlook and ECB staff calculations from SVAR models.
Notes: The chart shows the historical contribution of different types of oil shock to the logarithm of the real price of oil. The historical decompositions have been normalised to start at zero in January 1975. A negative value implies that the specific shock contributed to a reduction in the oil price, and a positive value implies that it contributed to an increase. The standard model refers to a four-variable model (production, demand, inventories and prices) which does not differentiate between OPEC and non-OPEC supply. The latest observations are for December 2016.

3 A narrative of oil price dynamics in the shale oil age

This section assesses the evolution of oil prices and major market fundamentals in the age of shale oil, taking 2011 as a reference date – the year when shale oil production started to expand at a faster pace. Three phases are considered: the period from January 2011 to mid-2014; from mid-2014 to October 2016 and from November 2016 to April 2017; each of which corresponds to a major change in OPEC's position and in oil prices. During the first period, oil prices

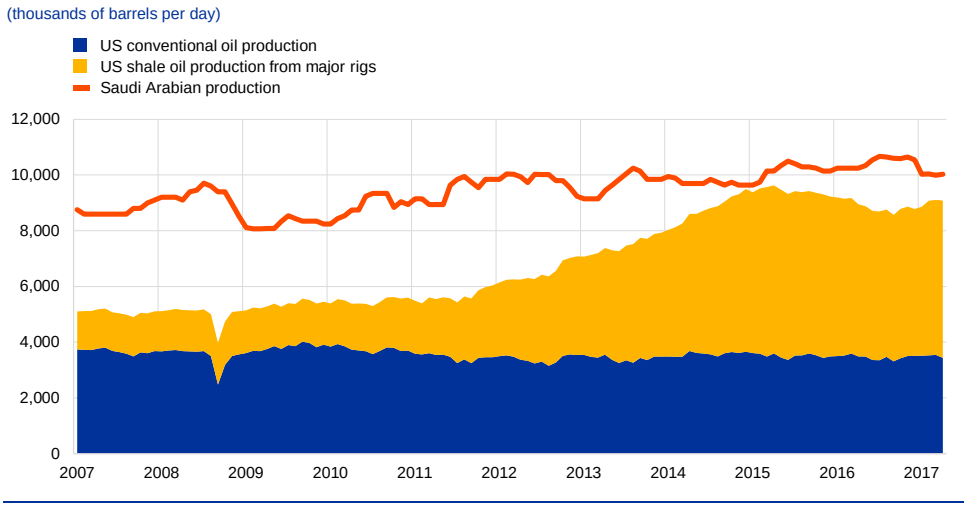
remained rather elevated owing to persistent geopolitical tensions and market segmentation, even though shale oil production was expanding. Prices dropped from around USD 120 per barrel to below USD 40 per barrel during the second period, and, more recently, prices have fluctuated within a range of values broadly compatible with marginal producers' production costs.

3.1 The first period of the shale oil age: January 2011 to mid-2014

During the initial phase of expansion (January 2011 until mid-2014) shale oil production trebled and drove the US share of the market to 12%, up from 7% in 2011. Total US production expanded by 76% from almost 5.4 million barrels per day at the beginning of 2010 to around 9.5 million barrels per day at the end of 2014 (see Charts 5, 6 and 7). This increase was principally due to production from major shale rigs – such as those in the Eagle Ford and the Permian regions – which had more than doubled since 2011, while US conventional production remained stable.

Chart 5

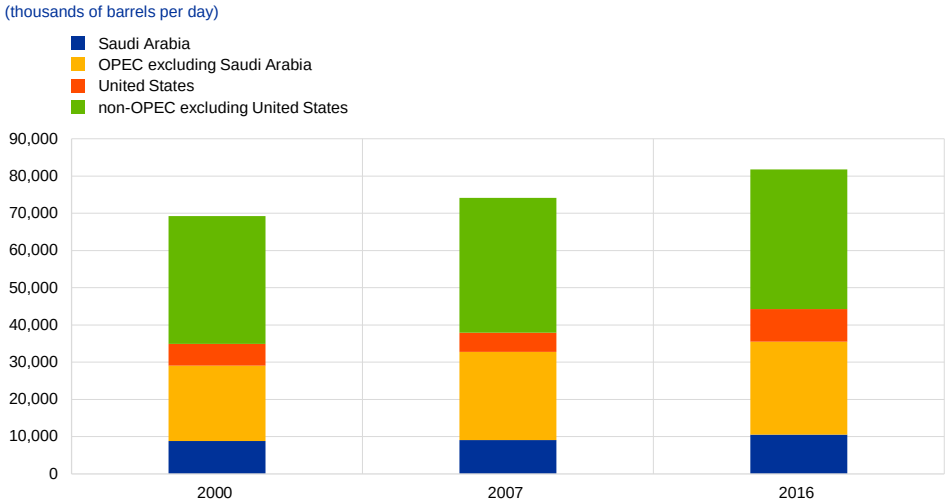
Expansion of US crude oil production since 2007



Source: US EIA.
Note: The latest observations are for 1 September 2017.

Chart 6

Changes in the structure of oil production (2000-2016)



Source: US EIA.
Notes: The value for the final month of a year is taken as the value for that year. The latest observations are for December 2016.

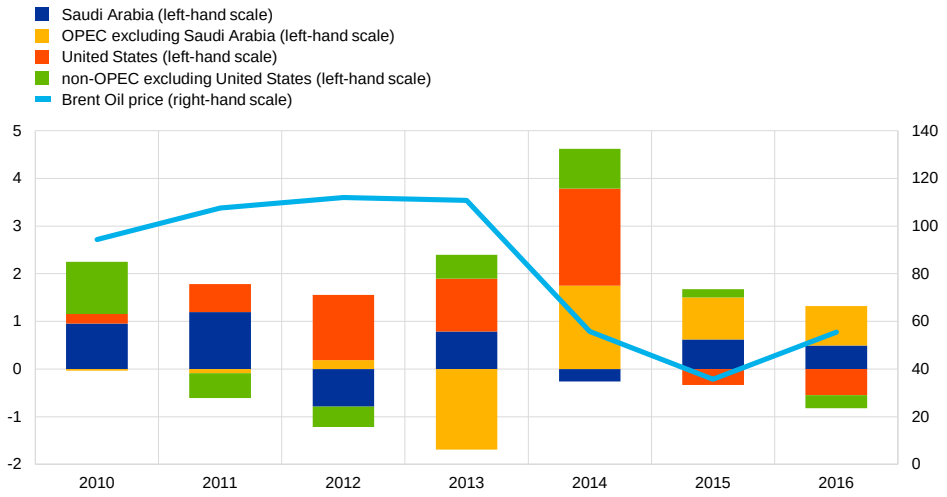
However, OPEC's share of overall production decreased only marginally, owing to declines in production by other major non-OPEC producers (Norway, the United Kingdom and Mexico). More significantly, Saudi Arabia expanded its production quota; in mid-2013 it exceeded the production share it had held prior to the global financial crisis. Acting as the OPEC swing producer, it compensated for production cuts in those Middle Eastern countries which were experiencing political instability and the effects of an international embargo (Libya and Iran, respectively).

In this initial phase, oil prices appear to have been supported more by positive developments in demand, while supply factors were relatively muted (see Charts 7, 8 and 9). The impact of shale oil producers was still fairly small, since they faced high production costs and rather limited production capacity. The first projections by the US EIA on shale oil production date back to 2011. Since then production has proved to be well above expectations, forcing the US EIA to regularly revise its forecasts upward. This is likely to have led to an OPEC strategy of "wait and see", and a period in which it incrementally fine-tuned its supply to keep the market well balanced so that the prices remained above USD 100 per barrel, especially in Europe. This is consistent with a SVAR analysis which shows that oil prices were driven by stronger oil demand during this period (see Box 2).

Chart 7

Contribution to annual crude oil supply growth (2010-2016)

(percentage points, left-hand scale; USD per barrel, right-hand scale)

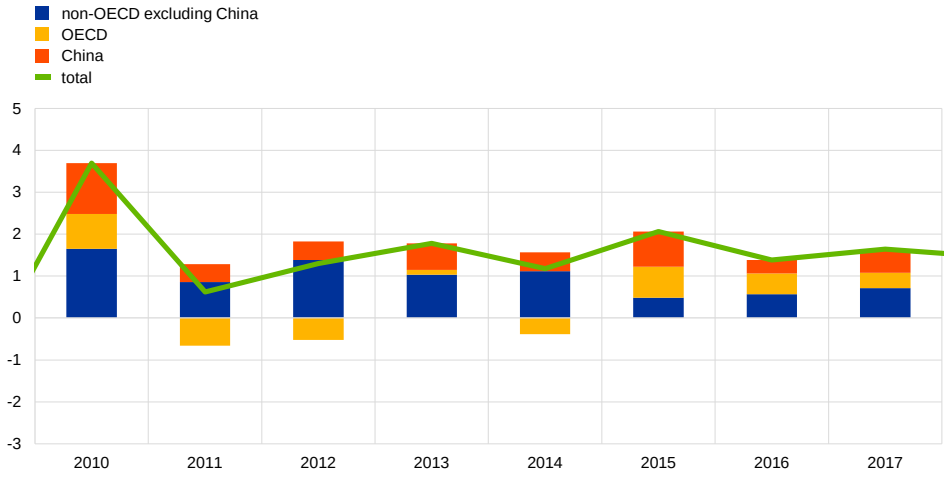


Sources: US EIA, Bloomberg and ECB staff calculations.
Notes: The value for the final month of a year is taken as the value for that year.

Chart 8

Contribution to annual oil demand growth (2010-2017)

(percentage points)

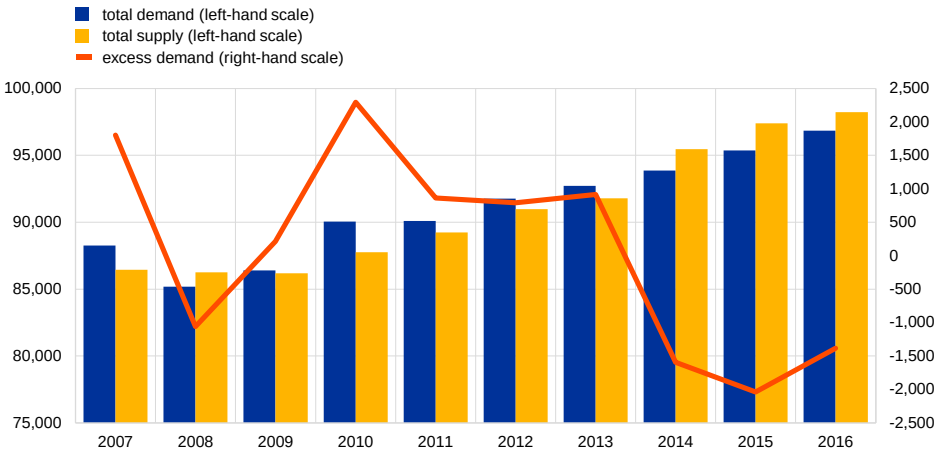


Sources: IEA and ECB staff calculations.

Chart 9

Changes in supply and demand (2007-2016)

(thousands of barrels per day)



Sources: US EIA and IEA.
Notes: The value for the final quarter of a year is taken as the value for that year. The latest observations are for December 2016.

Nevertheless, from the end of 2013 the pace of expansion of shale oil production picked up and proven reserves were heavily reappraised upwards from two billion barrels in 2011 to 11.6 billion barrels in 2015.[42] The extraordinary new capacity of shale oil production represented a fresh challenge to the prominence of OPEC's role in the oil market. In 2014, other non-OPEC supply also rose by around one million barrels per day, reflecting solid production figures in Brazil, Canada and Russia. OPEC rapidly started to lose market share (−2 percentage points between mid-2011 and mid-2014) and became concerned about the prospects for its high-cost producers.

3.2 Two years targeting market share

During the period from mid-2014 until October 2016, OPEC switched to a strategy of targeting market share. The reassessment of potential shale oil production growth in June 2014 can be considered as a turning point for the oil market, as it indicated that operators had underestimated the relevance of shale oil production. During the first half of 2014 not only did the US EIA repeatedly adjust its projections upwards[43], but more importantly, it extended its estimates of the life expectancy of shale oil production to 2030. In this context, OPEC realised that its loss of market share over the previous three years would not be regained without a change in strategy.

42 See *Review of emerging resources: US shale gas and shale oil plays*, Energy Information Administration, July 2011; and *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015,* Energy Information Administration, December 2016.

43 See *Medium-Term Oil Market Report 2014*, International Energy Agency, Paris, 2014.

While it is generally the role of swing producers to counteract temporary shocks, shale oil had modified the market structure permanently.[44] At this point, shale oil producers were still facing high break-even prices although production capacity was growing. Therefore an OPEC production policy consistent with maintaining high oil prices would have favoured continued development in the shale oil industry and progress in fracking technology, and resulted in further pressure on OPEC's market share. Supply growth from the United States and Russia was not offset by reductions in OPEC production, and global demand growth was showing signs of slowing down. This led the International Energy Agency (IEA) to revise its forecasts for 2014 and 2015 downwards, mainly due to weaker projections for Chinese and European oil demand growth.

On the back of these developments, OPEC took its decision in November 2014 to abandon production quotas. This attempt to regain market share was only partially successful. As a consequence of lower prices the investment plans of OPEC's competitors were heavily curtailed – especially in shale oil and non-conventional fields – but competitors were not driven out of the market. On the contrary, they became more efficient over time. The supply glut continued to drive prices to a level as low as USD 30 per barrel in early 2016. Despite the low prices, shale oil rig counts resumed their growth in April 2016, and shale oil production proved to be more resilient than expected as producing companies were able to compress extraction costs. The shale oil industry survived through mergers and acquisitions, as highly indebted mid-sized firms were acquired by larger entities with greater financial resources and capable of operating in an environment of low oil prices. In the period from mid-2014 to April 2017, oil prices were driven mainly by supply dynamics. This is consistent with the results produced by applying the oil market model presented in Box 2.

3.3 Reversion to a policy of price stabilisation

Targeting market share was proving too expensive for the strained public finances of OPEC members[45] **who agreed with major non-OPEC producers in November 2016 to adopt an approach of oil market rebalancing in order to support prices.** Global supply was cut by 1.8 million barrels per day but prices only rose to around USD 50 per barrel. However, the involvement of Russia and other major non-OPEC producers helped to partially preserve OPEC's role in the market; in September 2017 OPEC's production still represented 42% of global supply. Yet US production regained, and then exceeded, its 2014 level, suggesting that major shale oil production companies, at least in the short run, were economically viable at a price of around USD 50 per barrel.

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44 See Dale, S. "The new economics of oil", *The Oxford Institute for Energy Studies*, October 2015.

45 The market prices required to guarantee a balanced public budget in OPEC countries ("fiscal expenditures break-even prices") were estimated by the IMF to be between USD 58 for Qatar and USD 106 for Iran in 2015. It was estimated that oil prices of around USD 93 were needed in order to stabilise Saudi Arabia's fiscal situation. See the Statistical Appendix to the *Regional Economic Outlook: Middle East and Central Asia*, IMF, October 2016.

The decline in OPEC's production was a reaction to the considerable fall in the production costs of high-cost shale oil producers. In particular, these producers introduced a series of technological improvements that raised their competitiveness. The life of shale oil rig wells was extended by using injection liquids that had novel chemical compositions and, in particular, by the widespread use of re-fracking techniques[46]. Drilling closer to the "sweet spot"[47] increased the recovery rate and contributed further to reductions in break-even prices. The resilience of shale oil producers to low prices exacerbated the excess supply and kept oil prices persistently below the levels justified by production costs. Prices that fluctuate around USD 50 per barrel seem to be more consistent with short- to medium-term equilibrium prices. In order to progress with the rebalancing of the oil market through global supply restraints, member countries who signed up to the November 2016 OPEC agreement have recently extended it until the end of 2018, with the possibility of a review in June of that year.

Box 2
Historical decomposition of the oil price in the shale oil age

Prepared by Irma Alonso Álvarez and Virginia Di Nino

This box provides an assessment of the factors affecting oil price dynamics in the shale oil age – which began in 2011 – based on the framework and the methodological approach explained in Box 1. The developments in oil prices and in OPEC's decisions can be divided into three distinct periods, identified by local peaks and troughs in prices: the periods from January 2011 to May 2014; from June 2014 to February 2015; and from November 2016 to April 2017.

While demand factors were more relevant until mid-2014, the estimates obtained from the SVAR model suggest that since then, oil prices have been driven by supply dynamics. In the first period, which coincides with the beginning of the shale oil revolution, the 14% increase in oil prices was driven by stronger oil demand growth (+38%), partially balanced by a slight increase in supply (+10%) which contributed negatively to the price dynamics. However, since mid-2014, it is OPEC's decisions which have been key in explaining the developments in oil prices. In November 2014, OPEC abandoned production quotas. Indeed, the empirical analysis reveals that most (39%) of the 57% price drop experienced in the second half of 2014 and until early 2015 was due to supply factors. In particular, market share targeting represents 25%, and an additional 7% can be attributed to the price stabilisation policy. Speculative demand, which in this period can be interpreted as expectations of future excess supply, delaying destocking of inventories, made a negative contribution of another 7%, while demand factors contributed 9% to the drop in the oil price over the same period.

Since autumn 2016, supply factors have continued to be key drivers of prices, as OPEC switched back to a policy of price targeting. It announced the reinstatement of production quotas in an attempt to facilitate the reabsorption of excess supply. Chart A shows that it was primarily supply factors related to market share stabilisation which supported upward movements in

[46] See "Hydraulic fracturing accounts for about half of current U.S. crude oil production", *Today in Energy*, Energy Information Administration, March 15, 2016.

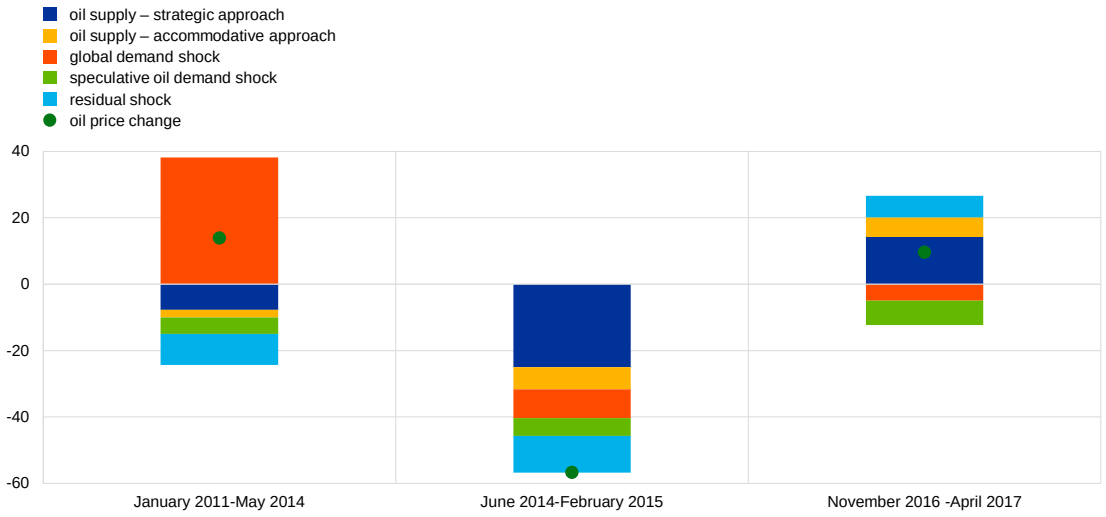
[47] "Sweet spot" is the term used for the area of a shale basin with the highest concentration of crude oil, generally associated with lower extraction costs and higher efficiency rates.

prices (contributing around 15% of the increase from November 2016 to April 2017), although the price stabilisation strategy also contributed, but to a lesser extent (6% of the increase). Conversely, demand factors were less relevant until the first quarter of 2017 and seem to have depressed prices slightly since then (see Chart A).

Chart A

Historical decomposition of oil price dynamics (2011–2016)

(percentage points)



Sources: IEA, US EIA, WEO and ECB staff calculations from SVAR models (see Box 1).
Note: The latest observations are for April 2017.

4 The relevance of shale oil in the medium term according to micro evidence

Shale oil will remain an important factor in oil production in the future. The hypothesis maintained throughout this analysis is that producers began to be perceived as effective competitors once their supply capacity expanded and their break-even prices fell. However, how relevant is shale oil production expected to be in the medium term? This section provides evidence, based on the latest projections from Rystad[48], that shale oil will remain an important factor for at least two reasons: i) the additional efficiency gains it is expected to achieve, and ii) the rapid increase of investment flows into the industry which are expected over the coming years.

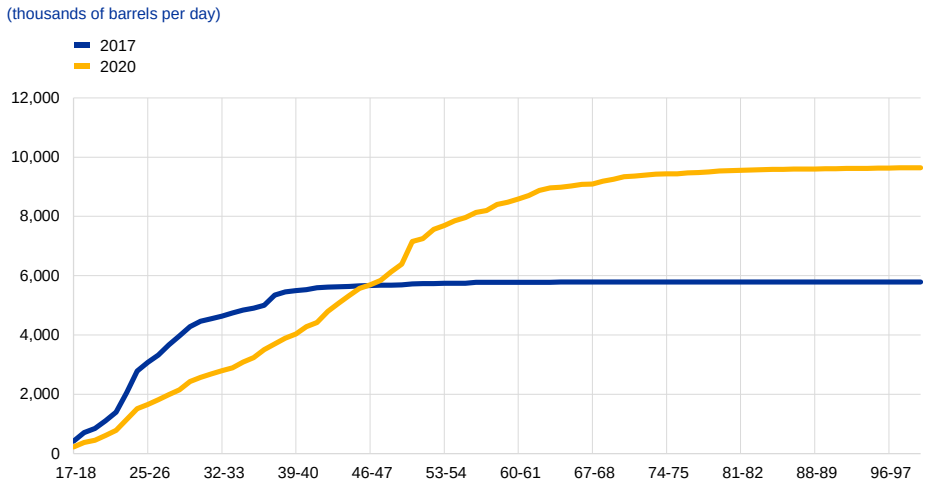
Technological progress has succeeded in consistently reducing the break-even production prices of shale oil. Based on data released by Rystad in August 2017, Chart 10 shows the potential production in millions of barrels per price range in 2017 and in 2020, for given current and prospective shale oil wells (based on current

[48] Rystad is a specialised provider of the datasets on oil market variables that have been used in this section to assess the potential evolution of shale oil production.

ongoing and exploration projects). The data can therefore be interpreted as inverse aggregate shale oil supply curves; the blue line plots the current supply and the yellow line plots the forecasted supply. Almost the entire supply from currently active rigs can be produced economically for prices in the range of USD 40-45 per barrel (see Chart 10); this is a reduction of 30% from the production costs of a few years ago.

Chart 10

Current (2017) and future (2020) shale oil production by break-even price



Sources: Rystad data and ECB staff calculations.
Note: The horizontal axis shows break-even price (BEP) ranges in USD. The definition of BEP in the oil sector is the costs related to the entire oil cycle production. These include selling, general and administrative expenses, property acquisition costs, finding costs, costs of licensing rounds, signature bonuses, the costs of drilling, exploration and development of wells , production and maintenance costs, transportation costs, taxes or royalties paid to the host state, return on capital and a risk premium to cover the uncertainties inherent in oil and gas investments.

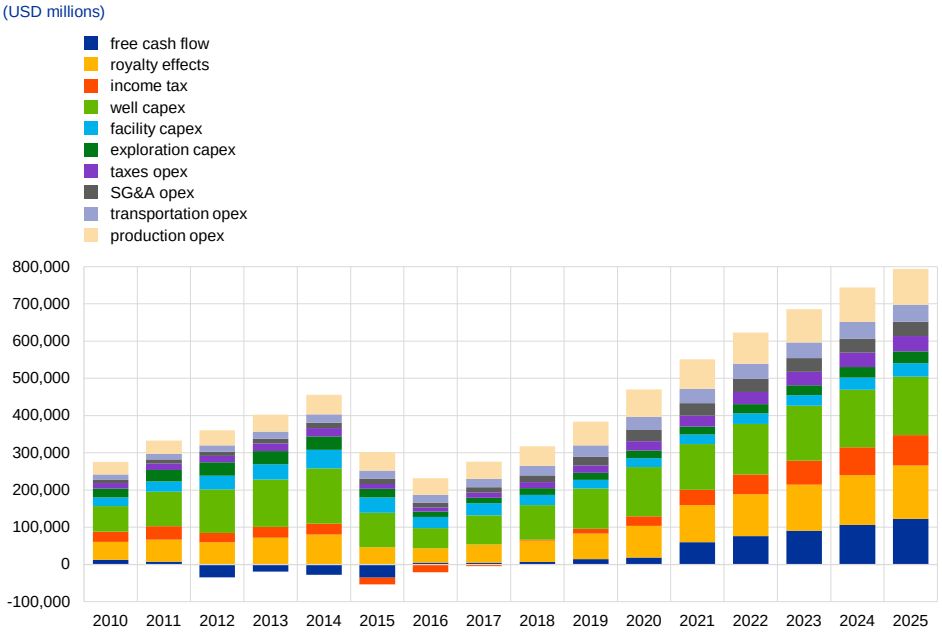
The comparison of the two curves (2017 and 2020) in Chart 10 also shows that current production of existing wells is limited to six million barrels per day. However shale oil supply is expected to expand rapidly beyond that limit at prices above USD 40-45 per barrel in the future. In particular, the development of newly approved projects could – according to these estimations – sustain a supply of around nine million barrels per day (equivalent to an increase of more than 50% over three years) provided that oil prices rise above USD 65 per barrel, which corresponds to the break-even price of just a few years ago. A note of caution accompanies the 2020 supply curve: since currently viable wells will be largely exhausted within two years and they are operating at prices below USD 40-45 per barrel, the curve shows that production in three years is expected to be lower than today if prices remain within that range over the medium term (see Chart 15). Similar analyses, conducted on other on-shore (non-shale) and off-shore production, show instead unchanged inverse supply curves, revealing a constant cost/supply structure and confirming that additional supply in the future will also almost exclusively come from shale oil.

The development of capital investment in US shale oil production also provides evidence of the resilience of shale oil production over the coming years. Capital inflows into the industry are underway and are expected to become particularly pronounced in the medium term. As shown in Chart 11, capital

investment in the next five years is expected to be stronger than in the past (growing at an average of 18% per year, compared with the five-year average of 14% for the period ending in 2014). Capital investment in wells, which includes construction and drilling costs (among other factors), will experience one of the largest rises – in line with expected increases in US shale oil production mainly in the Permian region (Midland and Delaware).

Chart 11

Capital investment in US shale oil production (including projections)



Sources: Rystad data and ECB staff calculations.

5 Conclusions

This article has reviewed the contribution made by market fundamentals to oil price dynamics in response to the emergence of a key novel factor – shale oil production. Empirical results from a SVAR model with sign restrictions suggest that, especially since 2014, shale oil has had an effect on developments in oil prices: directly, by contributing to global supply growth; and indirectly, by influencing OPEC production policies. OPEC was incentivised to pursue market share as shale oil production increased but was not competitive enough. However, as shale oil producers gained in competitiveness, OPEC preferred a policy of price stabilisation around a value compatible with the break-even cost of the marginal producers.

Micro evidence suggests that not only has shale oil modified other producers' incentives and therefore the mechanism of price formation over recent years, but it will remain a crucial element of oil production, at least for the next 15 years. Rapidly increasing investment inflows are expected to maintain the robust pace of production growth, thereby highlighting the relevance of technological improvements in oil production. However, important questions remain open concerning, for

example, the life expectancy of the shale oil revolution – particularly given the unlikelihood that it will expand beyond the geographical borders of the United States to any significant extent. Geological conditions, environmental concerns, water shortages and less efficient supply chains have so far prevented the widespread diffusion of shale oil technology elsewhere.