Factors Behind the 2014 Oil Price Decline

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- Oil prices have declined sharply over the past three years. Brent prices, for example, fell from an average of US$110 per barrel between January 2011 and June 2014 to a low of US$29 in January 2016 and an average of only US$50 since 2015.
- While both supply and demand factors played a role in the large oil price decline of 2014, global supply growth seems to have been the predominant force. This view is supported by economic models designed to disentangle the effects of shifts in supply and demand factors.
- The surprising growth of US shale oil production together with the decision by the Organization of the Petroleum Exporting Countries to maintain output played a key role in the initial decline in oil prices. Weaker-than-expected global growth and concerns over the Chinese economy in late 2015 also help explain the persistence of the price decline.

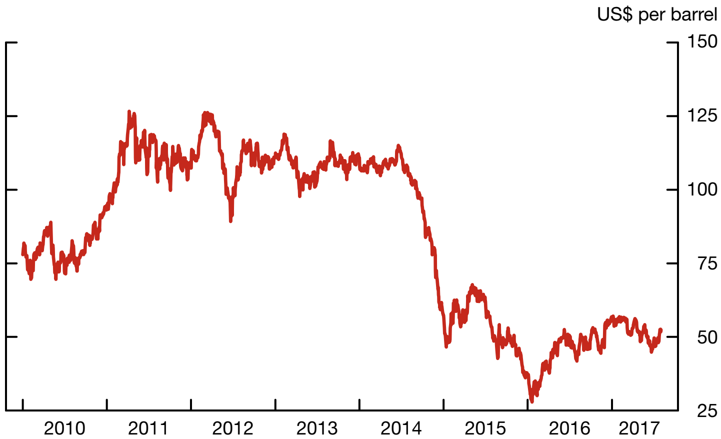
Between January 2011 and June 2014, Brent oil prices were relatively stable around US$110 per barrel—a three-and-a-half-year average that, in real terms, had never been seen before. However, oil prices fell steadily from that point, reaching a low of US$29 in January 2016, and have averaged US$50 since 2015 (**Chart 1**). In this article, we argue that both supply and demand played a role in the large oil price decline after June 2014 but that strong supply growth was the key factor.

The 2014 decline in oil prices coincided with a large increase in oil production and inventories as well as a modest increase in consumption. This pattern is consistent with an outward shift in the oil supply curve, which is empirically supported across a range of economic and statistical models designed to disentangle the price effects of shifts in the global supply and demand curves.

Although these models cannot isolate the specific shocks that led to this outward shift in the oil supply curve, this article discusses the events that likely had the greatest impact. In part, the strong supply response can be traced back to rising levels of economic growth in emerging-market economies (EMEs), particularly China, in the early 2000s. This growth helped support oil demand and pushed prices to levels that encouraged new

Chart 1: Crude oil prices since 2014

Brent crude oil prices, daily data



Source: Intercontinental Exchange via Haver Analytics

Last observation: August 2, 2017

investment in oil production. However, after the rebound in global output following the global financial crisis, economic growth began to be persistently overestimated, eventually resulting in an excess of oil production that helped precipitate the 2014 price collapse.

On its own, a misjudgment of future demand conditions would likely only have a temporary—though potentially long-lasting—effect on oil prices. If, for example, producing a new barrel of oil costs US$100, prices should be expected to return to that level once the excess supply in the oil market has been absorbed. However, other factors have also contributed to the outward shift in the supply curve, with the potential of permanently affecting future oil prices. In particular, innovations in US shale production have developed a new, potentially lower-cost source of supply that can respond more quickly to changes in oil prices—a major change in an industry where there have traditionally been long lags between price changes and new output.[1] The uncertainty caused by this new source of supply led the Organization of the Petroleum Exporting Countries (OPEC) to refrain from cutting output and instead take a wait-and-see approach, further exacerbating the oil price decline in mid-2014.

Oil and gas extraction made up roughly 30 per cent of total business investment in 2014

The decline in oil prices in 2014 had a significant impact on the Canadian economy. Canada is a net oil exporter, and the price of oil affects the country's terms of trade, its gross domestic income and the value of its dollar. Furthermore, while oil and gas extraction accounts for only 6 per cent of Canadian gross domestic product (GDP), it made up roughly 30 per cent of total business investment in 2014. Initial Bank estimates found that in the absence of any monetary policy response, the oil price decline would have reduced the level of Canadian GDP after 2014 by roughly 2 per cent (Bank of Canada 2015). The Bank therefore decreased interest rates twice in 2015 to help the economy adjust to lower oil prices.

Looking ahead, there are structural factors that could push the price of oil in either direction. Technological innovation in US shale oil extraction continues to progress, and novel techniques are slowly spreading in ways that could boost oil production in other countries, especially Canada. The recent

1 In this article, we use "shale oil" to refer to all forms of tight oil, which are light crude oils contained in low-permeability rock formations that can be accessed through hydraulic fracturing.

oversupply has, however, caused many oil firms to slash their exploration and production budgets. Since conventional oil projects take three to five years to build, on average, this reduction in investment raises the risk of insufficient supply if shale oil is unable to satisfy the growth in global oil demand. Finally, there are growing concerns among some market participants that "peak demand" could be imminent in the oil market. As policies are developed to address climate change and as electric vehicle battery technology improves, the demand for oil in transportation, one of the main sources of the demand for oil, could fall sharply.

Structure of the Global Oil Market

Before discussing the drivers of the 2014 oil price decline, we provide a short review of the structure of the global oil market. Roughly 60 per cent of global oil production comes from low-cost countries where government policy plays an active role in output decisions. This group is composed of national oil companies (NOCs) that are both in OPEC—which makes up about 40 per cent of global liquid fuel production—and in other, non-OPEC countries, such as Russia or Mexico.[2] Because the oil industry is traditionally characterized by long lags between price changes and new output, these NOCs can influence the price of oil by temporarily increasing or withholding production (Golombek, Irarrazabal and Ma 2014; Huppman 2013). These limited interventions likely help anchor price expectations in periods of temporary excess supply or demand. However, research suggests that longer-term co-operation is rare (Almoguera, Douglas and Herrera 2011; Dale 2015), in part because of the significant problems with coordinating actions across so many different producers.

The ability of this first group to affect the market price of crude oil is limited by the presence of another group of highly competitive firms that, individually, have no market power (i.e., the competitive fringe). This group includes a wide variety of firms: oil sands producers in Canada; large, private international oil companies; and small shale oil production companies in the United States. When the competitive fringe improves its ability to produce crude oil, as it did in the years leading up to the oil price decline, it weakens the market power of OPEC and other NOCs. The competitive fringe can do this in two ways: by reducing its costs of production or by reducing the lag between oil price movements and new output—both of which played a role in the recent oil price decline and will be discussed in greater detail in this article.

When the competitive fringe improves its ability to produce crude oil, it weakens the market power of the Organization of the Petroleum Exporting Countries and other national oil companies

Identifying the Factors Behind the Oil Price Decline

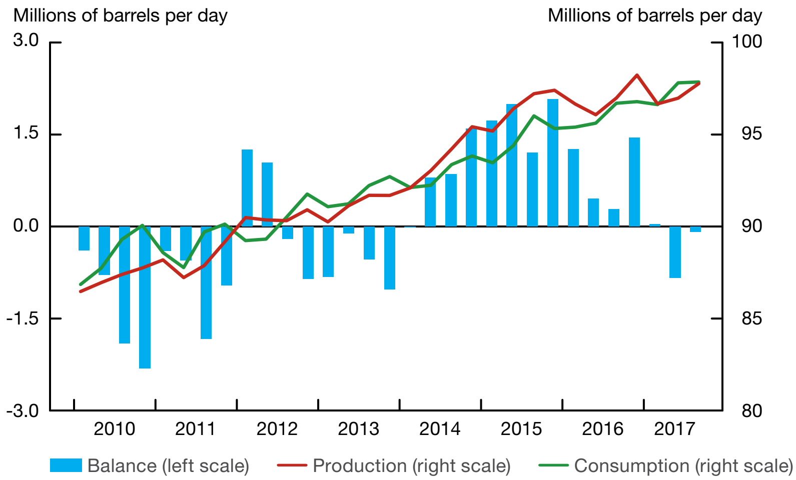
Economic theory provides three explanations for declines in oil prices.[3] First, prices could decline because of an outward shift in the oil market's supply curve. In this case, the price decline should be associated with an immediate increase in production and eventual rise in consumption. Second, they could decline because of an inward shift in the oil market's demand curve. In this case, the price decline should be associated with an immediate decrease in consumption and eventual decline in production.

2 NOCs are oil companies that are fully or majority-owned by national governments.

3 In this article, we focus on supply and demand factors rather than shocks. For this reason, we do not analyze the results of the Kilian and Murphy (2014) model, which is a model of shocks. A short example can help us understand the difference between the two. An outward shift in the oil market's supply curve is considered a supply factor, but the original reason behind that shift is known as a shock. If the supply curve shifted outward because of expectations of strong future demand, it would be caused by a demand shock.

Chart 2: Global oil market since 2010

Global petroleum production and refined products consumption, quarterly data



Note: "Balance" is the difference between total global production and total global consumption.
Sources: International Energy Agency and Bank of Canada calculations

Last observation: 2017Q3

Finally, if agents believe that future oil market conditions will be much less favourable for oil prices than current conditions, they would react by selling their level of oil inventories on hand. Note that shifts in the demand for oil inventories comprise expectations of future supply relative to future demand and thus can be driven by either supply or demand factors.

Output began to exceed demand after the second quarter of 2014

To get a sense of what drove the oil price decline in mid-2014, we first examine data on global oil production and consumption from the International Energy Agency (IEA, **Chart 2**). Between 2010 and 2013, production and consumption moved closely together, with each growing close to their 2001–13 annual average of 1.4 per cent.[4] However, output began to exceed demand after the second quarter of 2014, and production growth rose to an average of 2.7 per cent in that year, while consumption growth remained in line with its longer-term average. This imbalance persisted for 12 consecutive quarters, the longest such run ever recorded. Over time, the size of the imbalance shrank as production growth moderated, and consumption growth rose modestly above its long-term average. As of the second quarter of 2017, the gap between production and consumption appears to have closed. Nevertheless, the imbalances from 2014 to 2016 led to a large buildup in oil inventories, which has yet to be fully drawn down (**Chart 3**).

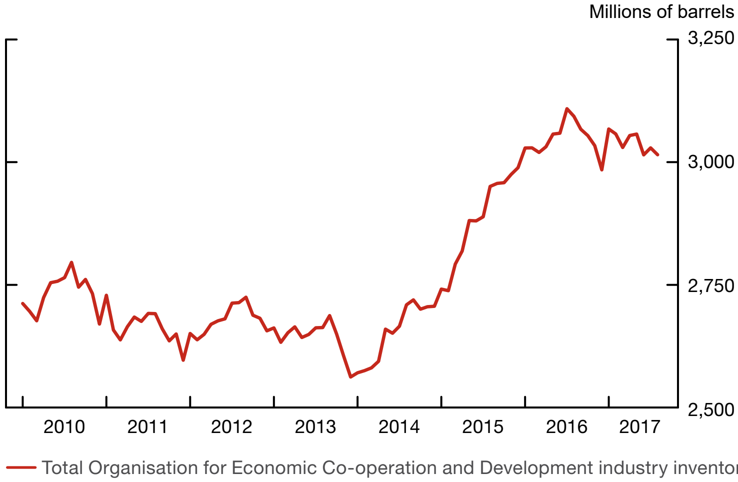
A pickup in production growth followed by an eventual rise in consumption growth suggests that supply factors explain most of the decline in oil prices since mid-2014. This analysis is supported by a range of models designed to disentangle the effects of supply and demand factors on oil prices (see **Box 1** for an explanation of these models).

Chart 4 (panels a and b) presents the oil price decompositions from our models. The model of oil demand and the commodity price factor model find that shifts in oil demand explain roughly 20 per cent and 40 per cent,

4 We chose 2001 as the starting point to coincide with the end of a recession in the United States and the Chinese accession to the World Trade Organization, both of which are considered important events for oil demand.

Chart 3: Elevated levels of petroleum inventories

Private inventories of refined and unrefined products, monthly data



Sources: International Energy Agency and Bank of Canada calculations

Last observation: August 2017

Box 1

Models of Oil Supply and Demand Factors

This article uses two different models to decompose oil price movements into supply and demand factors. Using multiple models can help give us greater confidence in our results if these models all point in the same direction. We explain the structure and interpretation of these models below.

Model 1: Model of oil demand

This model, first presented by Hamilton (2014) and later modified by Bernanke (2016), relates changes in oil prices to factors that proxy for oil demand and are independent of oil supply. These factors include changes in copper prices, in the 10-year US Treasury interest rate, in a broad-weighted index of the US dollar, and in stock market volatility (proxied by the volatility index derived from stock options [VIX]).[1] The equation is estimated using ordinary least squares. Changes in the price of oil predicted by the model are meant to measure movements in oil demand, while all other movements are attributed to oil supply. Note, however, that to the extent that demand factors are not fully specified in this model, the model may be overestimating the effect of supply factors. In addition, this model is unable to determine whether supply or demand factors are driven by current conditions or by movements in future expectations.

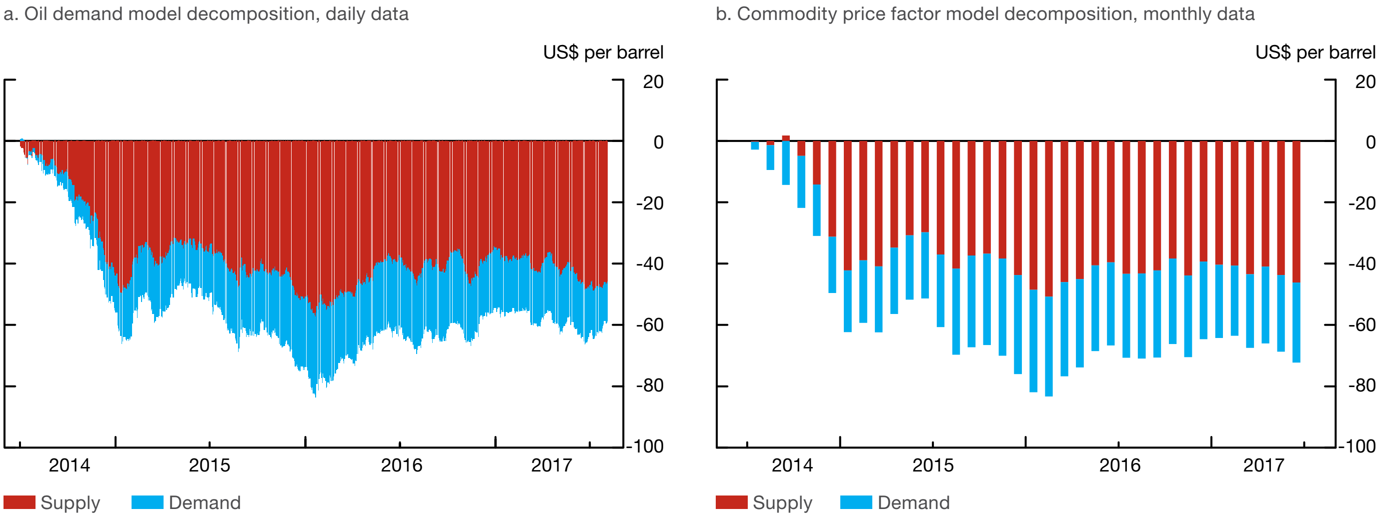
Model 2: Factor model of commodity prices

This model was first presented by Delle Chiaie, Ferrara and Giannone (2015) and was later extended to better match commodities that are of interest to Canada by Bilgin and Ellwanger (2017). The model uses a quasi-maximum likelihood estimation to break down the common movements across a large cross-section of commodity prices into three distinct categories: a global component; a group-specific, or block, component; and a commodity-specific, or idiosyncratic, component. The global component captures price trends that are common to all commodities included, which are typically related to global commodity demand (Alquist and Coibion 2014). One limitation of this approach is that movements in the global component could also be driven by changes in the US dollar, the currency in which most commodities are priced. Furthermore, this model cannot distinguish whether block or idiosyncratic components are driven by supply factors or by commodity-specific demand factors, though the narrative evidence that we provide for oil prices suggests these movements are mostly related to supply factors (e.g., the rise of US shale oil production).

1 How independent some of these factors are from oil supply can be disputed. For example, the United States is a net oil importer, so a decline in oil prices should boost the US dollar, all else being equal. We make no attempts to control for these issues in this article.

Chart 4: Decompositions of price shocks to crude oil prices

Cumulative dollar shocks since June 2014



Note: Supply is the sum of the block and idiosyncratic components, and demand is the global component.

Source: Bank of Canada Last observation: August 4, 2017

Source: Bank of Canada Last observation: June 2017

respectively, of the oil price decline between June 2014 and August 2017. The remainder, constituting the bulk of the oil price decline, is attributed to shifts in oil supply.

While these models can help decompose price movements into supply and demand factors, they are not designed to identify the specific supply and demand developments that drove these movements over the 2014 oil price decline. To complement the findings from these models, the next section outlines the major events that we believe provide the best explanation for the movements in supply and demand since 2014. We pay particular attention to three events: the lagged effect of previously strong demand conditions, the development of new oil extraction technologies and OPEC's decision to not cut production in late 2014.

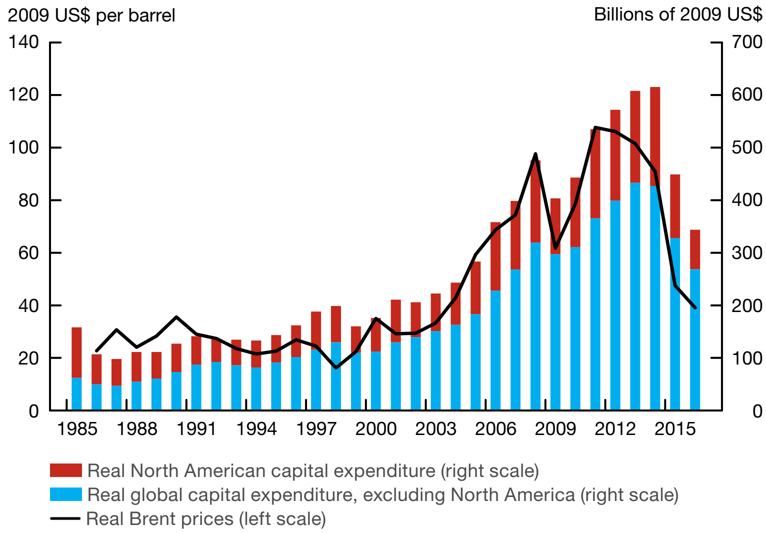
Past Demand Conditions Fuel an Excess Output Response

Strong economic growth in the early 2000s, especially in EMEs and particularly in China, led to steady growth in oil demand and upward pressure on oil prices. This process—where a period of high commodity prices over time eventually leads to new investment and output and an eventual decline in commodity prices—is sometimes referred to as a commodity price supercycle (for a survey, see Büyükşahin, Mo and Zmitrowicz 2016). As growing demand increased the price of oil, it also led to a substantial increase in oil-related capital expenditures (**Chart 5**). This new capital helped develop previously unprofitable areas of oil production, such as the oil sands in Canada, offshore deepwater oil in the Gulf of Mexico and, especially, shale oil in the inland United States.

However, after the sharp recovery in global output following the global financial crisis in 2009, this process started to reverse. Starting in 2011, there was a broad decline across all commodity prices, suggesting concerns about the underlying strength of global economic growth. In part, this weakness likely reflected a series of downward revisions to global growth

Chart 5: Global oil-related capital expenditures and the price of oil

Chained 2009 dollars, annual data

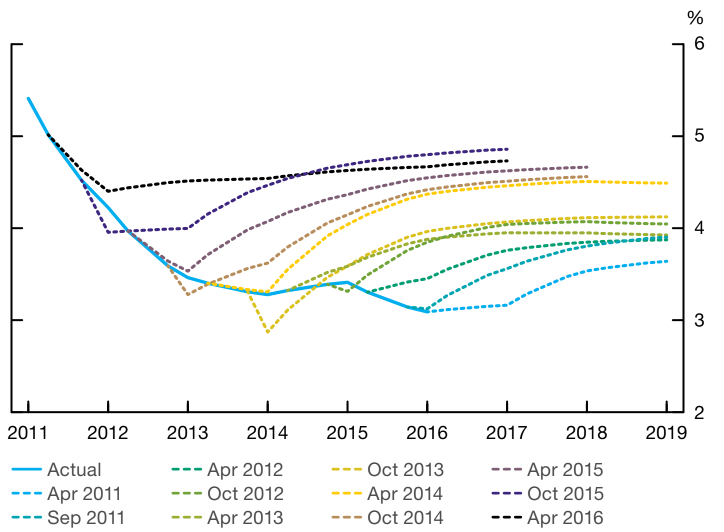


Sources: US Bureau of Economic Analysis and *Financial Times* via Haver Analytics, Barclays and Bank of Canada calculations

Last observation: 2016

Chart 6: World gross domestic product forecasts

Annualized real gross domestic product growth forecasts, by IMF *World Economic Outlook* vintage



Source: International Monetary Fund

expectations. **Chart 6** shows that global GDP growth was 3.5 per cent by 2014, almost 1.5 percentage points lower than what the International Monetary Fund, along with most other analysts, had expected three years earlier. Many oil projects that had been sanctioned in earlier periods when demand was much stronger only began to come online during this period of slowing growth, likely contributing to a slow but progressive excess in the amount of oil production over demand.

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Developments in China have been especially important for the decline in oil prices. China accounted for almost 70 per cent of the increase in global oil consumption between 2000 and 2014. As such, initially strong forecasts for

Chinese growth followed by repeated downward revisions likely contributed to the excess oil supply response and had an outsized effect on prices. Furthermore, concerns over future expected Chinese growth were particularly important for the decline in oil prices in early 2016, when the Brent oil price hit a low of US$29 in January of that year. At that time, a correction in the domestic Chinese stock market touched off concerns over the sustainability of future economic growth, but oil prices began to recover steadily as those concerns eased.[5]

New Technologies Also Help Set the Stage

The steady increase in oil prices over the 2000s also helped spur the development of several new oil extraction technologies that are still being improved upon today. The expansion of US shale oil extraction has proven to be particularly disruptive to the way oil is produced. The main technology behind the exploitation of shale oil involves fracking: a process where high-pressure liquids are injected into subterranean formations to fracture them and make it possible to extract the oil and gas they contain.

The expansion of US shale oil extraction has proven to be particularly disruptive to the way oil is produced

Over the years, fracking has been combined with other technologies that have allowed it to become competitive with conventional oil development.[6] The US Energy Information Administration (EIA) estimates that between 2008 and 2016 US shale oil production rose from close to zero to about 4.25 million barrels per day of crude oil (EIA 2017). This represented roughly 48 per cent of total US crude oil production and 5 per cent of global crude oil production in 2016. For perspective, US shale crude oil production, which took around 7 years to develop, now roughly matches total oil production in Canada, which took approximately 70.[7]

Moreover, shale oil production can respond to changes in oil prices much more quickly than traditional oil projects (i.e., its output response is more elastic to price shifts).[8] **Chart 7** shows that most projects started in the 2000s took three to five years to develop, meaning there was a substantial lag between changes in oil prices and new production. This situation gave oil-producing countries with significant spare capacity—particularly Saudi Arabia—the ability to influence oil markets by releasing or withholding supplies at strategic times. The rise of US shale oil production has attenuated this ability. Because US shale oil can be brought to market within six months to a year, it can react more quickly to price changes. Note, however, that while US shale oil is quick to develop, it is also quick to deplete relative to conventional oil production (Kleinberg et al. 2016). This means that to remain constant, relative to conventional oil, shale oil production requires a more rapid discovery of new deposits and a steady stream of new investment.

Finally, improvements in fracking technology have cut extraction costs, which means that lower oil prices can be sustained over longer periods than before. **Chart 8** shows evidence from Rystad Energy, a major independent oil consultancy, that the oil price needed to profitably develop a US shale oil well (the "break-even" price) declined by roughly 50 per cent between

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5 This contention is also supported by the results of the oil price decomposition models discussed previously, which all point toward demand factors as the reason behind the oil price drop in early 2016.

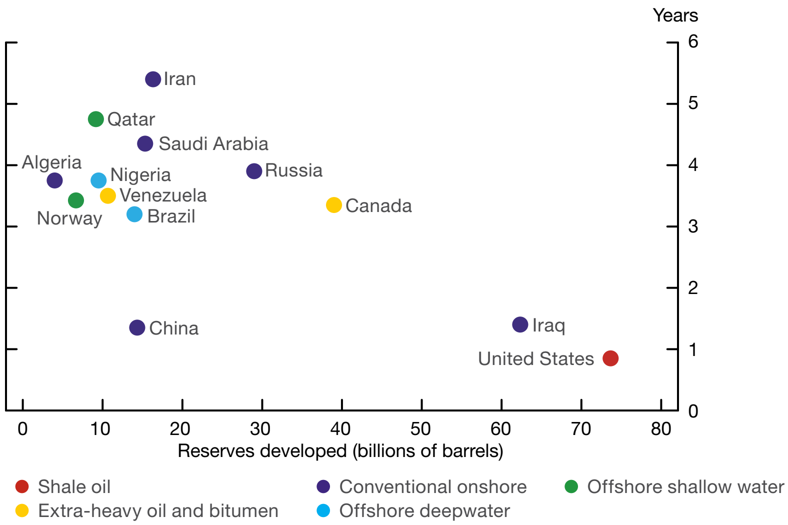
6 These include horizontal well-drilling, enhanced seismic imaging and improved drilling techniques, such as pad drilling and greater rig mobility (EIA 2012).

7 This comparison uses total liquids production, the International Energy Agency's broadest definition of oil and oil substitutes, encompassing crude oil, natural gas liquids and nonconventional oil production (e.g., output from oil sands mines).

8 This is due in part to the greater resemblance of tight oil production to a manufacturing-style process, where the same rigs and processes can be used to drill many wells in similar locations (Dale 2015).

Chart 7: US shale versus other oil investment, by country

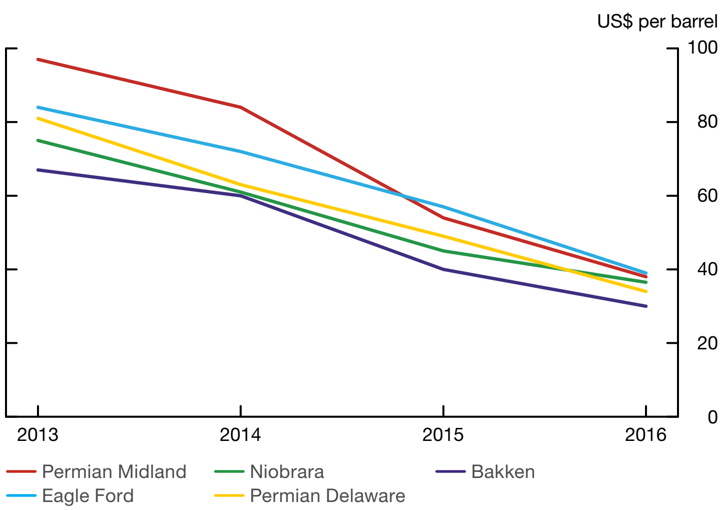
Average lead times after final investment decision announcement (2000–14)



Source: International Energy Agency

Chart 8: Break-even prices across US shale oil basins

Wellhead break-even prices



Source: Rystad Energy

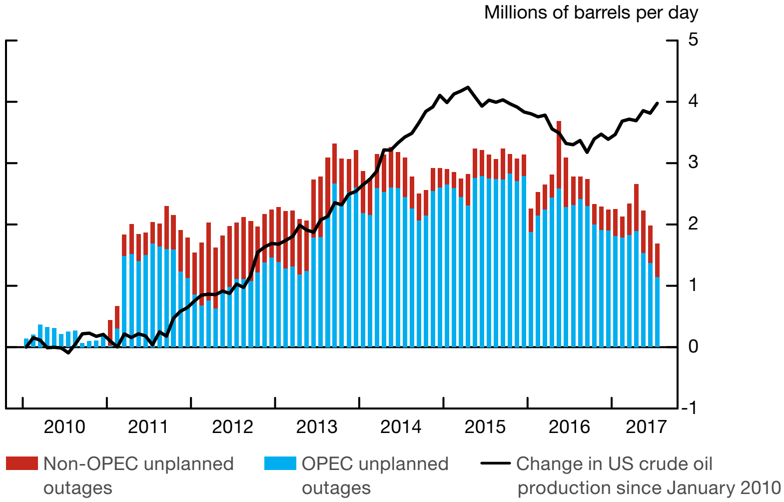
Last observation: 2016

2013 and 2016 across all major producing regions (Rystad Energy 2016). These rapid cost declines are likely one of the key factors holding back any sustained recovery in oil prices over the past three years. Nevertheless, it remains unclear to what degree these cost declines will persist. For example, Rystad Energy also presents evidence that the decline in oil prices led to weaker demand for oil field services, temporarily reducing their cost, a process that should reverse as demand for drilling activity picks up (i.e., the cost declines result more from shifts in economic rent than technological factors). The evolution of break-even costs for US shale oil remains a key uncertainty for oil price forecasting going forward.

The effects of fracking on oil prices took a few years to be fully realized. US shale oil was initially seen as a relatively high-cost source of supply, and its supply elasticity was unknown. The ability of shale oil producers to continue

US shale oil was initially seen as a relatively high-cost source of supply, and its supply elasticity was unknown

Chart 9: US shale oil production and global unplanned outages, including those from the Organization of the Petroleum Exporting Countries



Sources: Energy Information Administration, International Energy Agency and Bank of Canada calculations

Last observation: July 2017

to reduce costs in the face of falling oil prices—while definitely highlighted as a risk (Bank of Canada 2015)—only became clearer over time. In addition, **Chart 9** shows that, until mid-2014, the surprising growth in US shale oil production was offset by a rise in unplanned production outages in the rest of the world. These outages were the result of geopolitical events, including the civil war in Libya, economic sanctions against Iran, and the rise of the group known as the Islamic State in Syria and Iraq. After 2014, the level of unplanned outages began to abate, but US shale oil output continued to grow strongly, helping precipitate the imbalance between production and consumption seen in **Chart 2**.

OPEC's Decision Exacerbated the Oil Price Decline

The decision by OPEC to refrain from cutting oil production in November 2014 also contributed to the decline in oil prices. While this decision caught markets by surprise, it was broadly consistent with the behaviour of Saudi Arabia—the key player in any OPEC agreement—since the oil price collapse of 1986 (Fattouh, Poudineh and Sen 2015). Several studies have sought to model Saudi Arabia and OPEC's decision-making process more formally (see Behar and Ritz 2017 for a recent example). These models broadly agree that a minimal set of conditions must be in place for Saudi Arabia to sign on to any agreement to cut production. We can summarize these conditions as follows:

1. The ability of other OPEC members to raise their own output must be limited; otherwise, they could offset the effects of a Saudi cut.
2. The ability of non-OPEC producers to raise their own output in response to a cut should be limited and well understood.
3. The shock facing the oil market should be considered temporary, which helps to ensure that any agreement has a built-in expiry date (Dale 2015).

These conditions were absent between November 2014 and September 2016. On the OPEC side, Iran was making progress toward the removal of economic sanctions against its oil exports, and Iraq was finally solving the infrastructure bottlenecks that had plagued it since 2003. In fact, Iraqi oil production had already increased by around 0.7 million barrels per day (mb/d) between 2011 and 2014, contributing to the overall excess of supply. As a result, neither country was ready to discuss any formal agreement to restrict output in November 2014. On the non-OPEC side, US shale oil was clearly changing the nature of the oil market. Faced with these conditions, Saudi Arabia seemed willing to allow prices to decline enough to slow down non-OPEC production growth and increased its production amid falling prices. While counterintuitive, this decision was likely the rational, revenue-maximizing decision, especially when the price level needed to manage non-OPEC output was uncertain. A similar reasoning can explain why later OPEC meetings in December 2015 and April 2016 also ended without any formal agreement or guidance on future policy.

Conditions had shifted by the time of the September 2016 OPEC meeting. By then, output from Iran and Iraq had plateaued, lessening the concern that they could easily offset any output cuts. Also, the nature of the US shale supply curve was—at that time—thought to be better understood. By December 2016, Saudi Arabia therefore helped orchestrate an output cut of 1.8 mb/d between OPEC and other non-OPEC oil producers. This agreement had the limited goal of reducing oil inventories that had built up over the preceding three years back to their five-year average. However, it remains to be seen whether this will be achieved, given the ongoing technological progress occurring in US shale oil projects.

Future Outlook

Some of the trends outlined here are still developing, and thus the future path for oil prices remains highly uncertain. Below we sketch out some of the most important developments that could affect the oil market in the foreseeable future.

Shale oil technology could spread around the globe

The United States is the only country to have massively increased its oil production through shale oil development, but this could change. Substantial shale oil deposits have been identified in Argentina, China and Russia. The development of these deposits has thus far been hampered to some extent by unfavourable political and regulatory environments (Alquist and Guénette 2013). Should this change, shale oil development could quickly spread outside North America. In addition, much of the drilling technology recently developed for shale oil is already being used in Canada and Russia and could be applied to conventional wells (Farchy 2016; Tertzakian 2017). If these technologies continue to spread, any rise in oil prices could be constrained over the longer term.

New technology and policy could lead oil demand to decline

There are growing concerns among some market participants that demand for crude oil could peak soon and then begin to decline over the next few decades, which would also negatively affect oil prices. New technologies, such as electric vehicles (EV), could significantly reduce the demand for oil. For example, the IEA expects the number of EVs being driven to rise twentyfold in the next 10 years, reducing oil demand by 0.3 mb/d (IEA 2016).

The outlook for EV penetration remains highly uncertain because it is difficult to predict how fast the technology will evolve and how much support it will receive from governments.[9]

In the past, economic considerations have driven the trend toward greater energy efficiency, but environmental policies could play a more important role in the future. Despite a recent pullback in the United States, most countries are committed to slowing, or even reversing, the effects of commodity consumption on air and water quality and the climate, especially after the 21st Council of the Parties agreement on climate change was signed in December 2015. If the governments of these countries implement the committed regulatory changes, such as carbon pricing, these efforts could reduce future oil consumption.

Current pace of oil-related capital spending may be insufficient to meet future demand needs

As shown in **Chart 5**, oil-related capital expenditures tend to track oil prices closely. The decline in oil prices since 2014 has raised concerns that these capital expenditures are now so low that future oil supply may be insufficient to meet demand and, thus, could lead to a significant spike in oil prices. Given the rate of decline in traditional oil fields and continued demand increases driven by economic development in EMEs, the IEA has estimated that an additional 22 mb/d of non-US shale oil production could be needed by 2025 (IEA 2016). This is a staggering amount—it would require newly sanctioned oil projects to return to levels last seen in the 1970s and would likely require a sharp rise in oil prices for production to meet demand.

Conclusion

In this article, we argue that both supply and demand factors played a role in the large oil price decline of 2014. A long-delayed output response from a time of higher oil prices, the surprising growth of US shale oil production and the OPEC decision to maintain output levels played key roles in the initial decline in oil prices. The weakness in oil prices has also been supported by slower-than-expected global growth as well as concerns over the Chinese economy in early 2016.

9 For example, the governments in France and the United Kingdom recently committed to banning the sale of petroleum and diesel engine vehicles after 2040, suggesting that future policy decisions could also play a key role in future EV penetration.

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