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Working Paper

Understanding the decline in the price of oil since June 2014

CFS Working Paper Series, No. 501

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Suggested Citation: Baumeister, Christiane; Kilian, Lutz (2015) : Understanding the decline in the price of oil since June 2014, CFS Working Paper Series, No. 501, Goethe University Frankfurt, Center for Financial Studies (CFS), Frankfurt a. M., https://nbn-resolving.de/urn:nbn:de:hebis:30:3-368487

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CENTER FOR FINANCIAL STUDIES

CFS Working Paper Series

No. 501

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Understanding the Decline in the Price of Oil since June 2014

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Understanding the Decline in the Price of Oil since June 2014

January 24, 2015

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Some observers have conjectured that oil supply shocks in the United States and in other countries are behind the plunge in the price of oil since June 2014. Others have suggested that a major shock to oil price expectations occurred when in late November 2014 OPEC announced that it would maintain current production levels despite the steady increase in non-OPEC oil production. Both conjectures are perfectly reasonable ex ante, yet we provide quantitative evidence that neither explanation appears supported by the data. We show that more than half of the decline in the price of oil was predictable in real time as of June 2014 and therefore must have reflected the cumulative effects of earlier oil demand and supply shocks. Among the shocks that occurred after June 2014, the most influential shock resembles a negative shock to the demand for oil associated with a weakening economy in December 2014. In contrast, there is no evidence of any large positive oil supply shocks between June and December. We conclude that the difference in the evolution of the price of oil, which declined by 44% over this period, compared with other commodity prices, which on average only declined by about 5%-15%, reflects oil-market specific developments that took place prior to June 2014.

JEL Code: Q43, C53
Key Words: Oil price declines, OPEC, oil supply, oil demand, shale oil.

Acknowledgements: The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Bank of Canada. We thank Christopher Hau for excellent research assistance. We thank Lucas Davis and Ryan Kellogg for helpful discussions.

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1. Introduction

Between June 2014 and December 2014, the monthly average price of crude oil fell by nearly 44% (see Figure 1). This price decline has put severe economic stress on oil producers around the world and has even called into question the sustainability of alternative forms of energy production. For example, in Germany gasoline blends with high ethanol content, which traditionally sold at a discount, given their lower performance, now have become more expensive than conventional gasoline. The decline in oil prices has also undermined the fiscal stability of countries such as Iran, Russia and Venezuela that rely heavily on foreign exchange earnings from crude oil exports, while providing an economic stimulus to many net oil importers. There is growing concern that further steep declines in the price of oil may threaten the economic and political stability of oil-producing countries, but also the hope that lower oil prices would add much needed strength to the global economy.

It remains an open question what caused this decline in the price of oil, the severity of which surprised even industry experts. Although sustained declines in the price of oil have occurred before, notably in 1986 and in late 2008, a natural question is whether this oil price decline is different and, if so, how. The objective of this paper is to examine these questions, drawing on insights from the literature on the determinants of oil prices and on forecasting oil prices. Building on recent advances in modelling oil markets and forecasting oil prices, we provide evidence that more than half of the decline in the price of oil between June and December 2014 was predictable as of June 2014. Only in July 2014 and December 2014 is there evidence of large negative forecast errors for the price of oil. We show that neither of these two forecast errors is consistent with the occurrence of a large positive shock to the supply of oil. We also provide evidence that the December 2014 shock did not reflect the November 27 OPEC

announcement that OPEC would not counter the production increases of other OPEC and non-OPEC producers. The pattern of the forecast errors for December, however, is highly suggestive of a large negative flow demand shock associated with an unexpectedly slowing global economy; while the July forecast error appears consistent with a negative shock to storage demand reflecting a more positive outlook on oil production, a gloomier outlook on the global economy, or both.

Our analysis provides the first quantitative analysis of the question of what caused the decline in oil prices since June 2014. Our conclusions differ in several dimensions from common conjectures based on the casual inspection of oil market data. Although we find no evidence in support of the hypothesis that recent unexpected increases in oil production were responsible for the slide in oil prices after June 2014, our evidence is consistent with unexpected oil production increases prior to June 2014 having contributed to the slide in the oil price along with demand shocks associated with the global business cycle and shocks to the demand for oil stocks.

The remainder of the paper is organized as follows. In section 2 we review the salient data. In section 3, we outline our methodology. Section 4 contains the main results. Section 5 presents an outlook for early 2015 based on the information available in December 2014. In section 6 we compare the 2014 oil price decline to similar episodes in the past, and we discuss similarities and differences across these episodes. Section 7 explores the implications of declining oil prices for oil producers. Section 8 examines the question of whether the global oil market is still working normally in light of the continued decline in oil prices. The concluding remarks are in section 9.

2. What Has Changed since June 2014? A Review of the Data

Before presenting our methodology it is useful to review some of the key oil market data since

June 2014. Given the speed of the decline in the price of oil, it is natural to suspect that there should be large shifts in other observables as well. As we show, this is not the case in general. Most oil market indicators other than the price of oil have evolved smoothly and no indicator shows nearly the same variability as the price of oil.

2.1. Global Oil Production

A first question is whether there have been important changes in global oil production since June 2014. Unexpected changes in oil production traditionally have been considered important in explaining oil price fluctuations (see Hamilton 2003). Arezki and Blanchard (2014), for example, cite surprise increases in global oil production as one of the main causes of the decline in the price of oil. They attribute these supply surprises notably to the recovery of Libyan oil production and the resilience of oil production in Iraq. Table 1 shows that indeed Libya, Iraq and Syria combined have been able to increase their oil production since June 2014 by 18%, but the increments are nevertheless modest in that Iraqi oil production as a share of world oil production only increased from 3.9% in June to 4.0% in December.

Among the three largest oil producers in the world, Saudi Arabia reduced its oil production ever so slightly by 0.23%, whereas oil production in the former USSR and in the United States continued to grow by 1.9% and 3.9%, respectively. Overall, both OPEC and non-OPEC countries increased their production, with the world total growing at 0.9%. This point is important because its suggests that widely publicized increases in oil production in some countries such as the United States have been offset to some extent by lower oil production elsewhere. Figure 1 illustrates that global oil production has been largely flat since June 2014, notwithstanding the surge in U.S. shale oil production in recent years (see Kilian 2014).

It may be tempting to suggest that oil supply shocks cannot have been important in the second half of 2014 because global oil production hardly moved. This conclusion is not valid in general. What matters for answering this question is not whether oil production moved or not, but whether it moved relative to what it was expected to be. If oil production was expected to decline, for example, but did not because of a positive oil supply shock, then this shock would trigger an additional adjustment of the price of oil without a change in observed oil production. In section 4, we will show how this question can be addressed empirically.

2.2. Global Real Economic Activity

Figure 1 also plots the global real economic activity indicator originally developed in Kilian (2009). This index has been designed as a measure of the business cycle in industrial commodity markets and can be interpreted as a leading indicator for global industrial production (also see Bakshi, Panayotov and Skoulakis 2011). Negative index number values represent recessionary phases and positive numbers expansionary phases. The magnitude of the deviation from zero in the index has no intrinsic meaning. It should only be viewed in relation to its own past. The bar chart provides evidence of a weakening global economy, especially in the first half of 2014, with some recovery in the second half, as the price of oil declined, followed by a sharp deterioration in global real activity in December 2014. Again it is important to keep in mind that this index measures the state of the economy rather than shocks to the economy.

2.3. Other Commodity Prices

It has been noted that there is a close relationship in the long run between the price of crude oil and the prices of other industrial commodities. Both respond to fluctuations in the global business cycle (see, e.g., Barsky and Kilian 2002; Baumeister and Kilian 2012). Baumeister and Kilian (2014a) recently showed that there is a similar business-cycle driven component also in

the price of food commodities. The fact that the price indices of industrial raw materials, metals and food all have declined since June 2014 therefore is a strong indication of a reduction in the demand for crude oil. The fact that the cumulative decline is on average between 5% and 15% compared with 44% for crude oil, tells us that there must be additional oil-market specific explanations for the decline in the price of oil.

2.4. Crude Oil Inventories

Another potential explanation of the decline in oil prices may be related to declining stocks of crude oil. The role of inventories and of forward-looking behavior in the market for crude oil has recently received increased attention with contributions by Hamilton (2009), Kilian and Murphy (2014), and Knittel and Pindyck (2015), among others. It can be shown that an unexpected reduction in the demand for storage is followed by lower oil prices as well as lower oil inventory holdings. At first sight, this explanation may seem at odds with the recent crude oil inventory data. IEA data shows that industry crude oil stocks in OECD countries have remained largely flat, with only a slight decline between July and September (see IEA 2015). It is important to keep in mind, however, that these data are by no means inconsistent with strongly reduced demand for oil storage putting downward pressure on the price of crude oil.

For example, the work of Kilian and Murphy (2014) shows that, following an unexpected reduction in the demand for storage in anticipation of a future excess of oil supplies relative to demand, one would expect oil inventories to fall. It also shows, however, that an unexpected reduction in the flow demand for crude oil associated with a weakening global economy would cause oil inventories to rise, as would a positive shock to oil supply, representing higher than expected oil production. All three types of shocks are potentially important (and not mutually exclusive) explanations of the oil price decline since June 2014. Their net effect on the path of

inventories is indeterminate without further information on the magnitude of these shocks. For example, the observed nearly flat path of inventories in Figure 1 would be consistent with a situation in which lower flow demand for oil and/or a higher flow supply of oil increased oil stocks, while at the same time lower demand for storage (associated with expectations of an increasing oil glut) reduced oil stocks, resulting in approximately unchanged inventories.

How plausible is it that demand for storage declined unexpectedly in recent months? Arezki and Blanchard (2014), for example, attribute a large part of the recent decline in oil prices to a shift in expectations about the future path of global oil production, following OPEC's announcement on November 27 that it would not reduce its oil production to compensate for higher oil production elsewhere. It is not clear that this explanation fits the data. First, at best this explanation could help account for the additional decline in the price of oil starting in December. It leaves unexplained the earlier decline. Second, if this explanation were correct, assuming no major change in global oil production or real activity, one would have expected a sharp drop in the price of oil and in inventories in November and in December. The OECD inventory data in Figure 1 do not show such a drop in November. Nor does a simple event study using daily Brent spot prices show a clear effect of the announcement on the Brent price of oil relative to the ongoing decline in the Brent price. If there are any effects, they appear short-lived. Unless this OPEC decision was anticipated by the market in the months leading up the OPEC meeting or the December data to be released in one month turn out to be much lower, the data thus seem to rule out this explanation.

Of course, expectations of weaker demand for oil from Europe and Asia could have lowered demand for storage independently and more gradually. The apparent failure of Abenomics leading up to the Japanese elections in November 2014; Draghi publicly announcing

in November that he was willing to purchase government bonds, given the euro zone's weak growth during the summer; the renewed discussion about a Greek exit from the euro zone starting in July 2014; concerns over the effects of sanctions against Russia on the European economy starting in July 2014; as well as the slowdown of the Chinese economy starting in the third quarter of 2014 all could have lowered oil demand for storage in a more gradual manner.

2.5. The Role of the U.S. Dollar Exchange Rate

The last panel of Figure 1 shows that the U.S. dollar trade-weighted exchange rate has appreciated against a broad range of currencies by 8 percent since June 2014. It is common in the press to attribute oil price fluctuations to the depreciation or appreciation of the dollar. Because crude oil is traded in dollars, an appreciating dollar all else equal makes it more expensive for refineries outside of the United States to buy crude oil, reducing non-U.S. demand for oil. It may seem that this mechanism could help explain the extent of the fall in the price of oil in recent months. There are three reasons to be skeptical of any exchange-rate based explanation. First, an appreciating U.S. dollar also stimulates exports outside the United States, which in turn increases the demand for oil, potentially offsetting the initial effect. Second, this argument applies equally to the dollar price of crude oil and the dollar-denominated price of other commodities, but Figure 1 showed much more modest declines in other commodity prices than in the price of oil. Third, the premise that the U.S. exchange rate appreciation was unrelated to the determinants of the price of oil is not credible. To the extent that both the price of oil and the U.S. exchange rate depend on the evolution of the global economy, one cannot think of the exchange rate having an independent or additional effect. Indeed, there is no evidence of a systematic predictive relationship between the trade-weighted U.S. exchange rate and the price of oil over extended periods of time (see Alquist et al. 2013).

3. Measuring Surprises in the Data

The discussion so far highlights that identifying oil supply and oil demand surprises requires more than studying the evolution of key indicators. It may seem that the question of why the price of oil declined after June 2014 could be answered simply by fitting a suitable structural oil market model to the data ending in December 2014 and constructing a historical decomposition of the price of oil, but for now estimating such a model is not feasible, given that the data for inventories in particular are yet to be released.

What we can answer is whether this decline in the price of oil was predictable given the information actually available as of June 2014 (or for that matter, given the additional information available in subsequent months). Answering this question is helpful because it tells us whether this decline was triggered by economic shocks occurring prior to July 2014 or by more recent shocks. It can also help us in identifying when these shocks occurred and in determining what type of economic shock provides a plausible explanation for the decline in the price of oil.

There are many ways of predicting the price of oil (see Alquist, Kilian and Vigfusson 2013). In this paper, we follow Baumeister and Kilian (2012) and related studies in employing a four-variable vector autoregressive VAR forecasting model for the real price of oil. This model is the reduced-form representation of the structural oil market model developed in Kilian and Murphy (2014). It contains the real price of crude oil (measured by the U.S. refiners' acquisition cost of crude oil imports), the percent change in global oil production, a proxy for changes in global crude oil inventories, and a measure of global real economic activity proposed due to Kilian (2009) specifically designed to capture fluctuations in demand for industrial

commodities.[1] It has been shown that this class of forecasting models, even when implemented subject to real-time data constraints, has significant predictive power at horizons up to 6 months, especially when there are persistent shifts in economic fundamentals as occurred in 2003-09.[2]

As our baseline model we consider a model specification with 24 lags, an intercept and seasonal dummies, as in the analysis of Kilian and Murphy (2014), estimated recursively by least squares on data extending back to 1973. Forecasts from this model may be converted to forecasts for the Brent price by applying a scale factor, as discussed in Baumeister and Kilian (2014b). We focus on the Brent price because of the recent instability in the spread between the Brent and WTI price (see Kilian 2014). The real oil price forecasts are converted to nominal U.S. dollar prices based on a monthly version of the real-time inflation gap forecasting model proposed by Faust and Wright (2013).

4. What Did the Real-Time Forecasting Model Fail to Predict?

Figures 2a-2f show the evolution of the nominal price of Brent crude oil together with the forecasts of the Brent price generated by the VAR model in real time using only information available as of the time marked by the vertical line. Our objective in Figure 2 is to assess to what extent the observed decline in the price of oil since June 2014 was predictable and to what extent it was associated with unpredictable variation in the price of oil that must be associated with economic shocks hitting the oil market in recent months. The discussion focuses on the VAR(24) model, but we also include two alternative VAR forecasts for comparison.[3]

[1] For details on the definition and construction of the data the reader is referred to Baumeister and Kilian (2012).
[2] Real-time data constraints refer to the fact that a forecaster generating a forecast as of today must operate subject to the constraint that the most recent observations of many time series are not yet available, or, if they are, are still subject to subsequent revisions. These data limitations make it considerably harder to forecast out of sample than suggested by simulated forecasting exercises based on fully revised and complete data. Our approach, in contrast, uses only information that is publicly available as of the time the forecast is generated.
[3] Figure 2 reports additional analogous results for a VAR(24) model estimated using the data-based Bayesian estimation procedure of Giannone et al. (2015) and a more parsimonious version of the VAR model with only 12

Figure 2a shows that the decline in the Brent price between June 2014 and December 2014 was predictable to a large extent. The model predicted that the price of oil would fall to $99 by October and to $84 by December. At forecast horizons between 1 and 5 months ahead, the model systematically overpredicts by roughly the same amount of $8. This pattern of forecast errors can be traced to the one-step ahead error, the effects of which are propagated to subsequent months. Only the December 2014 forecast is off by a more substantial amount of $21.

This raises the question of what the model missed in the July forecast. The bar chart in Figure 3 shows the one-step ahead forecast error of the VAR(24) model for the price of oil, for global oil production, for global real economic activity, and for crude oil inventories, when available.[4] The first entry in each of the bar charts, corresponding to the errors in forecasting July 2014 based on the information available in June 2014, shows that the oil price forecast error of -$9 coincided with a negligible negative forecast error for global real activity (compared with the index value in Figure 1), with a large negative forecast error for the change in inventories (corresponding to about 3.4% of OECD industry oil stocks), and with a small negative forecast error for global oil production (corresponding to 0.35% of global oil production). To appreciate the small magnitude of the latter forecast error, it is useful to compare it with the oil supply shocks studied in Hamilton (2003) which involved reductions in oil production of between 7% and 10% of global oil production.

The evidence in Figure 3 allows us to rule out that the forecast error for the price of oil

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lags. Although the VAR(24) model is less parsimonious than the other forecasting models and would not have been the preferred forecasting model in the 1990s, for example, when available samples were much shorter, in the current context we have the benefit of being able to rely on the full sample until June 2014 in estimating the model, allowing us to use the same lag structure as in Kilian and Murphy (2014).

[4] The global oil production data in the Baumeister and Kilian (2012) forecasting model are based on data in the EIA's Monthly Energy Review. These data only become available with a delay of three months. We therefore extrapolate the EIA world oil production data using the growth rates of IEA world oil production data. Although the level of these two series differs, their growth rates are quite similar, justifying this approximation.

was caused either primarily by a negative oil supply shock or primarily by a negative flow demand shock. The former possibility can be ruled out because such a supply shock all else equal would raise the oil price and global real activity. The latter possibility can be ruled out, given the negligible forecast error in global real activity. This is useful information because it helps us rule out two of the leading explanations of declining oil prices that have been proposed for this episode, as least as the primary explanation. The observed pattern, however, appears consistent with the forecast error being driven primarily by an unexpected reduction in the demand for storage, given the simultaneous unexpected decline in inventories and the price of oil. Such a shock to storage demand could reflect expectations of lower demand or of higher oil production or both.

Figure 2b examines the forecast implied by the model as of July 2014. With the benefit of an additional month of information, the one-step ahead forecast error of the previous forecast is corrected for, and the VAR(24) model forecasts are much closer to the realizations of the price of oil in all months from August until December. The VAR(24) model predicts a decline in the price of oil to $74 in December, followed by a recovery to $77 in January 2015. The forecast as of August 2014 in Figure 2c comes very close to the actual price of oil in September, October and November. It only misses the December realization by $17. This pattern is repeated in Figures 2d and 2e, showing the forecasts generated as of September and October 2014.

Figure 2f shows that even as of November 2014, the model misses the December price by $13. This evidence suggests that a second important price shock occurred only in December 2014. What was the cause of this shock? The December entry in Figure 3 suggests that the observed forecast error for the price of oil is associated with a strongly negative forecast error for global real activity (corresponding to almost two thirds of the December value of the real activity

index in Figure 1) and a negligible positive forecast error in global oil production (corresponding to 0.24% of global oil production, which again is small by the standards of the shocks discussed in Hamilton (2003)). There are no inventory data available at this point for December. This pattern is compatible with a large negative flow demand shock in December 2014, but inconsistent with a large positive supply shock in this month. We can also rule out that this pattern can be explained by a negative shock to storage demand, even in the absence of data on oil stocks for December 2014, because such a shock would raise global real activity, as the lower oil price would stimulate oil consumption. This implication is inconsistent with the strongly negative forecast error for global real activity. Thus, a strong case can be made for the largest forecast error in our sample having been caused by an unexpectedly weakening global economy in December 2014.

To reiterate, first, a substantial part of the decline in the price of oil after June 2014 was predictable. It may seem that this result would be at odds with the path of oil futures prices. Oil futures prices may be interpreted as the market expectation of the price of oil in the absence of a risk premium. Unlike our forecasting model, Brent futures prices failed to predict the decline in the price of oil as of June 2014. The Brent futures curve is nearly flat. It may seem that our results would imply that the traders in this market made systematic mistakes in predicting the price of oil. This is not necessarily the case. Recent work by Baumeister and Kilian (2014d) shows that there is a time-varying risk premium in oil futures prices that drives a wedge between the oil futures price and the market expectation of the oil price, especially at longer horizons. This risk premium can be very large. Baumeister and Kilian estimate the risk premium based on the term structure model of Hamilton and Wu (2014), which they show to be the most reliable risk premium model for the oil futures market. Estimates of the risk premium at the 6-month

horizon may be as high as $26. Thus, the market expectation of the price of oil can differ substantially from the futures price, calling into question the use of oil futures prices as oil price forecasts. This point is consistent with robust evidence that oil futures prices at the 6-month horizon fail to improve on the no-change forecast (see, e.g., Alquist et al. 2013).

Second, we showed that only in July 2014 and December 2014 is there evidence of large forecast errors. Both of these forecast errors were negative. Neither of these two forecast errors is consistent with the occurrence of a large positive shock to the supply of oil. The pattern of the forecast errors in July is suggestive of an unexpected reduction in storage demand, caused by the anticipation of higher oil production, a gloomier outlook on the economy, or both. The pattern of the forecast errors for December, in contrast, is suggestive of a large negative flow demand shock.

This does not mean that oil supply shocks do not matter in general. Although we find no evidence in support of the hypothesis that recent unexpected increases in oil production were responsible for the slide in oil prices after June 2014, our evidence is consistent with positive oil supply shocks prior to June 2014 having contributed to this slide along with negative oil demand shocks associated with the global business cycle. Likewise, oil-market specific shocks prior to July 2014 may have taken the form of shocks to the demand for storage in response to expectations of increasing oil production.[5] By construction, the cumulative effects of all these earlier unobserved shocks is what is responsible for creating the momentum in the price of oil that is embodied in the model's prediction of declining oil prices after June 2014.

[5] Our conclusions have been based on the VAR(24) forecasting model. Figure 2 suggests that the real-time forecasts implied by this model tend to be closer to the realizations of the price of oil than the two other VAR forecasts, adding credence to our choice of baseline model. This result is consistent with the emphasis in Kilian (2009) and related studies on including enough lags in modelling long cycles in commodity prices. Although in some cases there are important differences in the degree of fit between our baseline model and the two alternative models, it is comforting to see that the pattern of the forecast paths is similar overall.

One potential concern is that this class of VAR forecasting models somehow may be prone to predicting a steep decline in all commodity prices because of the way the model is constructed. If this were the case, one would expect this type of model to predict a counterfactual large decline in other industrial commodity prices. This is not the case. Although there are no data on production and inventories that would allow us to extend the analysis in Figure 2a to other industrial commodity prices, we can evaluate the real-time forecast accuracy of a simpler VAR(24) model including only the real CRB index of industrial raw materials (which excludes crude oil) and the global real activity measure. This model as of June 2014 predicts a -5% cumulative decline in the nominal CRB index by December 2014. This forecast is quite accurate compared with the observed cumulative decline of -7% (see Figure 1). For comparison, fitting an analogous VAR forecasting model for the real price of oil and global real activity results in a predicted cumulative decline in the nominal Brent price of -9% by December. Thus, the much larger cumulative decline of -25% predicted in Figure 2a appears related to the inclusion of the global oil production and oil inventory data in the VAR forecasting model.

5. What Does the Future Hold?

A question of obvious importance is how the price of oil will evolve in 2015. Figure 4 shows that as of December 2014 all three real-time forecasting models predicted that the Brent price would bottom out at near $57 in January or February, followed by a slow recovery to between $64 and $70, depending on the model. These predictions, of course, are built around the working assumption that we do not expect any further demand or supply shocks in the coming months. An unexpected further deterioration of the global economy, for example, could easily drive the price down further. In that case, one would expect the price to approach a floor set determined by the long-run marginal cost of oil producers. As the price of oil approaches this floor, more and

more oil producers will be forced to exit the market, starting with the producers with the highest marginal cost, reducing the flow of oil production to the point that the downward price pressure ceases. Already there is a debate in the United Kingdom about shutting down U.K. oil production in the North Sea, which at current prices hardly seems sustainable. An unexpected global recovery, in contrast, all else equal would raise oil prices. Such forecast scenarios may be evaluated within the framework of Kilian and Murphy (2014), as illustrated in Baumeister and Kilian (2014c). For example, an unexpected increase in global oil production by 1% would cause a decline in the price of oil of close to $5 three months later.

6. How different is the Oil Price Decline of 2014 from the 1986 and 2008 Episodes?

This is not the first episode of falling oil prices. One prominent example has been the decline in oil prices from its peak level in 1980. This decline accelerated in January 1986, when Saudi Arabia ceased all attempts to prop up the price of crude oil and lifted the self-imposed restrictions on its oil production. The other prominent example in recent history is the sharp drop in oil prices after July 2008. Compared with the decline in oil prices following the Asian Crisis of 1997, these two episodes were less gradual.

Figure 5 compares the evolution of the nominal price of oil and of the global production of crude with that after June 2014.[6] All time series have been normalized to 1 at the beginning of each episode. Figure 5 shows that the recent episode is not unusual by historical standards. The cumulative decline in the price of oil in the six months since June 2014 was less than the corresponding decline in 1986 or 2008, and it occurred more slowly. Global oil production then as well as now remained largely flat. Even after July 2008 there was not more than a negligible reduction in global oil production.

[6] The price of Brent has been extrapolated backwards as discussed in Baumeister and Kilian (2014b).

There has been much discussion recently of the traditional role of Saudi Arabia as the swing producer in global oil markets. The presumption in this debate is that Saudi Arabia tends to reduce its oil production in times of low demand. This view dates back to the early 1980s when Saudi Arabia responded to the Volcker recession by reducing its oil production, allowing other oil producers to gain market share. The intent was to prevent the price of oil from falling further. This approach proved not only ineffective in that the price of oil continued to fall, albeit at a slower rate, but unsustainable in that falling production in conjunction with falling oil prices resulted in a substantial reduction in Saudi oil revenues. By the end of 1985, Saudi Arabia was forced to reverse course, and the real price of oil collapsed along with fears of what OPEC might do. Much of the decline in the price of oil in 1986 reflected a reduction in storage demand, as market fears regarding what OPEC might do dissipated (see Kilian and Murphy 2014). The remainder reflected increased Saudi oil production. Figure 5 illustrates that, five months after the change in policy, Saudi oil production rapidly accelerated. One obvious lesson from this episode has been that even Saudi Arabia is unable to control the price of oil and unable to preserve oil revenue by reducing production.

Thus, the recent November 27 OPEC announcement, which reflected the Saudi position in particular, should perhaps not have come as a surprise. Figure 5 confirms that Saudi Arabia has not lived up to its reputation as a swing producer after June 2014. One argument explaining why the market may have been surprised after all in November 2014 is that in late 2008, during the financial crisis, Saudi Arabia had responded to falling oil prices by reducing production. Figure 5 shows that this decision came four months after the price of oil had peaked. Then as now the decline in the price of oil was originally caused by lower demand. As it turns out, Saudi Arabia was the only major oil producer to respond in this fashion. U.S. oil production dipped

slightly in September of 2008, while Russia's oil production remained steady throughout this period. Oil production in the rest of the world hardly changed.

The case can be made that concerted action by the major oil producers is a coordination problem. As predicted by the theory of cartels, this problem proved insurmountable in the 1980s, when OPEC members deviated from the cartel policy of restricting oil production, prompting Saudi Arabia to act unilaterally (see Green and Porter 1984). With the rise of Russia, the United States, Canada and even China as major oil producers, this coordination problem has only increased. In the case of the United States and Canada an additional complication is that the oil industry is private and decentralized. In the case of Russia, the problem is that Russia heavily relies on oil revenues to sustain its economy much like many of the smaller OPEC producers such as Venezuela. This raises the question of what response is in the best interest of Saudi Arabia. It does not seem possible to construct a case for Saudi production restraint, given that such a policy would only involve a repeat of the failed pre-1986 policies. If Saudi Arabia is unable to stabilize the price of oil on its own, it would be foolish to try. If uncooperative high-cost oil producers such as Russia, Iran, or Venezuela (or for that matter companies engaged in deep-sea off-shore drilling) are ultimately forced to cease production, as a result of Saudi Arabia maintaining its current level of production, this side effect would presumably be welcome from the Saudi point of view, but it does not seem necessary to appeal to geopolitical factors to rationalize the Saudi position. It should be noted that the Saudi position today is not markedly different from that of, say, the United States, yet no one is calling for U.S. shale oil production to be scaled back for the benefit of foreign oil producers.

Producers concerned with their oil revenues in fact may have an incentive to increase their production in response to lower prices associated with lower demand. Table 1 shows very

modest increases in aggregate oil production only, suggesting that most producers, including notably Saudi Arabia, have not given in to this temptation, although they have not reduced production either. One clear exception is the United States, which continued to increase oil production in the second half of 2014. Whether the decision by many state-owned oil producers not to increase production has been a deliberate decision or reflects the fact that many producers are already at their capacity limit is not always clear.

7. Implications for Oil Producers

It seems that the only way to resolve this situation, unless the global economy (and hence the demand for oil) recovers, is for oil producers whose long-run marginal cost exceeds the current price of oil to exit the market. We are already seeing some oil producers experiencing severe economic strain. A similar, if less severe, adjustment occurred after 1986 when Saudi Arabia effectively eroded the profit margins of high-cost oil producers elsewhere. Once this process is complete, one would expect the price of oil to stabilize.

There are important differences in how oil producers in different regions of the world would be affected by lower prices. Saudi Arabia, for example, enjoys low marginal costs of production, but requires much higher oil prices in the long run to sustain its welfare state.[7] For the time being, Saudi Arabia is using the oil wealth it accumulated in years past to finance the fiscal deficits caused by falling oil prices. There is a good chance that Saudi Arabia will be able to sustain this response long enough for oil producers worldwide to consolidate. Other OPEC oil producers that rely on oil revenue for financing their welfare programs such as Venezuela appear much less prepared for weathering the current price slump. Oil producers in Western Canada, where unconventional crude oil is produced at relatively high cost from oil sands, are also likely

[7] Smith (2009), for example, cites marginal cost estimates for Middle Eastern oil producers ranging from $5 to $10.

to be vulnerable to a further downturn in oil prices.

In the United States, in contrast, the marginal cost of the production of shale oil, which a few years ago was quite high, appears to have fallen to the point that many shale oil producers are able to remain profitable at current prices. For example, the Wall Street Journal recently cited industry spokespersons for two major U.S. shale oil producers, suggesting that improved efficiency in shale oil production allowed their operations to remain profitable even at $40 a barrel in some locations (see Gold 2015). Even if reliable, these estimates need not apply to other companies or locations, however, making it difficult to generalize these observations. Figure 6 assesses the extent to which U.S. shale oil producers have come under pressure in recent months by plotting U.S. oil drilling rotary rig counts which may be viewed as a leading indicator of oil production. Although Figure 6 only shows a modest decline by the end of December, weekly rig counts show that by the third week of January 2015 rig counts have declined by 15% relative to their peak in October. This evidence suggests that the U.S. shale oil industry is not immune to the recent decline in oil prices, contrary to what some news reports seem to suggest. It also has been widely reported in the financial press that many oil companies are scaling back their investment plans and that oil support service companies such Baker Hughes, Halliburton and Schlumberger are laying off thousands of employees.

This does not mean that shale oil production will fall immediately. Although there are no reliable data on shale oil production for late 2014, current EIA estimates suggest that actual shale oil production may continue at grow for some time, before declining. Figure 6 shows EIA and IEA estimates of current total U.S. oil production (with the IEA data adjusted to exclude natural gas liquids for compatibility). There is no sign of a decline in U.S. oil production yet.

One reason for this sluggish response is that short-run operating costs tend to be quite

low, once a rig is in place. As stressed by Anderson, Kellogg and Salant (2014), it is simply suboptimal for oil producers to reduce oil production from existing wells, given the cost structure of the oil industry and geological constraints on oil extraction. Anderson et al. provide evidence that even in competitive markets oil production from existing wells need not respond to shocks to spot and expected future oil prices. Their theoretical analysis suggests that the adjustment of oil production instead works primarily through firms adjusting the number of new wells to be drilled, which affects oil production only with a delay. This result is consistent with the rig count and oil production data in Figure 6. It is also useful to keep in mind that there are substantial differences in long-run marginal costs across U.S. oil fields. Thus, one would not expect all of them to curtail drilling at the same time in response to a price decline. Rather this process would start with the least competitive producers and gradually include more and more operations, as the price of oil declines further.

8. Is the Oil Market Working Normally?

This sluggishness in the short-run response of oil production to a decline in the oil price caused falling demand has a long tradition in oil markets, as discussed in Kilian (2009). This feature of the oil market suggests the possibility of an undershooting of the price of oil. Given uncertainty about the long-run marginal cost of individual oil producers and the high fixed cost of restarting oil production following a shut-down, there is an incentive for each oil producer to test the resolve of its competitors to stay in the market. Given the high stakes involved, oil producers have an incentive to wait and see who blinks first and exits the market. This reasoning helps understand the recent posturing by proponents of U.S. shale oil on the one hand and of Saudi Arabia on the other about their ability to survive low oil prices. It also helps explain why so far we have seen little evidence of oil producers exiting from the market with most adjustment

taking the form of reduced investment in the oil sector.

An important question is whether anything about the response of oil producers so far to the fall in the price of oil since June 2014 has been unexpected or unusual, given the history of the oil market up to date, suggesting that existing models are inadequate. Our analysis indicates that there is no evidence of additional oil supply shocks in the second half of 2014 that would signal that producers are doing anything different from what one would have expected. In fact, if anything, had Saudi Arabia chosen to act as the swing producer in the current environment, this decision would have had to be considered the historical exception and would have been an oil supply shock in its own right.

There are some scenarios in which models such as ours that have done a good job at predicting the decline in the price of oil so far would not work as well going forward. One such scenario would be U.S. shale oil production responding to falling oil prices more sluggishly than predicted based on the responses of conventional oil production to similar shocks in the past. Another scenario would be a state-owned oil producer subsidizing its operating losses based on previously accumulated oil wealth, thereby forcing other producers into bankruptcy. Clearly, such outcomes would not be anticipated by our forecasting model and would result in negative forecast errors. Such oil supply shocks and/or an unexpected reduction in the demand for oil caused by a further weakening of the economy or by the liquidation of oil stocks indeed could drive the price of oil even lower than it already is. It should be kept in mind that in 1998 the Brent price of oil briefly reached $10 a barrel following a reduction in demand triggered by the Asian crisis in 1997. We are still far away from this point. Our forecast in Figure 4 shows that such a decline, while possible, was not expected based on the information available as of December 2014. The evolution of the price of oil in 2015 to date, however, strongly suggests that

additional unpredicted shifts in oil demand or oil supply have pushed the oil price well below the forecast shown in Figure 4. Thus, our evidence suggests that only now, in December 2014 and January 2015, the oil market has experienced important economic shocks with the earlier decline having been largely predictable based on information available in mid-2014.

Much has been made of the institutional characteristics of the crude oil market and of the special role of Saudi Arabia, but it is important to keep in mind that the behavior of producers of crude oil is not fundamentally different from that of iron ore producers, for example. Both markets experienced a surge in demand and in prices after 2003. Iron ore production companies responded by opening new mines and increasing production much like oil companies increased their production. The iron ore market is dominated by three companies: Blue Scope Steel, Rio Tinto and Vale. The main customer of these companies has been China, which makes about half of the world's steel. By early 2014 demand for steel from China weakened, and so did the demand for iron ore. As a result, the price of iron ore started plunging, yet to date there is no sign that iron ore producers have reduced their production growth. The reason is simply that, even at these lower prices, iron ore production remains profitable. Increased iron ore production in turn has put continued downward pressure on the price of iron ore. The result has been a fall in the spot price of iron ore for delivery in China that has been every bit as dramatic as the fall in crude oil prices. For example, the index of the spot market price of iron ore with 62% ferrous content for delivery in Qingdao port in China started falling as early as January 2014 and by the end of the year matched the cumulative decline in the price of oil.[8] In the absence of a recovery of the demand for steel, this process is likely to continue until the price of iron ore falls below the long-run marginal cost of iron ore production. This situation closely resembles recent developments

[8] The data source is Bloomberg. This fall in the price of iron ore clearly cannot be explained by oil prices lowering the cost of shipping, first, because then other commodity prices would have declined similarly, and, second, because much of the decline in the price of iron ore occurred well before the drop in the price of crude oil.

in the crude oil market.

9. Concluding Remarks

Understanding the recent evolution of the price of oil is important in assessing the macroeconomic outlook. It also has the potential to affect the political stability of oil producing countries, and it has profound implications for many industries and for environmental policies. Providing an assessment of the decline in the price of oil between June 2014 and December 2014 is complicated by the fact that only now are preliminary oil market data for late 2014 starting to become available. Existing analysis of this question has been very informal. The objective of this paper has been to advance the discussion beyond the truism that both oil demand and oil supply shocks may have had an important role to play. We relied on simple quantitative tools and insights from structural economic models of the oil market to assess the plausibility of competing explanations of the decline in oil prices.

Many observers have conjectured that factors specific to the oil market played an important role. Notably, Arezki and Blanchard (2014) suggested an important contribution of oil supply shocks, highlighting the examples of Libya, Iraq and the United States. They also suggested that a major shock to oil price expectations occurred when in late November 2014 OPEC announced that it would maintain current production levels despite the steady increase in non-OPEC oil production. Both conjectures are perfectly reasonable ex ante, yet we provided evidence that neither explanation appears supported by the data.

We showed that there were few large oil market shocks after June 2014, with the largest resembling a negative shock to the demand for oil associated with a weakening economy in December 2014. We illustrated that more than half of the decline in the price of oil was predictable in real time as of mid-2014 and therefore reflects the cumulative effects of earlier

demand and supply shocks rather than any more recent shocks. This result suggests that the difference in the evolution of the price of oil that declined by 44% between June and December of 2014, compared with other commodity prices that on average declined by only 5%-15%, reflects oil-market specific developments that took place prior to June 2014 (either in the form of positive oil supply shocks or in the form of unexpectedly low demand for storage in response to expectations of higher future oil production).

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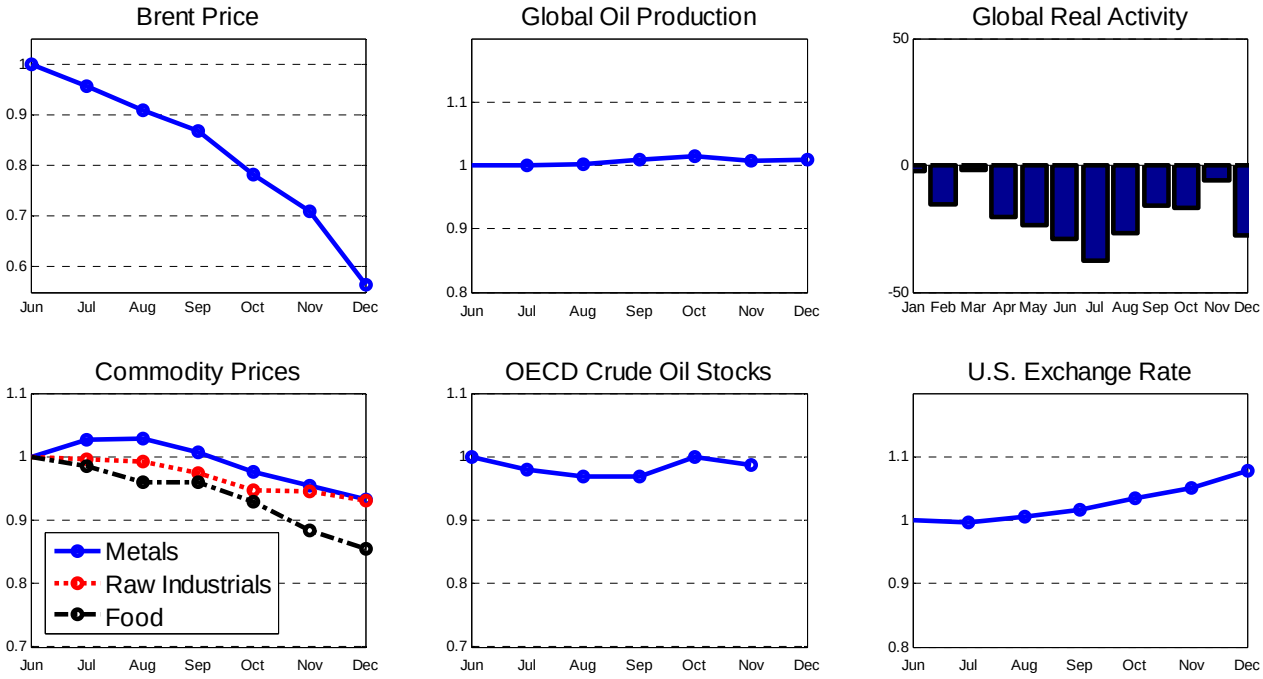
Table 1: IEA Crude Oil Production Estimates

	June 2014 – December 2014		
	Change in Oil production (*Mbd*)	Percent Change	Percent Share in World in Dec. 2014
Saudi Arabia	- 0.026	- 0.23	12.18
United States	+0.460	+3.87	13.12
Former USSR excluding Estonia	+0.263	+1.91	14.90
Iraq	+0.425	+12.64	4.02
Libya	+0.230	+85.19	0.53
Syria	+0.006	+21.43	0.04
Iraq+Libya+Syria	+0.661	+18.06	4.59
OPEC	+0.429	+1.17	39.25
Non-OPEC including processing gains	+0.389	+0.68	60.75
World Total	+0.818	+0.88	N.A.

NOTES: The data source is the IEA Monthly Oil Data Services at http://www.iea.org/statistics/mods/. The definitions employed by the International Energy Agency differ from those used by the U.S. Energy Information Administration with the IEA using a broader definition of crude oil production. This has little effect on estimates of the change in production over time, but may result in changes in countries' share in world oil production such as the relative position of Saudi Arabia and the United States.

Figure 1: Oil Market Indicators for 2014



NOTES: The data on global crude oil production and oil stocks held by industry in OECD countries are based on IEA estimates in the IEA's monthly *Oil Market Report*. The commodity price indices are from the Commodity Research Bureau. The global real economic activity indicator is based on Kilian (2009). This index has been designed as a measure of the business cycle in industrial commodity markets and is a leading indicator for industrial production. The U.S. dollar exchange rate from the FRED database is the trade-weighted nominal exchange rate measured against a broad basket of trading partners. The Brent price is from the EIA. All data but the global real activity index have been converted to an index that equals 1 in June 2014.

Figure 2a: Real-Time Forecast of the Price of Brent Crude Oil as of June 2014

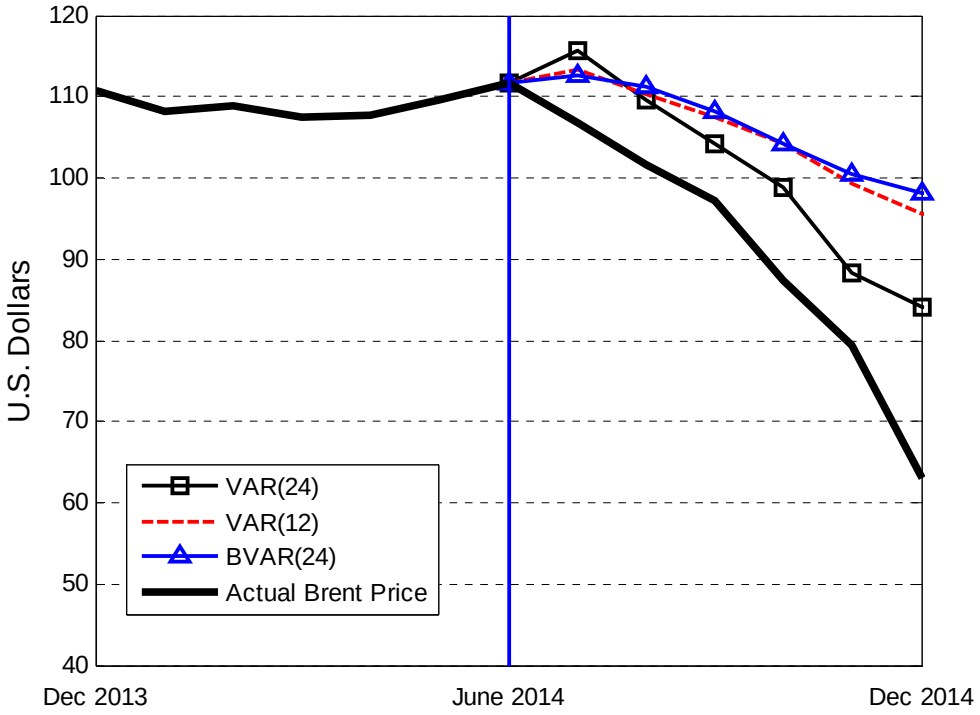


Figure 2b: Real-Time Forecast of the Price of Brent Crude Oil as of July 2014

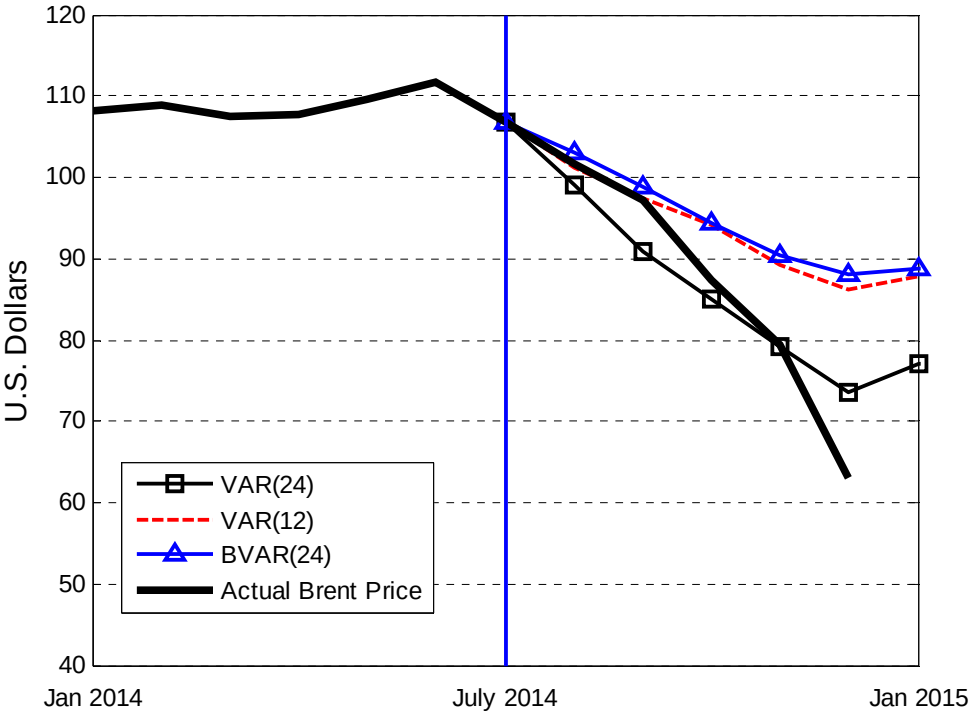


Figure 2c: Real-Time Forecast of the Price of Brent Crude Oil as of August 2014

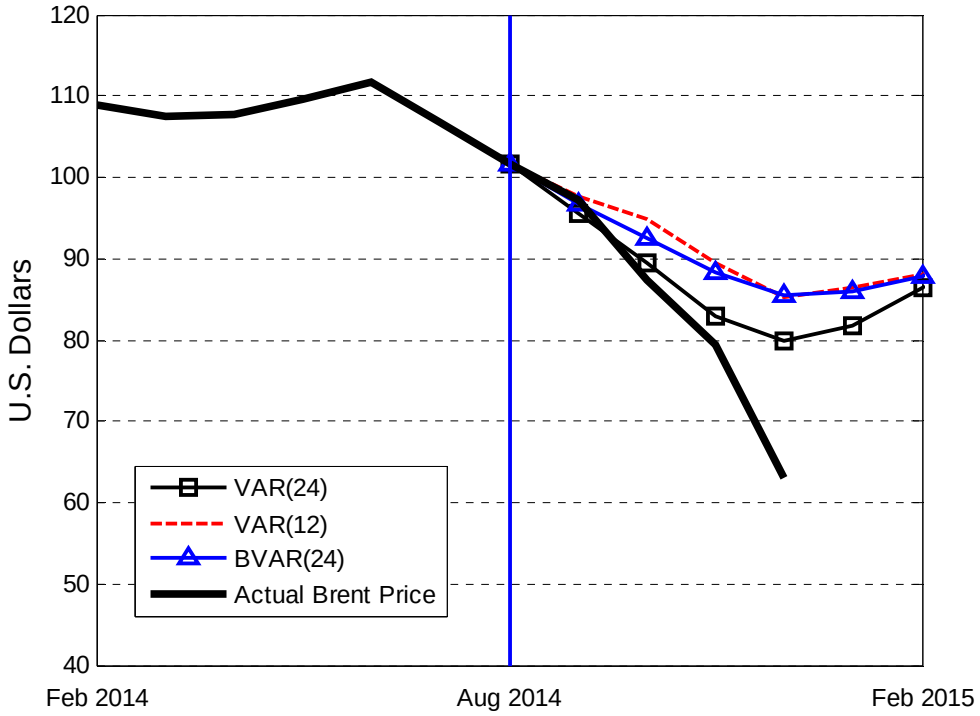


Figure 2d: Real-Time Forecast of the Price of Brent Crude Oil as of September 2014

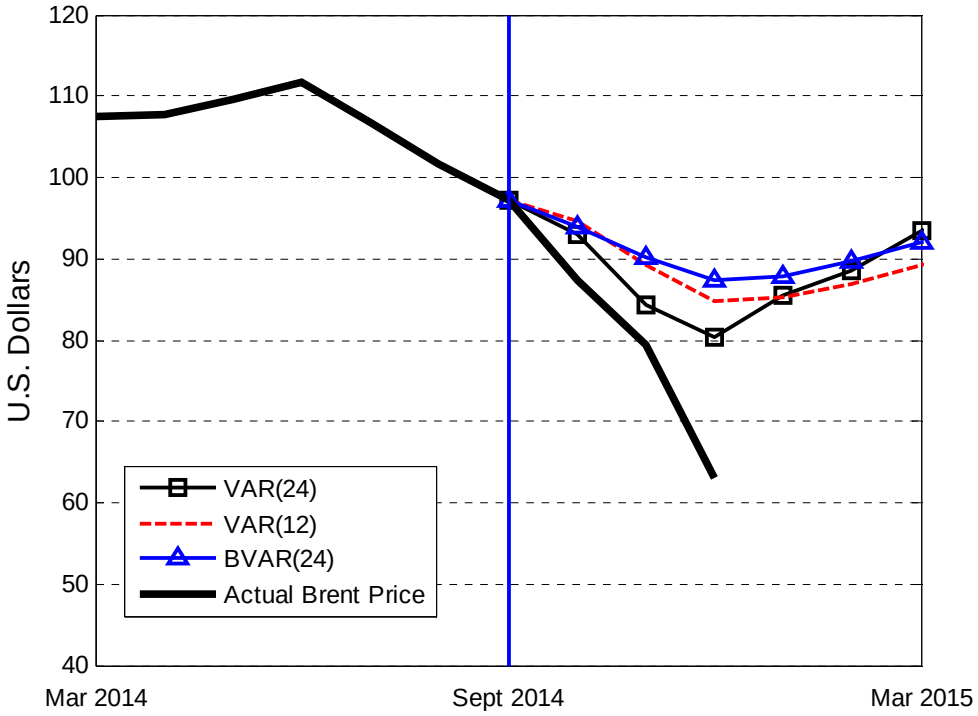


Figure 2e: Real-Time Forecast of the Price of Brent Crude Oil as of October 2014

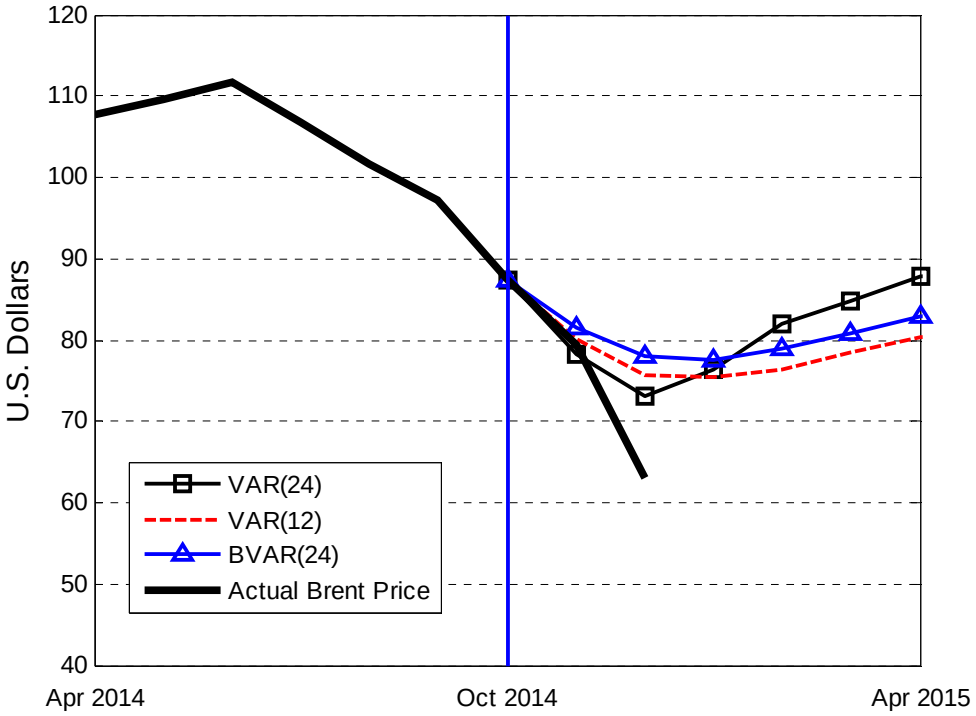


Figure 2f: Real-Time Forecast of the Price of Brent Crude Oil as of November 2014

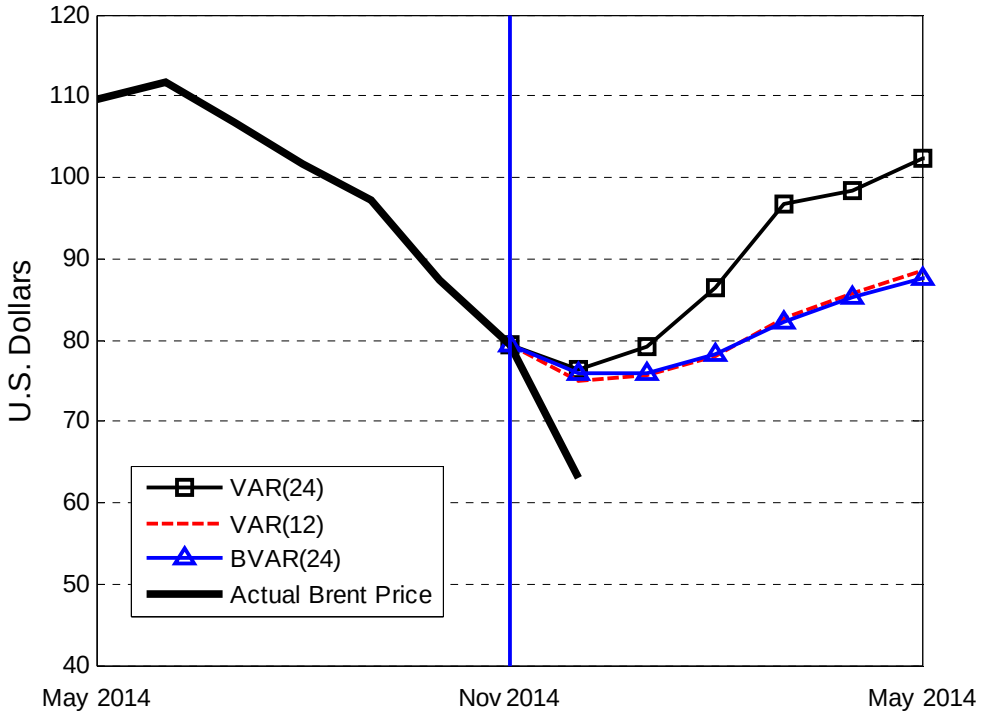
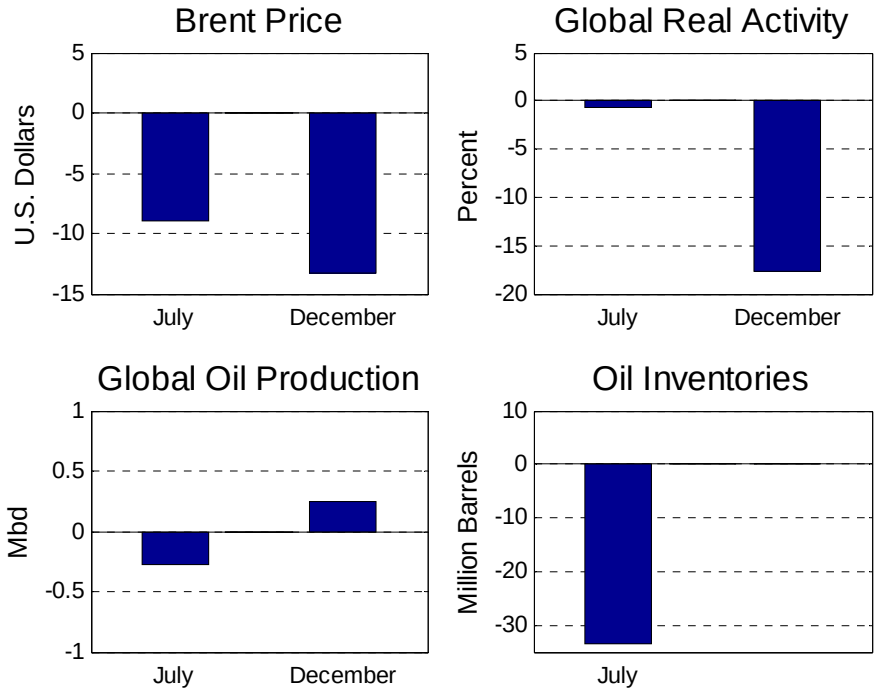


Figure 3: 1-Step-Ahead Forecast Errors for July 2014 and December 2014



NOTES: All forecast errors shown are from the VAR(24) model in Figure 2. The analysis focuses on the two months, in which large oil price forecast errors occur. No oil inventory data are available for evaluating the December forecast.

Figure 4: Real-Time Forecast of the Price of Brent Crude Oil as of December 2014

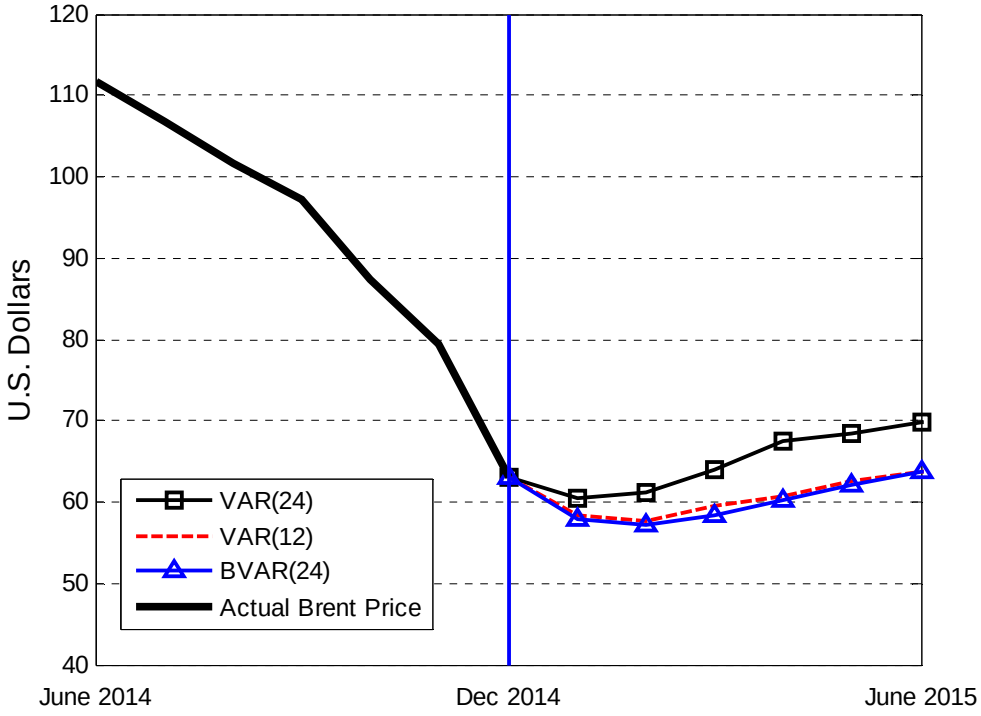
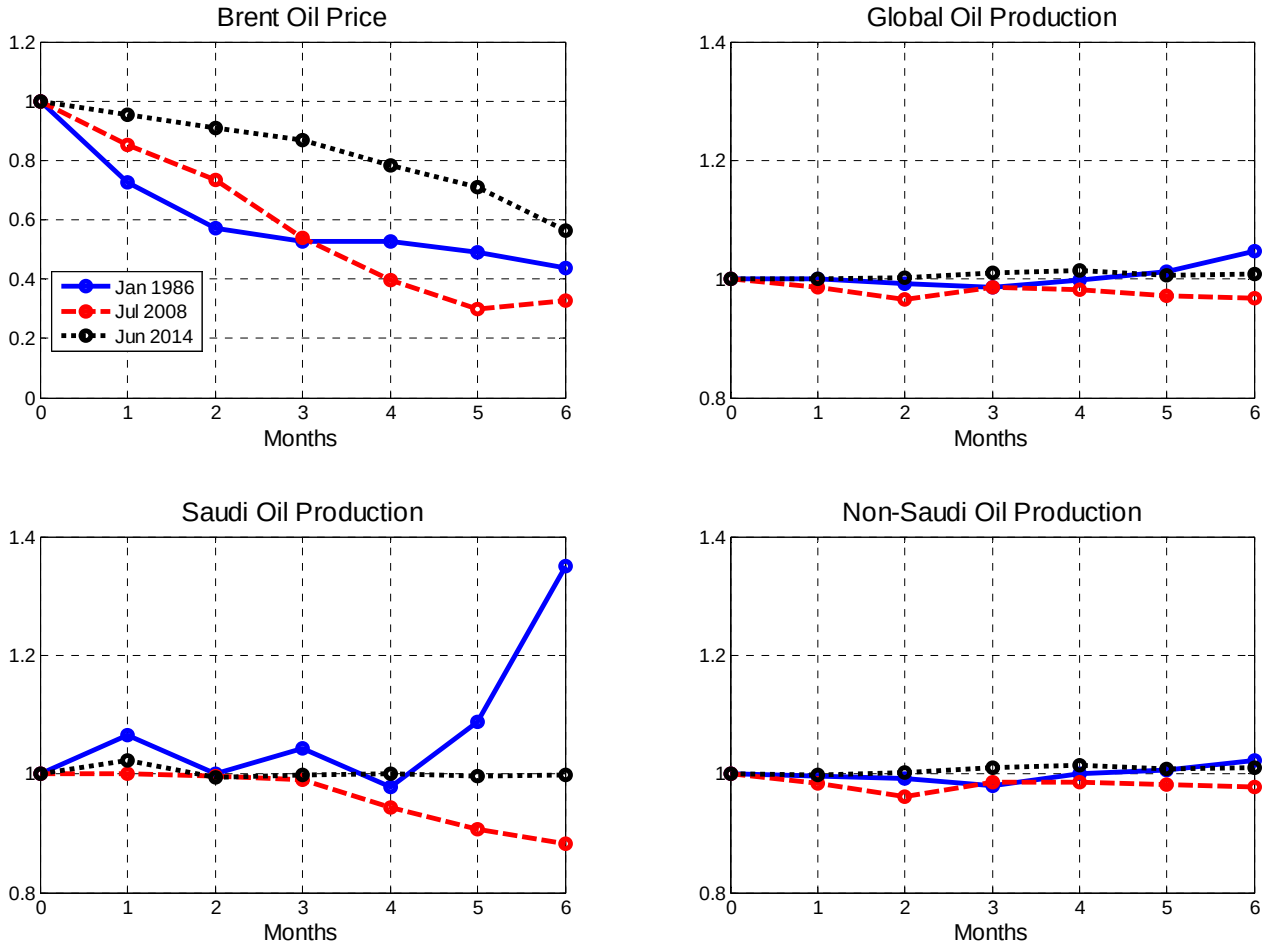
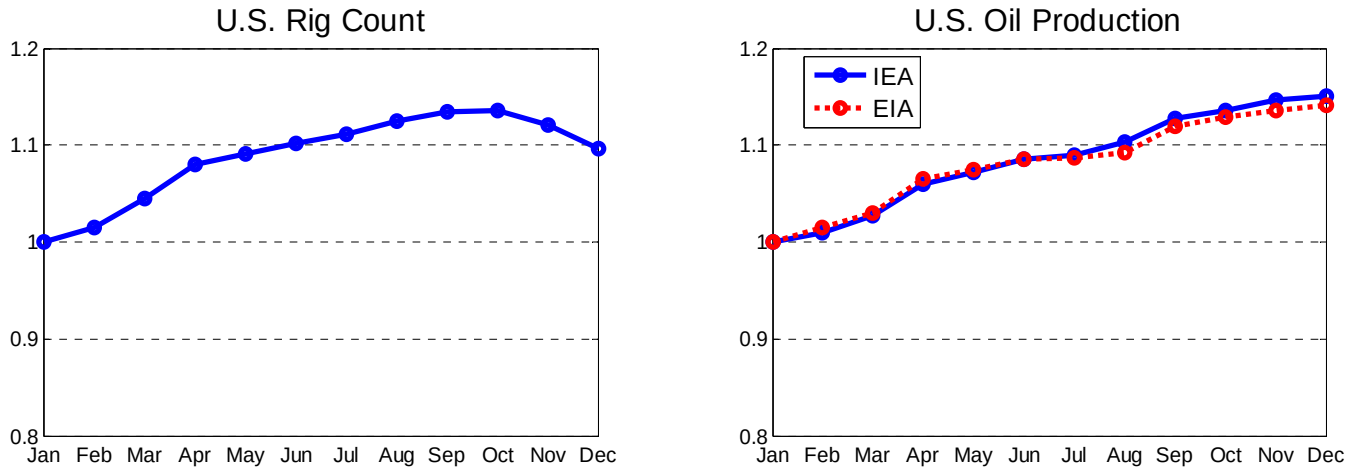


Figure 5: Oil Price Declines in Historical Perspective



NOTES: The data on global crude oil production are from the IEA's monthly *Oil Market Report*. The Brent price is from the EIA.

Figure 6: Indicators of U.S. Oil Production



NOTES: The IEA production data have been adjusted to exclude natural gas liquids. The rotary rig count is from Baker Hughes (http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother).

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