Evaluating a Year of Oil Price Volatility

By Troy Davig, Nida Çakır Melek, Jun Nie, A. Lee Smith, and Didem Tüzemen

Over the last 14 months, the average price of oil has fallen by about 60 percent. Oil prices fluctuate for a number of reasons. Rising global economic activity can increase demand and push prices higher, while rising production rates can cause prices to decline. Although simple supply and demand stories are useful in describing oil price movements, the factors driving such changes are often difficult to identify. As a result, large swings in oil prices can come as a surprise, as was the case with the recent decline starting in mid-2014.

The recent period of price volatility is not unique. Oil prices also fell by over 50 percent during the Great Recession of 2007-09. However, the price decline during the Great Recession was due primarily to a pronounced slowdown in global economic activity. Soft global demand during this period also caused prices for commodities other than oil to fall sharply. Prices for some of these commodities, such as copper, fell again in 2014, but nowhere near the extent of oil prices. These movements suggest that only a portion of the decline in 2014 is likely due to weaker global economic activity.

Increasing supply may be another explanation for the oil price decline that started in 2014. Total global oil production increased 3.7 percent year over year as of December 2014. This increase is on the higher side, though not remarkable by the standards of the past five years

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(*Oil & Gas Journal*). However, prices are affected not only by changes in the level of production, but by changes in production relative to what the market expected. Higher production levels in the United States due to new technologies were to some extent expected. But some developments on the supply side were unexpected, such as the comeback of Libyan production, the unwillingness of the Organization of the Petroleum Exporting Countries (OPEC) to reduce supply, and the probable future re-emergence of Iran on the global oil market, which likely caused shifts in expectations of future oil supply relative to demand.

Because oil is a storable commodity, changes in inventories can also drive oil price movements. In particular, changes driven by expectations of future supply relative to demand could change market participants' desire to hold inventory. In this context, "precautionary demand" can play an important role in oil price movements. Precautionary demand can be driven by sectors of the energy industry that have a direct use for crude oil, such as those involved in the refining business. These sectors then need to balance expectations of future oil prices with the availability and cost of storage. For example, news that future production will likely continue at a high level can cause precautionary demand for crude oil to fall. As a result, the price of oil may decline, but not due to a slowing of global economic activity or a sudden increase in the current supply. In this paper, we find shifts in precautionary demand specific to the oil sector played the primary role in driving oil prices lower from mid-2014 to mid-2015.

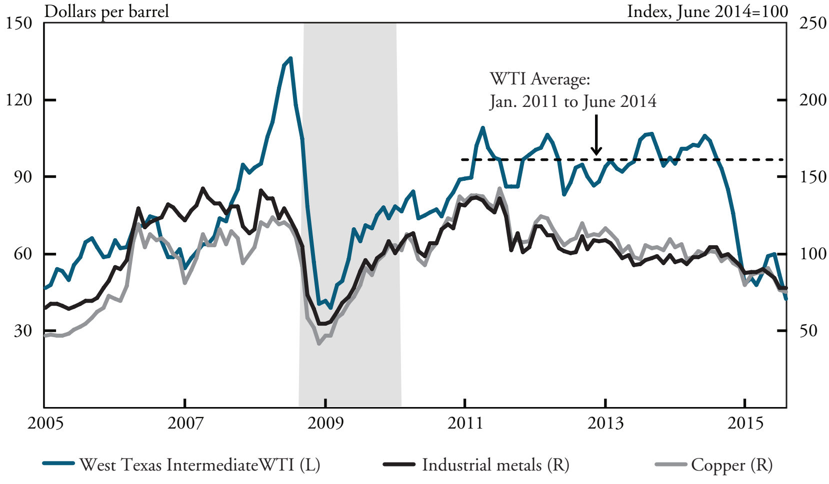
Section I of the article reviews possible sources of the oil price decline. Section II analyzes demand and supply factors using two different empirical approaches. Section III interprets the oil-specific demand factors and finds shifts in expectations of global economic growth and global oil supply have played major roles in the oil price decline since mid-2014.

I. The Global Developments Affecting Oil Prices

Crude oil prices fell sharply in the second half of 2014 after a period of relative stability, generating concerns about the source of the decline. Chart 1 shows oil prices reached a post-recession peak in 2011, remained relatively stable for a few years, and then declined about 50 percent in the second half of 2014.[1] In the first half of 2015, prices were

Chart 1

Prices of Oil and Metals



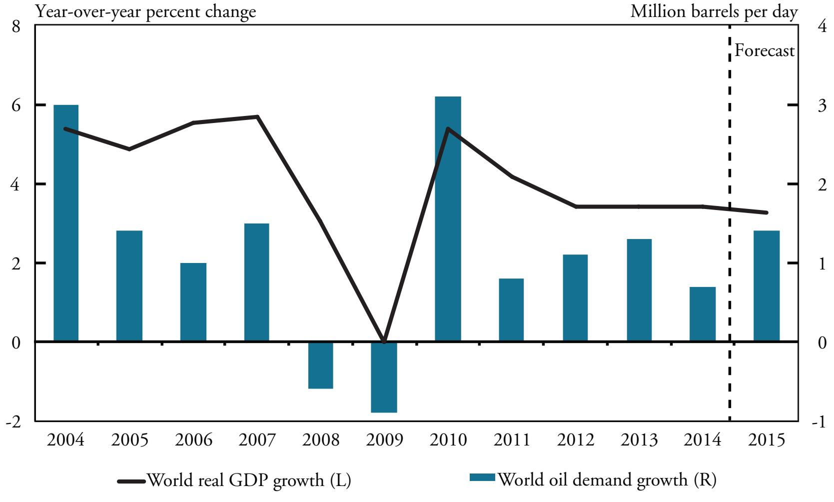
Note: Gray bar denotes NBER-defined recession.
Sources: Chicago Mercantile Exchange, Energy Information Administration, National Bureau of Economic Research, Standard & Poor's, *The Wall Street Journal*, and Haver Analytics.

again volatile, reaching a multiyear low in March before rising about 40 percent through mid-June. These gains reversed as prices fell back to multiyear lows by mid-August. Overall, from the peak in mid-2014 to August 2015, prices fell by about 60 percent. In general, the world experienced some important changes in both current supply and demand over this period, as well as changes in global oil markets that affected expectations about future conditions.

Global oil demand developments

Fluctuations in global growth and oil demand are one possible explanation for oil price volatility. However, if worldwide aggregate demand were the primary factor, other commodity prices would have likely displayed similar patterns. For example, Chart 1 shows copper prices and an index of industrial metal prices reached a post-recession peak in 2011 and have trended lower over the past few years. In general, commodity prices shared some of the same recent patterns as oil, but exhibited far less dramatic movements. In addition, Chart 2 shows world real GDP growth slowed in 2012 from its 2010 rate. Slowing global growth may have exerted downward pressure on commodity

Chart 2
Global GDP and Oil Demand Growth



Sources: International Energy Agency, International Monetary Fund, and Haver Analytics.

prices after 2011. But the slowdown in growth was relatively modest, and from 2011 until 2014, global oil demand actually increased. As a result, oil prices remained relatively stable until mid-2014. Since mid-2014, industrial metal prices also fell faster than their previous trend, but by far less than oil. These observations suggest that while changes in global growth may have played some factor in the oil price movements since mid-2014, they are unlikely to be the primary factor.

Global oil demand may have played more of a role in affecting oil prices in the first half of 2015. Oil price increases from March through June coincided with an improving outlook, partly from stabilizing conditions in Europe. However, global growth expectations again softened in July and August of 2015, likely reflecting concerns about growth in China, one of the largest consumers of oil. Still, the shifts in growth in various regions of the world were relatively modest and, on their own, offer a somewhat incomplete explanation for the observed volatility in oil prices.

Another possible explanation for oil price volatility is the growing foreign exchange value of the U.S. dollar. Akram presents evidence that a stronger dollar has historically been associated with declining oil prices. The rise in the dollar's value against other major currencies was substantial in the second half of 2014 and was a possible factor contributing to the declining price of oil. Oil is priced in U.S. dollars, so the decline of other currencies relative to the dollar makes oil more expensive for non-U.S. consumers. As a result, non-U.S. consumers may reduce demand for oil and thereby cause prices to soften. Through this channel, however, a stronger U.S. dollar by itself may not be the factor driving a change in oil prices. Instead, it may simply reflect changing global economic conditions.[2] In general, disentangling an independent effect of the U.S. dollar on oil prices is challenging. Furthermore, the correlation between the U.S. dollar and oil prices has changed over time.[3]

Global oil supply developments

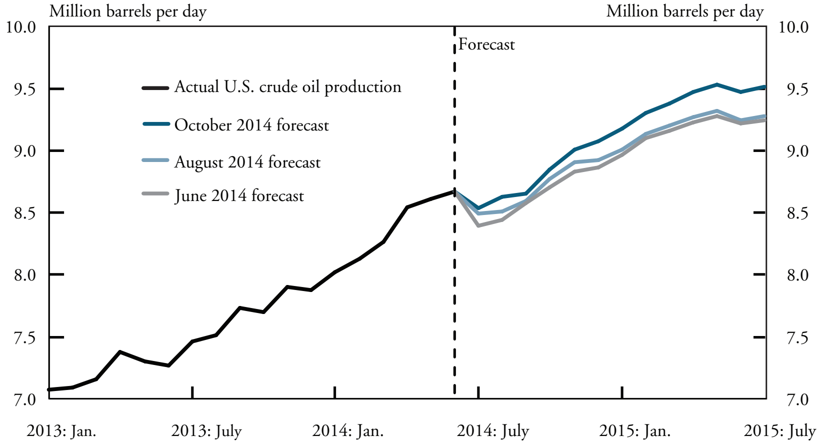
Changing global oil supply conditions offer another possible explanation for the substantial swings in oil prices since mid-2014. U.S. production increased remarkably from 2011 to 2013 and continued to rise unexpectedly throughout 2014, contributing significantly to global oil production gains. For example, Chart 3 shows the Energy Information Administration (EIA) repeatedly revised up its projections for U.S. production throughout 2014. More broadly, Chart 4 shows the cumulative increase in U.S. production since January 2010 left U.S. output four million barrels per day higher in January 2015 compared with five years earlier.

The rest of the world also experienced some significant, unexpected supply-side developments after mid-2014. Chart 4 shows unplanned OPEC production outages kept increasing until about mid-2014, largely due to unrest in Libya, Iran, Iraq, and Nigeria, and mostly offset increasing U.S. production. In the second half of 2014, however, Middle East supply disruptions were less prevalent or did not affect production as would have been expected. For example, production in Libya and Iraq increased despite unrest in both countries. Chart 5 shows the contribution from Libya was particularly significant in the third quarter of 2014, as production increased from around 0.2 million barrels per day in June to about 0.9 million barrels per day in October. Although Libyan production decreased at the end of 2014, an increase in Iraq production helped offset the decline.

Two announcements regarding expectations of future oil supply also affected energy markets significantly. In late November, OPEC

Chart 3

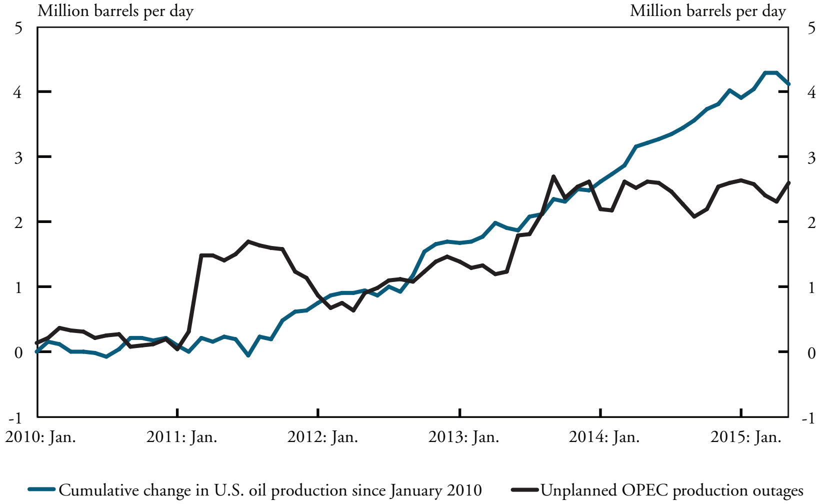
U.S. Crude Oil Production



Source: Energy Information Administration.

Chart 4

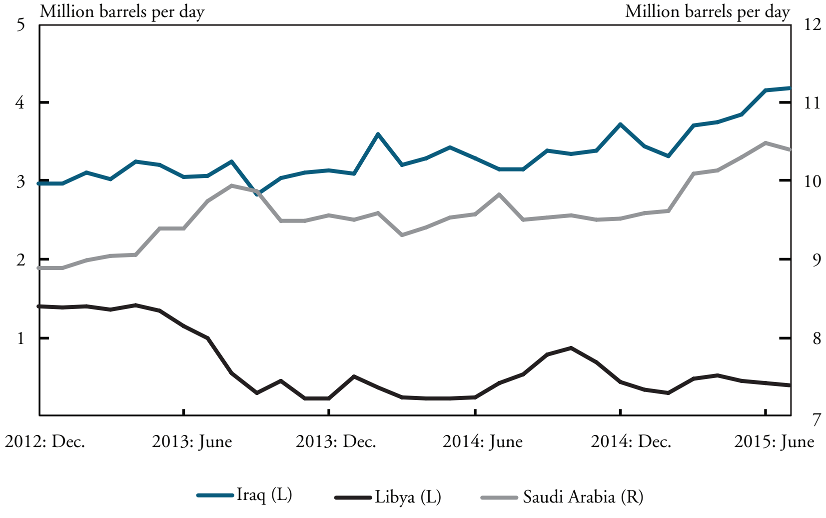
OPEC Oil Production Outages and U.S. Oil Production



Source: Energy Information Administration.

Chart 5

Oil Production by OPEC Country



Source: International Energy Agency.

announced a decision to maintain production at a level of about 30 million barrels per day, signaling something of a change in its objectives. Saudi Arabia, traditionally viewed as the swing producer, chose not to cut production and instead continued adding to already oversupplied markets. The second announcement was a nuclear deal with Iran that would lift oil-related economic sanctions, which coincided with oil prices somewhat stabilizing by the middle of 2015. The announcement of a nuclear deal suggested that another major oil producer may soon come online, and added to the prospect of oil being oversupplied in what was already a low-price environment. In all, developments on the supply side of global oil markets appear to offer a potentially better explanation for recent price volatility than fluctuations in global growth.

Of course, supply also responds to changes in oil prices. For example, drilling activity in the United States declined sharply in response to lower oil prices toward the end of 2014. The total number of rig counts dropped by about 60 percent from October 2014 to June 2015, though U.S. oil production has been affected only recently. For some time following the drop in rigs, U.S. production kept rising due to efficiency gains. In addition, Chart 5 shows OPEC producers, particularly Saudi Arabia, again increased production in the first part of 2015, bringing yet more oil to already oversupplied markets.

Overall, softening oil demand and rising oil production were likely important factors behind the decline in oil prices since mid-2014. However, whether they can fully account for the decline is not readily apparent. The next sections turn to frameworks that can better attribute these different factors to their effect on oil prices as well as incorporate the effect expectations about future conditions have on prices.

II. Quantifying Demand and Supply Factors Affecting Oil Prices

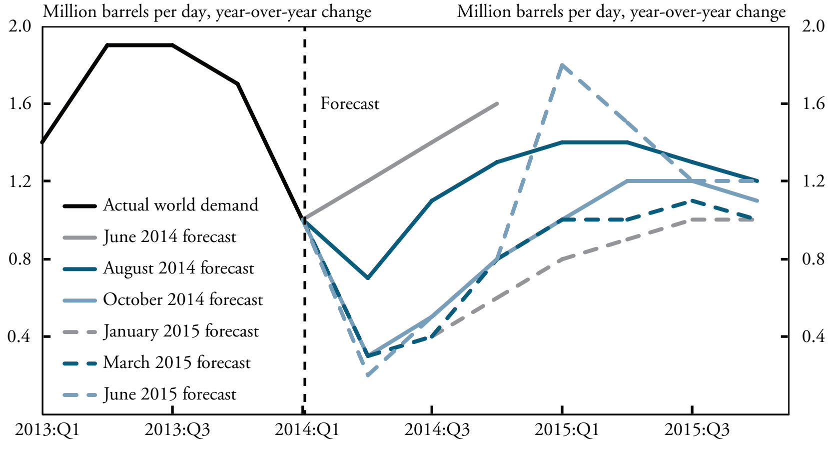
Quantifying the effects of demand and supply shifts in global oil markets on prices requires a model that can properly separate the effect of each factor. Identifying these effects is not always straightforward, so we use two approaches to better interpret changes in oil prices. Our first approach is based on a model from Hamilton (2015, 2014) that focuses primarily on global demand factors and their effect on prices. Our second approach is based on a model from Kilian (2009) that incorporates a measure of global demand while accounting for shifts in oil production and demand that stem from changes in expectations about future conditions in the oil market.

Hamilton's approach to evaluating the effects of global demand on oil prices

In general, global demand for energy is closely related to global economic activity. For example, the International Monetary Fund (IMF) downgraded its global economic outlook in 2014, partly reflecting slower economic growth in some major oil importing countries such as China and Japan.[4] Following the downgrade to global economic growth projections, the International Energy Agency (IEA) also marked down its estimate of global oil demand growth. Chart 6 shows that in June 2014, the IEA forecast an increase in oil demand of 1.6 million barrels per day by the end of the year. By October, the IEA revised its forecast for demand down to a rate of 0.8 million barrels per day. The downgrades could have reflected expectations of slowing global oil demand due to weaker-than-expected economic growth, particularly in some major oil-importing countries.

A natural question, then, is how much of the decline in oil prices can be explained by lower-than-expected global economic growth.

Chart 6
Forecasts of World Oil Demand



Source: International Energy Agency.

Hamilton (2015, 2014) details a relatively straightforward approach to answering this question in a series of blog posts. He identifies three factors related to global economic conditions: copper prices, the foreign exchange value of the U.S. dollar, and the yield on 10-year U.S. Treasury securities. A slowdown in global growth would weaken demand for all commodities, not just oil. For this reason, Hamilton uses the first factor, the price of copper, as an indicator of global demand.[5]

The second factor Hamilton considers is the yield on 10-year U.S. Treasury securities. A decline in yield can reflect either a fall in the expected path of shorter-term interest rates or a fall in the term premium, the additional compensation investors require to bear the risk of future short-term rates differing from their expected path. If the expected path of rates declines, the decline likely reflects a less optimistic outlook for U.S. economic growth. A low term premium may reflect large demand for safe assets, such as U.S. Treasury securities, possibly because of concerns about global growth prospects. From June 2014 to year-end, the yield on 10-year U.S. Treasury securities fell at a relatively steady pace by a total of 50 basis points due to both a lower term premium and a lower expected path of short-term rates.[6]

The third factor Hamilton considers, a rise in the foreign exchange value of the U.S. dollar, could also indicate weakness in the global economy. The U.S. dollar has been appreciating since late 2011, but the pace of appreciation accelerated in 2014, pushing its value against major currencies up by 13.9 percent from June 2014 to January 2015.[7]

Hamilton notes that these three potential indicators of global economic activity can help explain the decline in oil prices. To quantify the success of Hamilton's global demand indicators in explaining the recent drop in oil prices, we perform a regression analysis linking oil price to these three factors. We measure the price of oil as the monthly average, in dollars per barrel, of the spot price of West Texas Intermediate (WTI) crude oil, and we measure the price of copper using the end-of-month Comex cash spot price for high-grade copper, denominated in dollars per pound. We define the foreign exchange value of the dollar as the monthly average of the trade-weighted dollar index from the Board of Governors and the 10-year Treasury yield as the monthly average of the annual yield of a constant maturity 10-year Treasury note.[8]

The results from the regression model, shown in Table 1, confirm that Hamilton's three indicators are significantly correlated with global oil demand. First, higher copper prices are associated with higher oil prices. Specifically, when copper prices increase by 1 percent, oil prices tend to increase about 0.3 percent (Table 1, Row 2). This confirms Hamilton's expectation that higher demand for all commodities, reflected in higher copper prices, also raises oil prices. Second, higher U.S. government bond yield also correlates positively with higher oil prices. For example, the estimated coefficient suggests that a 10 basis point increase in 10-year Treasury yields is associated with a 1.6 percent increase in oil prices. Finally, a stronger U.S. dollar tends to generate significant downward pressure on oil prices. Oil prices are likely to fall by 2.3 percent when the dollar appreciates by 1 percent.

In addition to validating Hamilton's measures of global demand, we can also use the estimated model to investigate how much these demand factors contributed to the fall in the price of oil after July 2014. Chart 7 shows that the price of oil would have fallen from a monthly average of over $105 per barrel in June 2014 to $68 per barrel by January 2015 due to changes in the three indicators of global demand. But the price of oil actually fell to $48 per barrel over the same period, implying other factors were also at play. Hamilton's approach is a useful benchmark for understanding how aggregate demand factors

Table 1

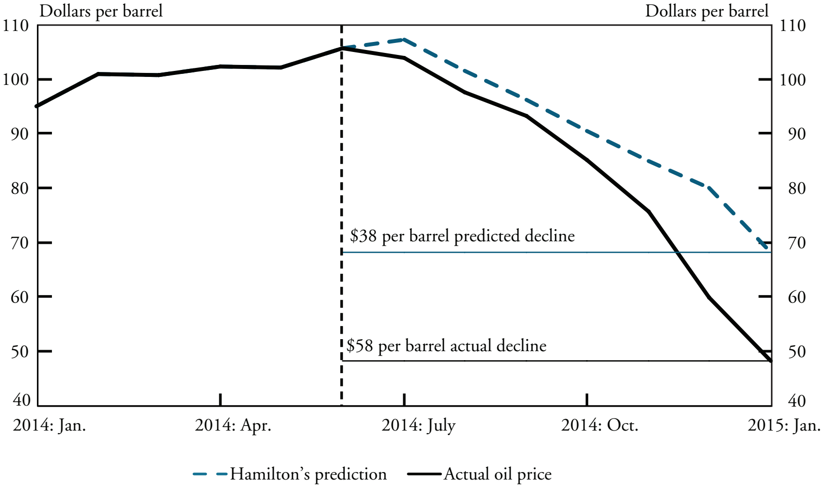
Regression Results

Dependent variable: log change in oil prices	Hamilton's specification
Log change in copper prices	0.29*** (0.09)
Change in 10-year Treasury yield	16.13*** (2.94)
Log change of dollar index	-2.32*** (0.40)
Constant	0.01 (0.01)
R^2	0.5993
Observations	93
Time period	April 2007-Jan. 2015

Standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.
Sources: Bureau of Labor Statistics, Chicago Mercantile Exchange, Energy Information Administration, Federal Reserve Board, FRED, OPEC, Thomson Reuters, *The Wall Street Journal*, Haver Analytics, and authors' calculations.

Chart 7

Accounting for the Oil Price Decline: Hamilton's Model



Sources: Bureau of Labor Statistics, Chicago Mercantile Exchange, Energy Information Administration, Federal Reserve Board, FRED, OPEC, Thomson Reuters, *The Wall Street Journal*, Haver Analytics and authors' calculations.

influenced the price of oil in the second half of 2014. However, it does not incorporate supply factors or demand factors that might be specific to oil markets. To better understand the 2014 oil price decline and price swings in 2015, we employ a model of the global oil market incorporating these other channels in the next section.

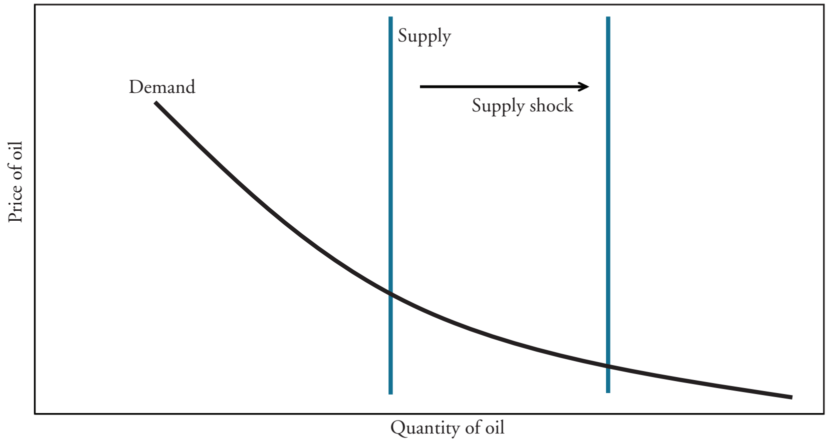
Kilian's approach to quantifying oil price movements

Decomposing price changes for any good or service due to shifts in supply and demand poses a number of statistical challenges. For the oil market, one approach to disentangling the factors driving oil price movements is to use a framework similar to Kilian (2009). Kilian proposes a structural vector autoregression (VAR) model to identify underlying demand and supply shocks in the global oil market.[9] More specifically, he identifies three shocks as key determinants of oil price movements: global demand shocks, oil supply shocks, and precautionary demand shocks.

In this framework, the Baltic Dry Index (BDI) is used as a single measure of global economic activity rather than the multiple measures used in Hamilton's analysis. The BDI is constructed daily by surveying shipping ports and obtaining prices paid by customers to ship dry bulk commodities along various routes throughout the world. When global activity increases and demand for shipping services of bulk commodities rises, the costs of transporting goods increase and push the BDI higher. In this context, the BDI serves as a proxy for global demand. Consequently, the BDI is assumed to measure the component of global economic activity that drives demand for commodities, including oil. The supply of large ships should be relatively constant within a given month—the time period for data in the VAR. In other words, movements in the BDI within a month are viewed as primarily reflecting changes in global economic activity rather than changes in the available shipping vessels.[10]

The VAR includes the log of the BDI, the percentage change in global oil production from the prior month, and the log of the WTI spot price of oil.[11] BDI and oil prices enter the VAR as monthly averages deflated by the consumer price index. The sample is at a monthly frequency and runs from January 1985 to March 2015.[12] The VAR has three lags as suggested by lag-length tests using the Akaike Information Criterion.

Figure 1
Supply Shock Identification in the VAR Model



Following Kilian, we decompose movements in oil prices into oil supply shocks, global demand shocks, and oil-specific or precautionary demand shocks. We distinguish these two sources of demand shocks from supply shocks by specifying that demand shocks immediately affect the price of oil, but not the quantity of oil produced. This approach is analogous to assuming the short-run oil supply curve is vertical, and that oil producers cannot change production plans within the month. In contrast, a supply shock affects global oil production and oil prices simultaneously. Figure 1 illustrates an oil supply shock in this framework. An unexpected increase in oil production is viewed as a supply shock and shifts out the supply curve, causing prices to fall. Figure 2 shows how an unexpected increase in global demand causes both the BDI and price of oil to rise. Finally, Figure 3 shows that even if global demand remains unchanged, the demand curve for oil can shift for reasons particular to energy markets, such as concerns about the availability of future oil supply relative to demand.

We include the BDI in the model to determine whether the demand curve for oil shifts because of a global demand shock or an oil-specific demand shock. When demand for all bulk commodities shifts, as captured by a change in the BDI, the demand for oil also shifts, which would be the case if there were a change in global economic activity. In contrast, oil-specific demand shocks only influence oil prices without affecting the demand for all bulk commodities.[13]

Figure 2

Aggregate Demand Shock Identification in the VAR Model

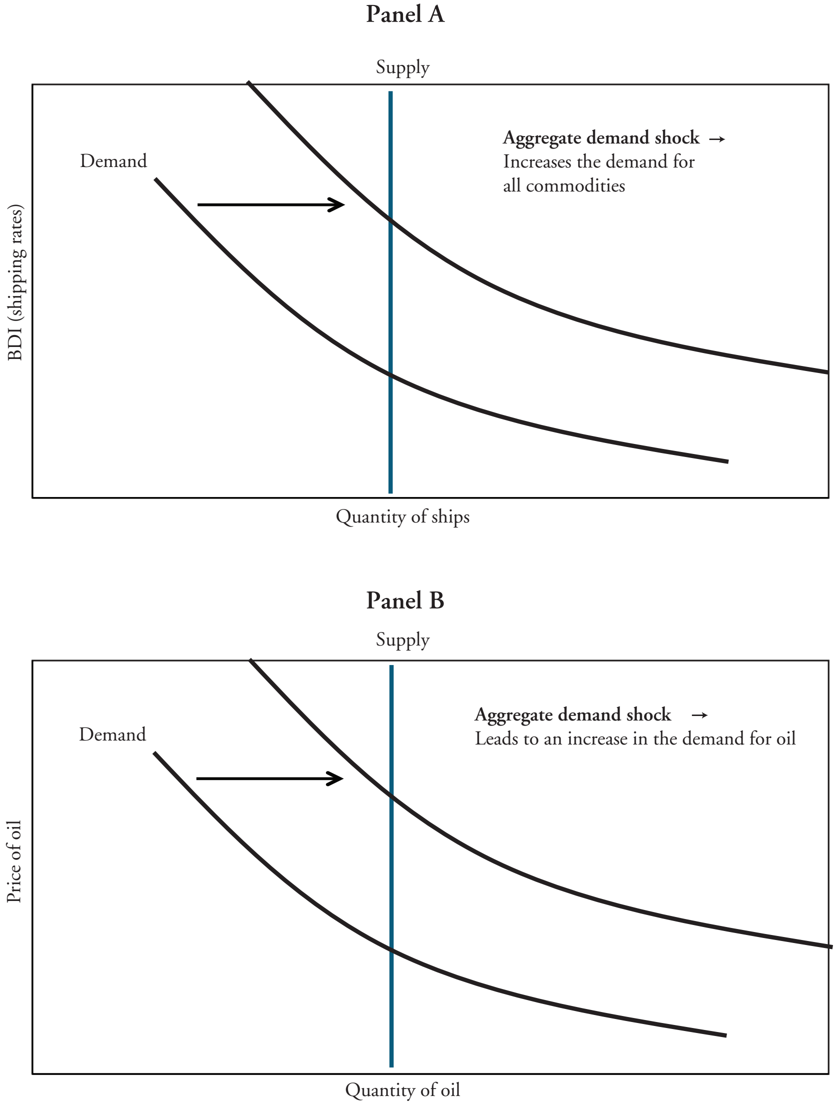
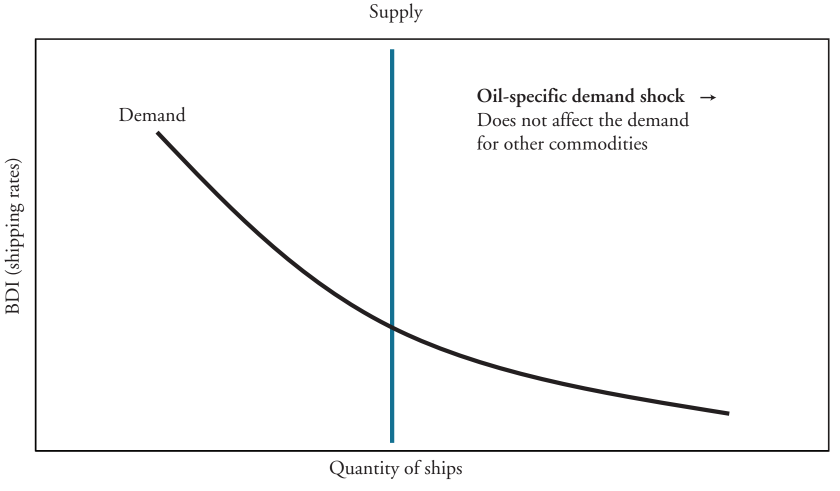


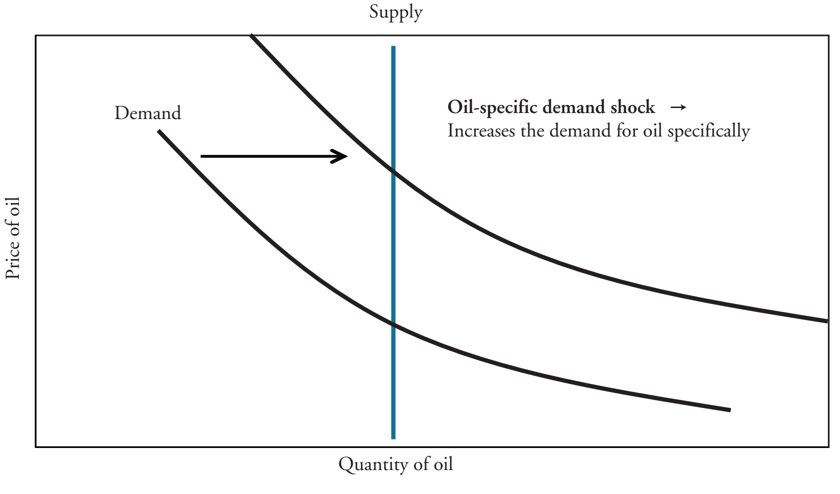
Figure 3

Oil-Specific Demand Shock Identification in the VAR Model

Panel A



Panel B



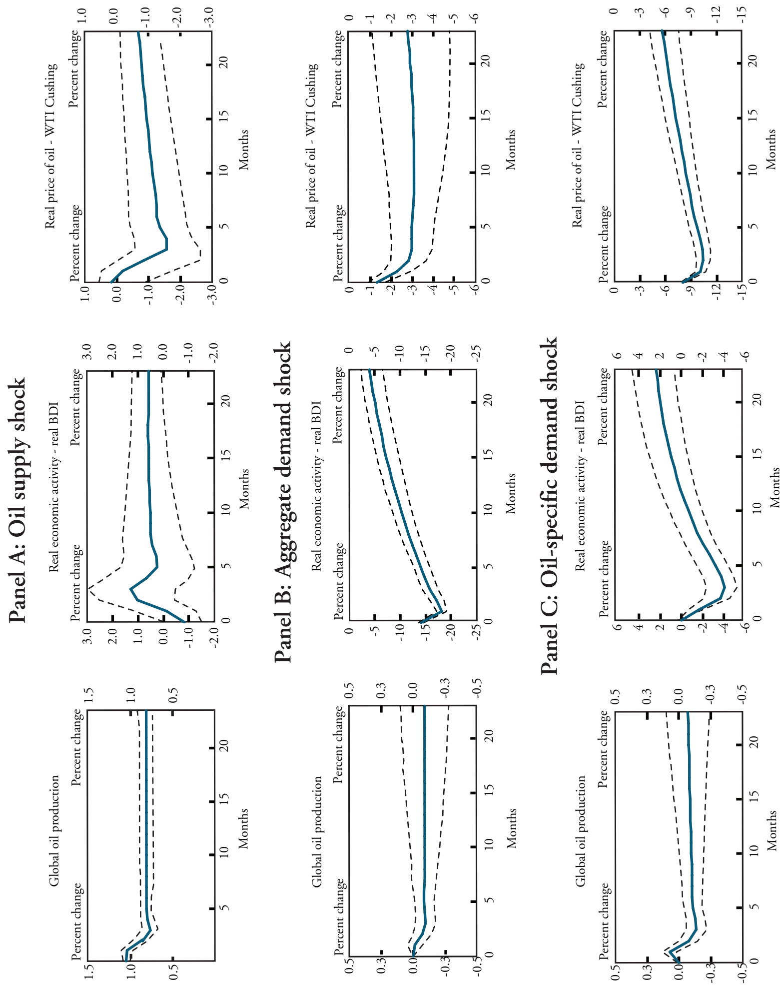
We first use the VAR model to estimate the responses of global oil production, global economic activity, and the price of oil to different types of shocks (Chart 8). Panel A shows a positive supply shock causes a sustained decline in real oil prices. The permanent response of global oil production to a positive supply shock implies that these shocks primarily drive oil production in the long run. However, demand shocks can, in principle, shape production in the short run. Panel B of Chart 8 shows a contraction in aggregate demand causes a sustained decline in the real spot price of WTI, causing producers to temporarily slow oil production. Finally, Panel C shows a shock to oil-specific demand causes both oil production and prices to fall. A surprise fall in oil-specific demand, which can be thought of as a decline in precautionary demand, causes real oil prices to decline sharply and persistently.

A historical decomposition can show the contribution of each shock to oil price movements. Intuitively, these decompositions are designed to show how oil prices would evolve if they were driven by only one shock. All of these counterfactual scenarios predict prices would fall from their June 2014 peak, but their magnitudes differ greatly from one another, suggesting no common, predictable component in the VAR drives oil prices over the medium term.[14] Thus, the resulting counterfactual scenario for oil prices allows us to evaluate the differing roles oil supply, global economic activity, and oil-specific demand shocks have played in shaping oil prices.

In this context, Chart 9 shows the historical spot price of WTI along with counterfactual time series for the spot price of WTI when conditioning on only one type of shock. As a reminder, oil prices fell from an average of $105 in June 2014 to an average of $60 in June 2015. Somewhat surprisingly, oil-supply shocks and aggregate demand shocks have made comparatively small contributions to the price decline. By far the biggest contribution has come from the oil-specific demand shock, (light-blue line) which likely reflects changes in expectations and uncertainty about future oil supply and demand.[15] More specifically, conditioning on only unexpected changes in current oil production (black line) shows WTI prices would have been $74 a barrel in June of 2015. Similarly, conditioning on only changes in aggregate demand (gray line) shows oil prices would have fallen to $70 a barrel in June. In contrast, conditioning on oil-specific demand shocks predicts a steeper price drop. If only oil-specific demand shocks had occurred over

Chart 8

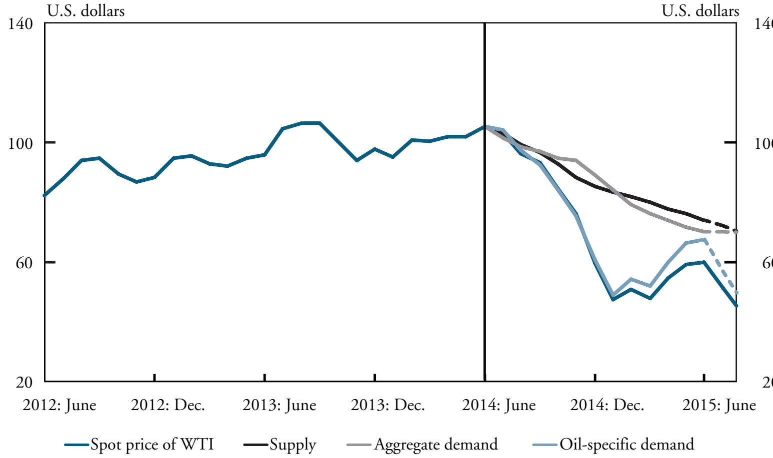
Impulse Responses to Supply and Demand Shocks



Note: The VAR model is estimated using the change in global oil production, but the impulse responses plotted above show the cumulative change in oil production (or the percent change in the level of global oil production).
Sources: Chicago Mercantile Exchange, Energy Information Administration, Thomson Reuters, *The Wall Street Journal*, Haver Analytics, and authors' calculations.

Chart 9

Historical Decomposition of the Price of Oil from the VAR Model (starting June 2014)



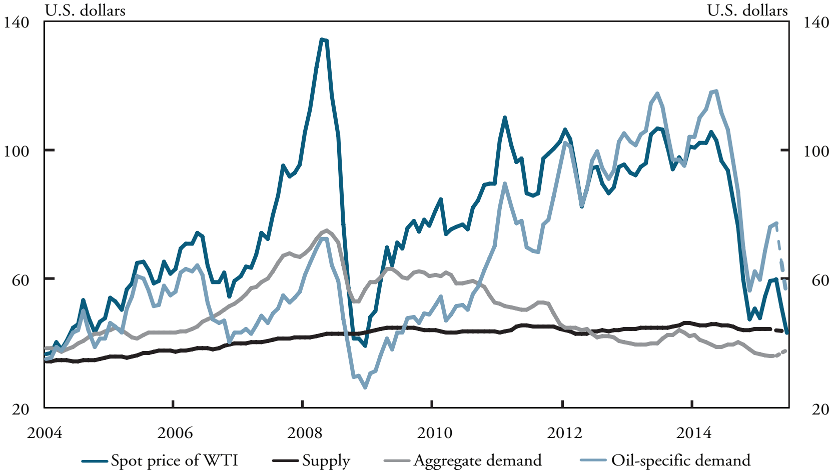
Note: Dashed lines show preliminary data for July and August 2015.
Sources: Chicago Mercantile Exchange, Energy Information Administration, Federal Reserve Board, FRED, Thomson Reuters, *The Wall Street Journal*, Haver Analytics and authors' calculations.

this time, oil prices would have averaged $67 in June 2015. From June 2014 to December 2014, oil-specific demand shocks explain essentially the entire decline in prices.

From December 2014 until June 2015, past oil-specific demand shocks were unwinding and global supply and demand factors were largely offsetting one another, resulting in a modest rise in oil prices from their March low. However, a fresh round of oil price declines started in July 2015 and has continued into August, raising questions of what is behind this latest drop. Oil prices declined 30 percent from their June 2015 average of $60 per barrel to an August 2015 average of about $43 per barrel. To disentangle the factors behind this most recent decline in oil prices, we use preliminary oil production data for July 2015 from the IEA's monthly *Oil Market Report* and assume as a baseline scenario that August 2015 production will grow at the same rate production has over the last year.[16] The dotted lines in Chart 9 show the resulting historical decompositions. Our preliminary estimates suggest the oil-price decline since June 2015 is largely due to oil-specific demand, similar to the decline in the second half of 2014.

Chart 10

Historical Decomposition of the Price of Oil from the VAR Model (starting May 1985)



Note: Dashed lines show preliminary data for July and August 2015.
Sources: Chicago Mercantile Exchange, Energy Information Administration, Federal Reserve Board, FRED, Thomson Reuters, *The Wall Street Journal*, Haver Analytics and authors' calculations.

As results from historical decompositions can be somewhat sensitive to the start date, we perform the same exercise as above but begin the decomposition in 1985. This provides not only a robustness check, but insight into how the most recent oil price declines differ from the decline that accompanied the 2008-09 financial crisis. Chart 10 shows that oil supply shocks have consistently made rather modest contributions, while oil-specific demand shocks have made larger contributions to the two recent periods of declining oil prices. Moreover, the recent episodes of oil price declines are noticeably different from the decline that coincided with the global financial crisis. Oil prices increased from 2009 through mid-2014, then fell, due in large part to factors specific to the oil market.[17] In contrast, in 2008-09, there was a broader rise and fall in aggregate demand for all commodities, suggesting oil prices were reflecting the global business cycle. Numerous other studies have similarly concluded that the increase in oil prices from 2003-08 and subsequent fall was due to global economic conditions not unique to the oil industry.[18] These results collectively suggest the recent swings in oil prices are much different from those during the 2003-09 period.

III. Factors Driving Oil-Specific Demand Shocks

Oil-specific demand shocks appear to have been the main drivers of oil price fluctuations in the past few years. To understand the decline in oil prices since 2014 at a deeper level, then, we must understand the factors changing oil-specific demand. Kilian (2009) provides one interpretation, explaining oil-specific demand may represent changes in the precautionary demand for oil associated with shifts in market expectations about the availability of future oil supply relative to future demand. In the VAR model, oil-specific demand shocks are designed to capture any factors affecting oil prices after controlling for oil supply and global demand shocks.

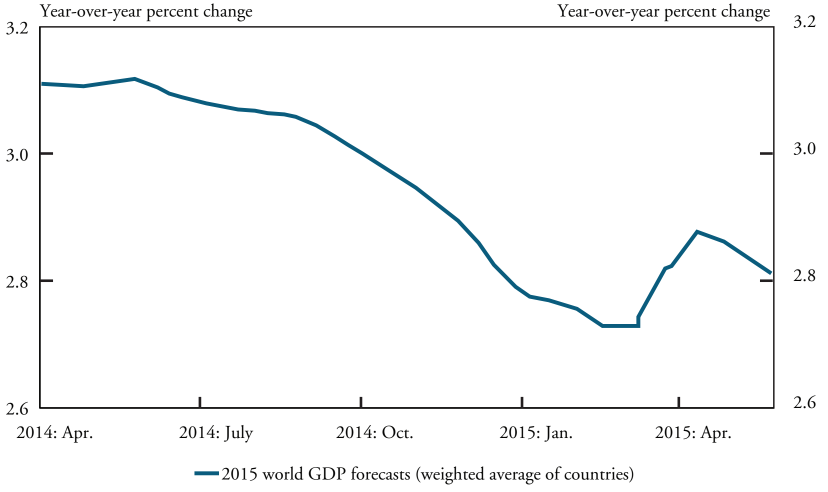
As an example of a precautionary demand shock, consider a scenario in which current production and global economic activity are unchanged, yet news arrives causing expectations of future global growth to decline. In this case, the demand for holding oil inventories is likely to decline and consequently cause oil prices to fall, since production and the quantity of oil flowing into inventories is likely to be slower to adjust to swings in expectations than prices.[19]

As another example, consider changes in expectations about the amount and stability of future supply. If those who have a flow-based need for crude oil expect high levels of production in the future, perhaps due to oil discoveries or more stable sources of supply, then future shortages and oil price spikes become less of a concern and the demand for oil inventories declines.

But why might precautionary demand have fallen since 2014? Technological advancements have clearly boosted U.S. production. For example, Çakır Melek forecasts that the sharp drop in U.S. rig counts will lead to only a modest decline in U.S. production. The stability of U.S. production in the face of falling oil prices has led market participants to believe that high U.S. oil production is likely to persist due to these technological improvements. Some international developments in the second half of 2014, however, were also quite surprising. The unexpected recovery of production in Libya, at least for a time, and increased Iraqi production supported expectations that global oil production had more capacity.[20] OPEC's announcement in November also surprised markets, though prices had already declined significantly by the time of the announcement. However, the announcement in July 2015

Chart 11

2015 Growth Forecasts



Source: Bloomberg.

regarding Iran's reemergence on the global oil market came at a time when oil prices were rallying, quickly ending any prospect of a rebound in crude prices.

In terms of expected demand, forecasters downgraded their global growth forecasts amidst developments in Europe related to the fiscal issues in Greece and slowing trend growth in China. Chart 11 shows the implied world GDP growth forecast for 2015, based on a weighted average of individual country forecasts by private sector analysts, declined markedly in the second half of 2014. Downward revisions to future oil demand from the IEA from July to November followed a similar pattern. Combined, expectations of higher or more stable future oil supply and weakening future demand would substantially lower precautionary demand for oil and thus appear to be the driving factors behind the substantial price decline in the second half of 2014.

The focus on oil-specific factors is not unique to this analysis. For example, Badel and McGillicuddy also highlight the role of oil-specific demand shocks. Baumeister and Kilian use a VAR model with 24 lags (compared with three in this article's VAR) and incorporate a specific role for inventories into their model. They find about half of the price decline in the second half of 2014 was predictable as of June 2014. The predictability of the price decline is based on the culmination of various supply and demand shocks occurring in the period before mid-2014 that unwound in a manner that subsequently pulled oil prices lower. In this article's VAR, these shocks would have immediately manifested in lower prices in the first part of 2014 in the absence of other shocks supporting prices. However, Baumeister and Kilian do find some of the decline was due to a negative oil-specific demand shock in July 2014.

In the end, Baumeister and Kilian suggest conditions in place prior to mid-2014 substantially pulled down prices. In this article's VAR, a decline in precautionary demand—likely due to expectations of slowing global growth as well as supply-side developments reflecting expectations of greater availability and stability of oil production—is the primary factor contributing to the oil price decline since mid-2014.

IV. Conclusion

After a period of relative stability, crude oil prices fell sharply starting in mid-2014. The implications of this decline for the global economy depend on the factors driving it. Fundamentals reflecting current supply and demand can play a significant role in oil price movements, but expectations about future fundamentals can be just as influential. We find oil-specific demand shocks largely drove the oil price movements since mid-2014, reflecting shifts in expectations about future supply relative to future demand. In particular, the driving factors behind the decline appear to be expectations that the future supply of oil will remain higher, or at least more stable, and concerns about weakening future demand due to slowing global growth forecasts.

Endnotes

[1]The average for January 2011-June 2014 is $96.54. During this period, WTI prices fluctuated from $83 to $109 per barrel.

[2]Basher, Haug, and Sadorsky show using variance decompositions that exogenous movements in exchange rates alone have a very small effect on oil prices. But movements in global economic activity and emerging market stock prices have a moderate effect on both oil prices and exchange rates.

[3]Fratzscher, Schneider, and Van Robays document that the negative correlation between the foreign exchange value of the dollar and oil prices largely emerged after the early 2000s.

[4]Japan's real GDP growth slowed to 0.1 percent in 2014 from 1.6 percent in 2013. China's growth was also weaker in 2014 relative to 2013, although the slowdown in China's growth was more modest than Japan's. China's growth decreased 0.4 percentage point from 7.8 percent in 2013 to 7.4 percent in 2014.

[5]From June 2014 to January 2015, the price of copper fell by 20.1 percent, much less than the decline in oil prices (Chart 1).

[6]See, for example, the decomposition of 10-year Treasury yields into expected rates and the term premium from Kim and Wright.

[7]Based on nominal trade-weighted exchange value of U.S. dollars versus major currencies.

[8]More specifically, we regress the monthly log changes in the dollar price of copper and the nominal trade-weighted value of the dollar against major currencies, along with the monthly change in the 10-year Treasury yield, on the monthly change in the log of the price of oil (WTI). All data used in the analysis are obtained using Thomson Reuters and Haver Analytics.

[9]This VAR approach to decomposing oil prices differs from previous approaches that treated oil price changes as exogenous, such as Hamilton (1996).

[10]A measure that more directly captures global GDP might seem more appropriate. However, such measures are not necessarily straightforward to construct and, more importantly, will be based on a quarterly frequency. Within a quarter, the productive capacity of the global economy and oil sector will certainly change, so this broader measure injects measurement issues into the analysis. In contrast, the BDI is available on a monthly frequency and is less prone to the effects of capacity changes within a given month.

[11]To account for aggregate price inflation, the BDI and the WTI spot price are deflated by the Consumer Price Index.

[12]Elder and Serletis show the dynamics of oil prices changed after 1985; therefore, starting the estimation sample earlier may call into question the use of a linear model.

[13]These exclusion restrictions are made only in the period in which each respective shock occurs. For example, it is possible that an aggregate demand shock

leads to more oil production as suppliers respond to higher prices. Similarly, it is reasonable to expect that an increase in the oil-specific demand for oil may increase the BDI through higher fuel prices and also elicit a supply response. These changes in the BDI and oil production rates are restricted to take place in subsequent months, not the month of the shock. Other orderings are easy to implement; however, the timing structure we describe seems most reasonable, since it allows for the price of oil to immediately respond to any changes in supply, aggregate demand, and oil-specific demand.

[14]This sort of in-sample forecasting consequently differs from the out-of-sample forecasting success of similar models found by Baumeister and Kilian (2012).

[15]Kilian (2009) shows that a combination of aggregate demand shocks and oil-specific demand shocks have been the main drivers of oil price shocks from 1975 to 2007.

[16]One complication is the lag in the publication of global oil production data from the Department of Energy (DOE). Since this period is especially of interest, we use the preliminary estimates of global petroleum production provided by the IEA's monthly *Oil Market Report*. Comparing these estimates with actual crude oil production data provided by the DOE, we find the IEA's advanced estimates can explain 95 percent of the variation in the DOE's final estimates using a simple linear regression.

[17]Ratti and Vespignani show that a portion of the increase in prices after 2009 was due to increases in global liquidity. This is consistent with our view that distinguishing oil-specific demand from global monetary policy is unnecessary, since easier monetary policy would likely increase expectations of future demand but only affect global economic activity with a lag.

[18]Hamilton (2009); Kilian and Murphy; Kilian and Hicks; Fattouh, Kilian and Mahadeva; Kilian and Vigfusson; and Kesicki all find evidence that the oil price swings from 2003 to 2009 were demand driven.

[19]Dvir and Rogoff provide evidence of a similar precautionary demand channel. They show that inventory storage tends to amplify oil price swings during persistent changes in economic growth.

[20]See Arezki and Blanchard.

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