Academic Research Monitor
Does Oil matter for Equity Markets?

Equities

Global
Quantitative

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A close look at the relationship of oil price shocks and the equity markets

Oil prices fluctuate due to demand and supply (production) shocks. How can we disentangle demand from supply shocks? How do these shocks affect equity market returns? How do these shocks affect equity market volatility? How did these shocks contribute to the recent oil price collapse? We provide a detailed review of four academic papers on the dynamics of the oil price that offer insight on these questions.

The effect on equity market returns

One of the papers that we review uses the returns of oil producing firms as a proxy for demand shocks and finds that oil demand shocks are generally perceived as good news; they are positively related to equity returns and affect more strongly industries with high use of oil. Conversely, oil supply shocks are negatively related to equity returns and affect more (negatively) strongly industries that produce consumer goods.

The effect on equity market volatility

Contrary to the effects on equity returns, equity market volatility appears to only respond to demand-driven shocks, another paper that we review finds. In particular, equity volatility falls when the aggregate demand for industrial commodities increases (perceived as good news), but it increases in the medium-term if the oil-specific demand increases due to concerns regarding future oil supply (perceived as bad news).

Commentary by the UBS Head of Oil Research, Jon Rigby

In order to improve our insights from reviewing the various academic papers, we have asked Jon Rigby, the Head of Oil Research at UBS, to share his views and insights. See page 16 of the report.

Introduction

The oil price has been in the headlines since June 2014, when it started its major fall and eventually reached multi-year low levels earlier this year (see Figure 1). This major decline has constituted one of the main concerns for global economic growth and its correlation with the equity markets – historically small and statistically insignificant – has increased strongly over this recent period.

With all the uncertainty about the effects of oil price shocks, their determinants and their time-varying relationship with the global equity markets, we decided to look into recent academic work focusing on oil price and put together a special edition of our regular Academic Research Monitor. We were happy to find a handful of interesting papers (see Figure 2), which employ quantitative techniques in order to establish the relationship between the oil price and the equity markets.

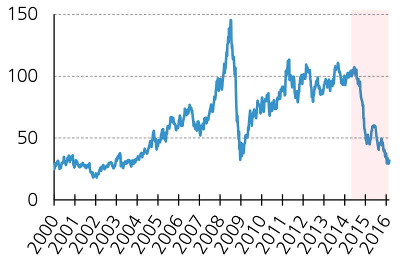
To start off, we briefly summarise, review and update an old-time classic paper on the relationship between the oil price and the equity markets. By updating the results of the paper, we find that the US and UK equity markets respond statistically strongly to past oil price changes, without exhibiting any overreaction features.

The next two papers that we review investigate the relationship between oil supply and demand shocks with the overall equity market and its volatility. Finally, we review a paper that takes a closer look at the driving forces of the 2H14 oil price fall and introduces a forecasting model for the level of the real price of crude oil.

The Head of Oil Research at UBS, Jon Rigby provides his independent view on the various topics discussed at the end of the report, in page 16.

A special edition of the ARM on the oil price, its dynamics and its effect on equity markets

Figure 1: WTI Crude Oil Price (spot)



Source: Datastream. Spot WTI Crude oil price in USD (Datastream Ticker: CRUDOIL). Weekly data between January 2000 and February 2016.

Comments offered by the UBS Head of Oil Research, Jon Rigby

Figure 2: Papers on Oil

"Oil and the Stock Markets" *Charles Jones and Gautam Kaul*	*Journal of Finance, Volume 51, Issue 2, 1996*
"Oil Prices and the Stock Market" *Robert Ready*	SSRN working paper, October 2015
"How does Stock Market Volatility react to Oil Shocks?" *Andrea Bastianin and Matteo Manera*	SSRN working paper, June 2015 Forthcoming at *Macroeconomic Dynamics*
"Understanding the Decline in the Price of Oil Since June 2014" *Christian Baumeister and Lutz Kilian*	*Journal of the Association of Environmental and Resource Economists, Volume 3, Issue 1, 2016*

Source: UBS

"Oil and the Stock Markets"

by Charles Jones and Gautam Kaul

Do markets react rationally to oil price moves or do they overreact, hence offering a possible trading opportunity?

Changes in the oil price can affect the unexpected returns to stock markets in two ways: i) changing the current or expected future cash flows to the firms (cash flow news) and ii) changing the future expected returns (discount rate news). In this classic paper that was published back in 1996, Charles Jones and Gautam Kaul investigate whether the stocks markets move more (i.e. overreact) in response to oil price shocks than can be justified by the effect of oil price changes on these two components.

Data

The authors proxy for changes in the current and future expected cash flows by using future realised industrial production growth. For future expected returns, it is harder to get such a direct proxy, so they use a list of variables known to be strongly linked to expected returns, including market dividend yield, the term spread and the credit spread.

They consider four stock markets: US, Canada, Japan and the UK. The empirical analysis is done using quarterly data. As already mentioned, the paper was published back in 1996, and their sample period stops in 1991. They have used as long a sample period as their data allowed, which was 1947 for the US, 1960 for Canada, 1970 for Japan and 1962 for the UK.

Oil prices do move markets

The authors first show that oil prices are associated with stock market returns in each of the four countries and, using a Granger causality test, that there is strong evidence that oil shocks do cause stock market moves.

Do markets overreact?

Then, in order to investigate whether there are any overreaction effects, they regress real stock returns on past and current oil price returns as well as on current and future cash flows (proxied by the changes in realised industrial production):

$$Real\ return_t = \alpha + \sum_{s=0}^{4} \theta_s Oil\ return_{t-s} + \sum_{s=0}^{4} \beta_s Change\ in\ real\ ind\ prod_{t+s}$$

If the coefficients of current and past quarterly oil price returns remain significant (tested using an F-test) after controlling for changes in current / expected quarterly future cash flows, this constitutes evidence of overreaction.

In the US and Canada those moves were rational…

The authors find that for the US and Canada, once we account for the current and future cash flows, the oil shocks turn insignificant. It appears that, for these two countries, the effect of the oil price on the market has been rationally priced (at least for the period tested in the paper); in other words, the market moved only as much as would be expected given the effect of the price shock on the current and future cash flows.

…but in Japan and the UK the markets appeared to overreact

In contrast, in the UK and in Japan, the authors found that the oil shocks remained significant, even after the inclusion of cash flow variables. This finding can be interpreted as oil shocks affecting future expected returns in these two countries.

To investigate the validity of this hypothesis, the authors additionally run the same regression as above after adding proxies for changes in expected future returns. Even with this adjustment, the oil price returns remained significant in the UK and Japanese universes (and remained not significant in the US and Canada). This suggests that in these two markets, oil price shocks were causing (at least up until 1991) the markets to move by more than what was rationally justified.

This paper has been a classic reference on the relationship between oil price changes and the stock market, so we have decided to update the findings with more recent data.

Updating the paper with recent data

In more recent times, both US and UK markets react rationally to oil price shocks

We have attempted to replicate the analysis of the paper for the US, using the S&P 500, and the UK, using the FTSE 100, over the period between 1992 and 2014. We stop the sample period a year in the past as we need four quarters of future industrial production growth for the regression. Figures 3 and 4 present the results of our analysis.

In the US, we found very similar results in our new sample period as the authors did in their paper. Oil returns are strongly associated with future returns to the S&P 500 and a Granger causality test suggests a causal relationship. When we run the regression using both the oil returns and the future industrial production growth (to proxy for changes in future cash flows) the coefficients of oil returns are not significant. This implies that, while the oil price shocks can move the US market, this does not overreact.

In the UK, we also find Granger causality, suggesting that oil price moves do affect future FTSE 100 returns. In contrast to the findings of the paper though, we find that, once we include the proxies for changes in future cash flows, the oil return is no longer significant to future returns of the FTSE 100. That suggests that the UK stock market no longer overreacts to oil price shocks. Put differently, the opportunity to profit from market overreaction to oil price shocks is no longer available in the UK.

Figure 3: Results of US regression

	Estimate	T-stat	Pr(>|t|)
Intercept	0.01	1.79	8%
Current cash flow	0.78	0.82	42%
Cash flow for t+1	1.52	1.36	18%
Cash flow for t+2	0.93	0.81	42%
Cash flow for t+3	-0.21	-0.20	85%
Cash flow for t+4	0.52	0.56	58%
Current return to oil	0.02	0.50	62%
Return to oil at t-1	0.05	1.07	29%
Return to oil at t-2	-0.09	-1.81	7%
Return to oil at t-3	0.01	0.22	83%
Return to oil at t-4	-0.01	-0.29	77%
Adjusted R-squared	21.2%		
F-statistic	3.40		
P-value	0%		

Are all of oil return coefficients are zero? – **Fail to reject null hypothesis**

F-statistic	1.05
P-value	40%

Source: UBS Quantitative Research. The regression is run using quarterly data between 1992 and 2014. For illustrative purposes only

Figure 4: Results of UK regression

	Estimate	T-stat	Pr(>|t|)
Intercept	0.02	2.28	3%
Current cash flow	0.37	0.52	61%
Cash flow for t+1	1.59	2.27	3%
Cash flow for t+2	0.31	0.41	68%
Cash flow for t+3	0.47	0.66	51%
Cash flow for t+4	0.40	0.59	56%
Current return to oil	0.00	0.02	98%
Return to oil at t-1	0.03	0.70	49%
Return to oil at t-2	-0.03	-0.62	54%
Return to oil at t-3	-0.01	-0.27	79%
Return to oil at t-4	-0.04	-0.99	33%
Adjusted R-squared	8.9%		
F-statistic	1.87		
P-value	6%		

Are all of oil return coefficients are zero? – **Fail to reject null hypothesis**

F-statistic	0.38
P-value	86%

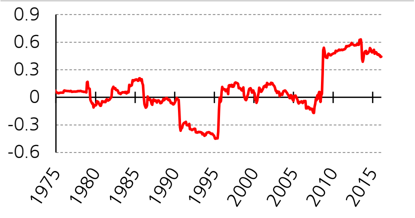
Source: UBS Quantitative Research. The regression is run using quarterly data between 1992 and 2014. For illustrative purposes only

"Oil Prices and the Stock Market"

by Robert Ready

Academic evidence (e.g. Hamilton, 2003) has shown that there is a statistically strong negative correlation between increases in oil price and *future* economic growth, as economic downturns typically occur following significant oil price increases, there appears to exist no statistically strong *contemporaneous* relationship between oil price changes and stock market returns; Figure 5 presents the 60-month rolling correlation between Brent crude oil price changes and MSCI World returns, which generally validates the above point.[1]

Figure 5: Equity-Oil Correlation



Source: UBS Quantitative Research, Datastream. The figure presents a 60-month rolling correlation between changes in Brent Crude oil price and returns of the MSCI World Index. The sample period is from January 1970 (hence first observation becomes available in January 1975) and February 2016.

At first glance, the lack of a contemporaneous relationship appears puzzling, given the importance of oil for the overall economy. This motivates Robert Ready to explore whether supply or demand driven shocks that cause oil price to change have genuinely different impact on stock returns.

An increase in the oil price can be:

- **Demand driven (good news)**
- **Supply/production driven (bad news)**

Trivially, the oil price moves if there is an imbalance between oil demand and oil supply. The oil price is expected to increase if the demand increases or if the supply falls. Interestingly, when demand increases, it is generally interpreted as good news for the overall economy. Instead, if the supply falls due to an oil production cut, this is generally interpreted as bad news for the overall economy. What becomes obvious from this discussion is that oil price shocks can have different interpretations depending on the underlying source of the shock.

Hypothesis:

- **The returns of oil producing firms can proxy for demand shocks**
- **Oil producing firms can act as a natural hedge against oil supply shocks**

Unfortunately, demand and supply shocks are latent and not directly observable. In order to estimate demand and supply shocks from observable quantities, the author of the current paper sets out the following hypothesis. Oil producing firms should generally benefit from increases in oil demand; if the demand for oil increases, the oil price generally increases and therefore oil producing firms sell more oil at higher prices. These dynamics should (all other being equal) lead to positive returns for the stocks of these firms. On the contrary, if the price of oil increases due to a production cut, the effects are not as clear; oil producing firms will generally sell less (though at a higher price), but at the same time their natural oil reserves will not be depleted at a high rate. To cut a long story short, oil producing firms can be thought of as a natural hedge against oil supply shocks.

Theoretical model and simulated results

Following this intuition, the author develops a stylised model of competitive oil producing firms. Based on the model assumptions, these firms take the price of oil as given and optimise their production levels in order to maximise firm value (i.e. maximise the discounted expectation of future profits from selling oil at the prevailing market price). The objective of the model is to examine whether the stock returns of such oil producing firms can indeed be used to separate the demand driven oil price shocks from the supply driven ones.

The model is first calibrated to real data and then simulated results are generated. These simulated results confirm the original hypothesis of the author: the returns of oil producing firms exhibit different type of dependence on supply and demand shocks; they are strongly and positively correlated to demand shocks, whereas they are virtually uncorrelated to supply shocks. This shows that the stock returns of oil producing firms can be used in practice in order to isolate oil demand shocks as

[1] It is worth highlighting that the most recent period (post-2008) has been characterised by relatively higher levels of correlation between oil price changes and stock returns.

long as we first control for any shocks in the discount rate (or equivalently, control for shocks in investor risk aversion).

Empirical analysis

Following from the insights gained from the simulated results, the author moves to the core empirical section of the paper and tries to construct supply and demand shocks using the following variables for the period January 1986 - December 2011:

- **Index of oil producing firms**: World Integrated Oil and Gas Producer Index, obtained from Datastream.
- **Oil price changes**: monthly returns of the second nearest maturity NYMEX Crude – Light Sweet futures contract.
- **Stock market returns**: aggregate US CRSP market index.
- **Unexpected changes in risk aversion**: the residuals from an ARMA(1,1) model on the changes in VIX are used to proxy for the unexpected changes in market discount rates, which may also drive aggregate market returns (see Bollerslev, Tauchen and Zhou, 2009).

The correlations between these four variables (see Figure 6) are completely in line with the thesis of the paper. Stock market returns are virtually uncorrelated with oil price changes, even though the returns of oil producing firms are both positively correlated with market returns *and* oil price changes. This effectively means that there must be some latent mechanism that blurs the transmission of information between market returns and oil price changes; the author claims that this is due to different market responses to oil supply and demand shocks. Interestingly, the unexpected changes in the level of VIX are (as expected) negatively correlated with stock market returns and oil producing stock returns, but show very little correlation with oil price changes.

Figure 6: Correlation Matrix

	(1)	(2)	(3)	(4)
(1) US Market Returns	1			
(2) Oil producer Index Returns	0.62	1		
(3) Innovations in VIX	-0.67	-0.45	1	
(4) Oil price changes	0.07	0.46	-0.11	1

Source: "*Oil Prices and the Stock Market*" by Robert Ready; part of Panel A/Table 3, reproduced with permission. Sample period is from January 1986 to December 2011.

Using three of the above variables (the oil producing stock returns, the oil price changes and the innovations in VIX), the author extracts the latent oil supply shock, oil demand shock and risk shock (this is just a scaled version of VIX innovation) at the end of each month. The demand shock is estimated as the proportion of the returns of oil producing firms, which is orthogonal to the unexpected changes in risk aversion (i.e. innovations to VIX), whereas the supply shock is estimated as the proportion of oil price changes that is orthogonal to both the demand shock and the innovations to VIX.[2]

Variation in oil price changes:

- **78% supply driven**
- **21% demand driven**
- **1% risk (VIX) related**

Once these shocks are extracted, the author then goes on and investigates their time-series relationship with stock market returns as well as industry returns. Before commenting on the results, it's worth reporting that 78% of the time-series variation in oil price changes is classified as supply shocks, 21% of the variation is classified as demand shocks and only 1% is captured by the VIX innovations.

By regressing US market returns on oil price changes on a univariate basis, the author does not uncover any statistically significant relationship, as it was expected following our discussion on Figure 5 in the previous page. However, when oil price changes are substituted with the three extracted types of shocks (supply, demand, risk), various significant relationships are uncovered:

[2] In matrix form:

$$\begin{bmatrix} Oil\ price\ changes\ (t) \\ Oil\ producer\ returns\ (t) \\ VIX\ innovations\ (t) \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 0 & a_{22} & a_{23} \\ 0 & 0 & a_{33} \end{bmatrix} \cdot \begin{bmatrix} supply\ shock\ (t) \\ demand\ shock\ (t) \\ risk\ shock\ (t) \end{bmatrix},$$

with the assumption being that the three types of shocks are orthogonal to each other.

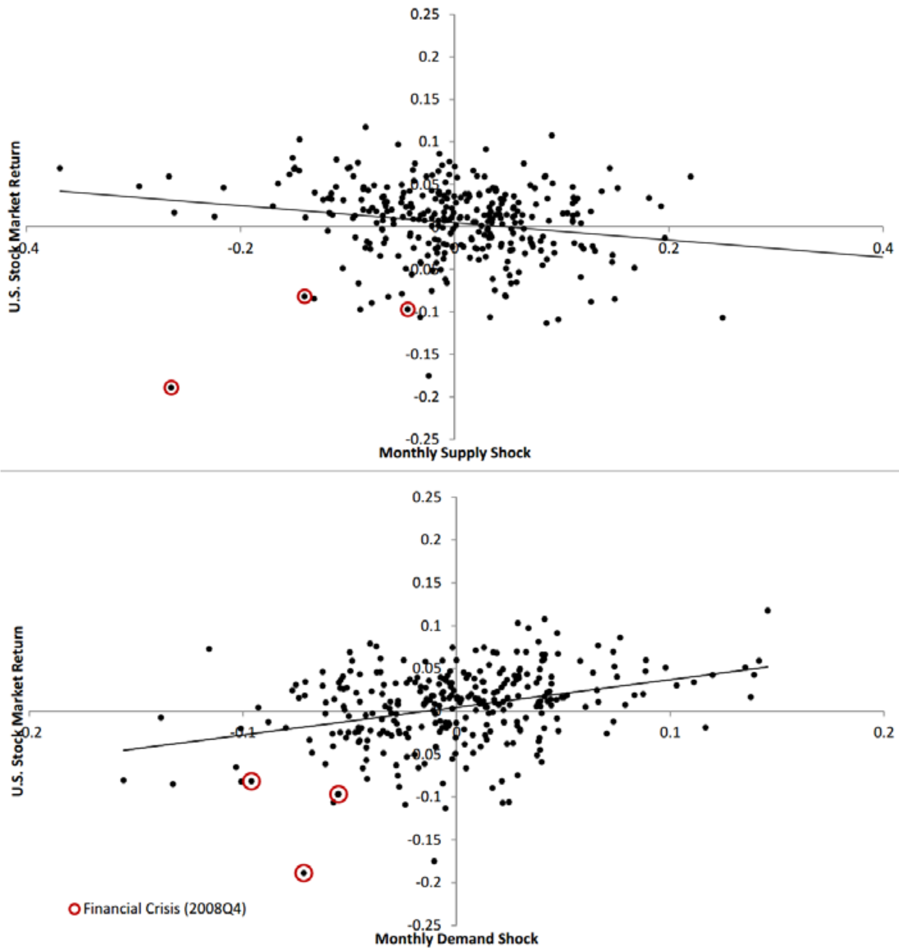
- Higher oil prices driven by a **demand shock** are **positively** and statistically significantly related to aggregate stock market returns and are therefore perceived as good news.
- Conversely, higher oil prices driven by a **supply shock** are **negatively** and statistically related to aggregate stock market returns and are therefore perceived as bad news.
- Lastly, and rather trivially, increases in the level of risk are generally related with lower aggregate market returns.

To illustrate the above points, Figure 7 below presents scatterplots between monthly supply and demand shocks against US market returns; the documented negative and positive respective relationships are quite apparent.

Figure 7: US Stock Returns and Oil Supply and Demand Shocks (01/86 – 12/11)

Demand-driven oil price shocks affect positively the stock market

Supply-driven oil price shocks affect negatively the stock market



Source: *"Oil Prices and the Stock Market"* by R. C. Ready; Figure 2, reproduced with permission. The figures contain the scatterplot between monthly US aggregate stock returns against realisations of oil supply and demand shocks. Monthly observations for the three months of the 2008 Financial Crisis (09/2008 – 11/2008) are circled. The sample period of the analysis is between January 1986 and December 2011.

The above findings are rather important as they reveal strong latent relationships between oil supply and demand shocks and the aggregate stock market, which are impossible to be identified if one only focuses at the observed oil price changes.

Having identified the above patterns, the author then looks into the interaction between oil demand and supply shocks and the returns of all different equity industries. This analysis is conducted between January 1986 and June 2008, so it is an important question whether the findings hold in the post-crisis period. We leave this question for further examination in a future UBS research note.

First, the author reports the supply shock and demand shock betas of the ten industry portfolios by Kenneth French[3]:

- All industries are **negatively** exposed to oil supply shocks (nine of them statistically significantly), but it is the industries which are highly dependent on **consumer spending** (consumer durables, consumer non-durables and retail) that exhibit the largest negative betas in the cross-section.
- All industries are **positively** exposed to oil supply shocks (eight of them statistically significantly), but the industries with **high oil use** (energy, utility, manufacturing) exhibit the largest positive betas in the cross-section.

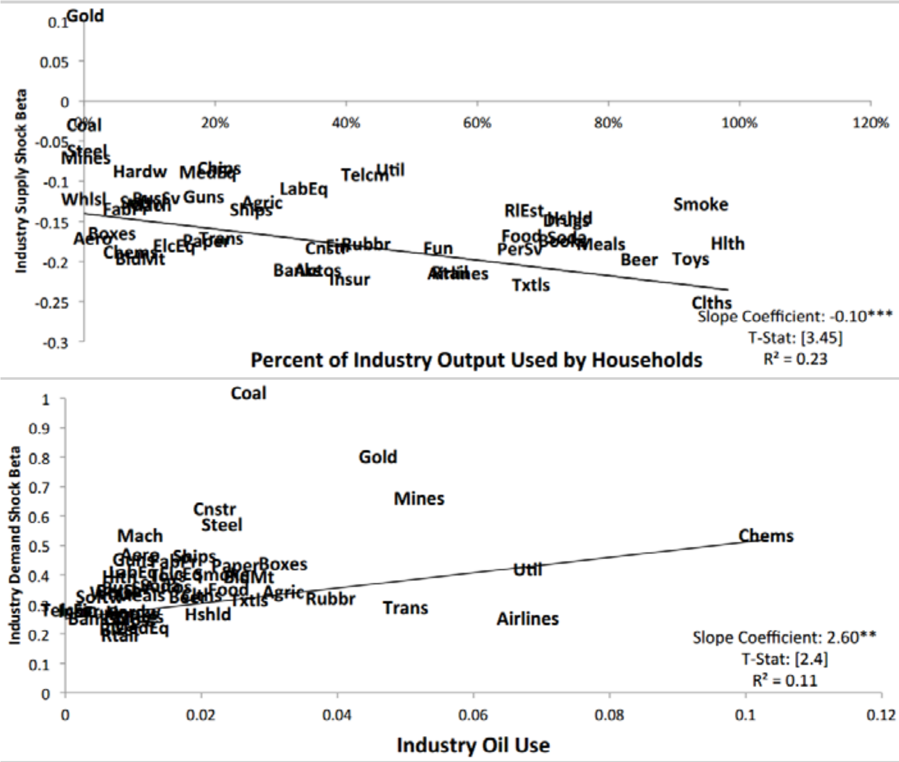
Industries:

- **…that produce consumer goods are more strongly negatively exposed to oil supply shocks**
- **…with high oil use are more strongly positively exposed to oil demand shocks**

Interestingly, both supply and demand shock betas are largely unrelated to market betas, hence showing that these shocks constitute a different source of return to aggregate market shocks.

Extending the analysis using more granular industry classification, the author explores the above dependencies in the 49 industry portfolios of Kenneth French. Figure 8 presents the supply shock betas of these portfolios against the proportion on output goods used by households (top chart) and the demand shock betas of these portfolios against the amount of oil that they use as input (bottom chart).

Figure 8: Oil Supply and Demand Betas Analysis



Source: "*Oil Prices and the Stock Market*" by R. C. Ready; parts of Figures 7 and 8, reproduced with permission. The figures contain the scatterplots between the supply shock betas of 49 industry portfolios against the proportion of output goods used by households (top chart) and the demand shock betas of these portfolios against the amount of oil that they use as input (bottom chart). Sample period: January 1986 to June 2008.

The results largely confirm the main findings of the paper; industries whose products are sold directly to consumers are more (negatively) impacted by oil supply shocks, whereas industries with higher use of oil are more (positively) impacted by oil demand shocks.

[3] The return series of the industry portfolio are obtained from the website of Kenneth French: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

"How does stock market volatility react to oil shocks?"

by Andrea Bastianin and Matteo Manera

What are the underlying sources of oil price changes and how do they affect US equity volatility?

The objective of this recent paper by Andrea Bastianin and Matteo Manera is to investigate the impact of oil price shocks on the volatility of the broad equity market. However, one could argue that the underlying cause of an oil price shock can have different implications to the stock market volatility. For this reason, similar to the previous paper that we reviewed and following from Kilian (2009), the authors first assume that the (real) price of crude oil would generally change due to the following supply or demand effects:

- **Supply-driven:**
  1. Shocks to the supply of crude oil
- **Demand-driven:**
  2. Shocks to the aggregate demand for industrial commodities
  3. Shocks to the demand exclusively for crude oil

The question therefore boils down to how these different supply or demand shocks that determine the oil price would eventually propagate to the equity markets and most importantly to the volatility of the equity markets.

To answer the question, the authors first recognise that these shocks are not directly observable and they therefore have to imply them from observable data. For this reason the empirical analysis in the paper is split in two major parts.

Step 1: identify the supply and demand shocks

Structural VAR model (Kilian, 2009):

- **Input:**
  1. Changes in oil production
  2. Real economic activity
  3. Real crude oil price
- **Output:**
  1. Oil supply shock
  2. Aggregate demand shock
  3. Oil demand shock

First, the authors isolate the underlying sources of oil price shocks by employing the heavily-cited structural vector autoregressive (SVAR) model of Kilian (2009), which effectively relates the supply (for oil) and demand (both aggregate and oil-specific) shocks to three variables:

- The **annualised logarithmic change in world crude oil production**: estimated using data on world oil production that is retrieved from the US Energy Information Administration's Monthly Energy Review.
- An **index of real economic activity**: the index captures the monthly changes in the world demand for industrial commodities, including oil, and has been constructed by Kilian (2009). Monthly observations for the index are available at Lutz Kilian's website[4].
- The **real price of crude oil**: this the refiner's acquisition cost of imported crude oil, as maintained by the US Energy Information Administration, deflated by the CPI for All Urban Consumers.

The model is based on two assumptions: (a) that oil supply is exclusively driven by changes in oil production and that it does not respond at all to changes in the demand side, and (b) that real economic activity is determined both by the oil supply and by the aggregate demand for industrial commodities, but is only affected by oil-specific demand in a lagged manner. For further details on this model, please refer to Kilian (2009). The sample period of this first step is between February 1973 and December 2013, with the first estimates for the supply and demand shocks becoming available in February 1975 (this is because the SVAR model uses 24 monthly lags).

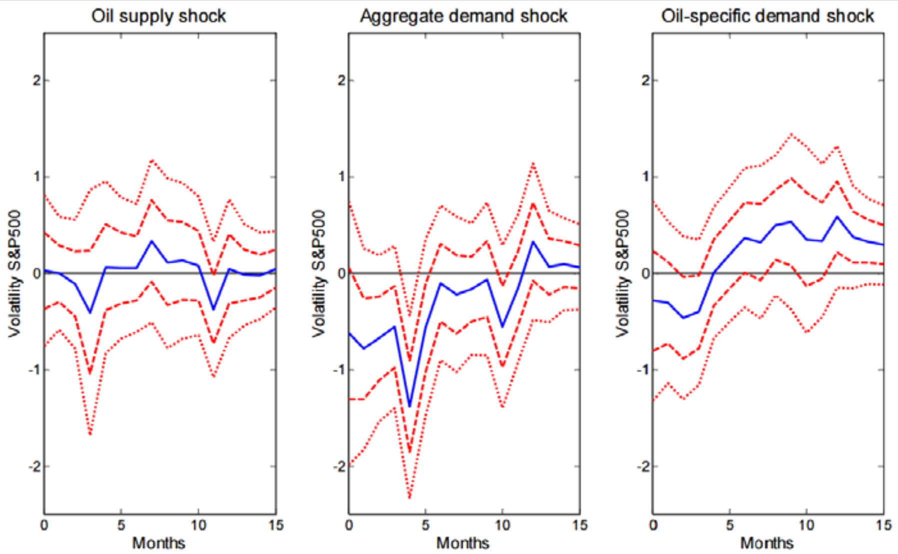
[4] Data for the index of real economic activity can be found at the website of Lutz Kilian. Direct link to the data: http://www-personal.umich.edu/~lkilian/reaupdate.txt

Once the underlying supply and demand shocks are extracted from the time-varying covariance structure of the above variables, the authors subsequently investigate the way by which these shocks affect future equity market volatility. For that purpose, they estimate three bivariate vector autoregressive (VAR) models (using 12 lags) that relate each one of the extracted supply or demand shocks to realised market volatility. These models are built based on the assumption that, even though crude oil price responds to past information, there is no instantaneous feedback between realised volatility and oil shocks. This broad assumption has been relatively common in the respective academic literature and has also been empirically supported by the findings of Kilian and Vega (2011).[5]

Step 2: explore how lagged oil supply and demand shocks affect stock market volatility

The output of the three VAR models are impulse response functions that describe how different types of supply and demand shocks for oil and industrial commodities eventually propagate to equity market volatility. Figure 9 presents the response of the realised volatility of S&P500 (along with confidence interval bands) to a one-standard deviation shock to the supply of oil, the aggregate demand for industrial commodities and the oil-specific demand.

Figure 9: Responses of S&P500 volatility to (positive) structural oil shocks



Source: *"How does stock market volatility react to oil shocks?"* by A. Bastianin and M. Manera; Figure 1, reproduced with permission. The figure presents the response of the annualized realised volatility of S&P500 to a one-standard deviation structural shock (continuous line), as well as one- (dashed line) and two-standard error bands (dotted line). The sample period is February 1975 to December 2013.

The evidence shows that the response of equity market volatility to an oil supply shock is very small in magnitude and statistically insignificant. Instead, the equity market volatility appears to mainly respond to demand-driven shocks. In particular, a demand shock for industrial commodities appears to be generally perceived as good news, hence causing a significant reduction in market volatility (especially for the first few months), which lasts even up to a year, though eventually lacking statistical significance. On the contrary, a demand shock specifically for oil, even though it initially appears to reduce volatility, after a semester the effect switches sign and causes a statistically significant increase in market volatility. This delayed effect could potentially be related to the fact that increased demand for oil could be driven by uncertainty about future oil supply and therefore constitute

Findings: market volatility…

- …is **unrelated** to oil supply shocks
- …**falls** when aggregate demand for industrial commodities increases ("good news")
- …**increases** in the medium term when (precautionary) oil demand increases ("bad news")

[5] This assumption is also supported by the paper by Ready (2015) that we have just reviewed in pages 5-8 of the current report, which finds that only 1% of the time-series variation of oil price changes is due to unexpected changes in VIX.

precautionary activity. Along these lines, such an oil-specific demand shock can indicate greater macroeconomic uncertainty, which is then reflected in equity market volatility.[6]

Industry and Country analysis

Following the documentation of these patterns in the US equity market, the authors then continue their analysis by exploring similar links across different industries and countries. In particular, they investigate whether supply or demand driven shocks in crude oil or in industrial commodities have significant impact on the volatility of four US industry portfolios[7] (oil and gas, precious metals, automobile, and retail) and three (other than US) country equity markets[8] (Japan, Norway, and Canada). The sample period remains February 1975 to December 2013 for the industry analysis and shrinks to January 1988 to December 2013 for the country analysis due to data availability.

The nature of the industry or the country matters very little for the relationship between stock volatility and oil supply or demand shocks

Broadly speaking, the documented evidence for the US market carries over to the industry and non-US equity market volatilities. There are a few exceptions to the general patterns (please see the paper for further details), but the overall finding is that the heterogeneity of different industries or countries does not seem to play a significant role on the way that their volatility responds to different supply or demand shocks or crude oil and industrial commodities. This is of course contrary to what happens to the real stock prices themselves, which are significantly more (or less) related to the oil price shocks depending on the nature of the industry or the country of interest (see also the analysis in page 8 and Figure 8 of this report).

The most pervasive effect across all four industries and countries is that their respective volatility falls for a period of even up to six months, following a significant increase in the aggregate demand for industrial commodities. In other words, such a demand hike is generally considered as good news irrespective of the energy intensity of the industry or of whether a country is a net exporter or net importer of oil.

Finally, the authors conduct a series of robustness checks: different oil shock proxies, different model, different sampling frequency (quarterly instead of monthly) different volatility estimates (using GARCH or even using implied volatility, VIX). Their main findings remain qualitatively unaltered.

One remark

One interesting remark, before we continue with the next paper: the last two papers that we reviewed, first by Ready (2015) and this one by Bastianin and Manera (2016) use two different methodologies to extract oil supply and demand shocks. It would be interesting from a research perspective to investigate how consistent their results are with each other. In other words, how similar are the supply and demand shocks that are extracted from these two methodologies? We leave this for future research.

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[6] For those familiar with the relevant literature, the results of this paper seem to be partly at odds with the results of Degiannakis, Filis and Kizys (2014), who similarly study the effects of oil shocks on the volatility of the European market and report no significant link between oil-specific demand shocks and market volatility. The authors of the paper that we review attribute the difference in the results to methodological and data/sample period differences.
[7] Monthly returns for the industry portfolios are retrieved from the website of Kenneth French: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[8] The selection of the countries is partly motivated by data quality and availability and partly for comparison purposes with other existing academic studies. Based on calculations of the authors of the paper, as of 2010, US and Japan were the #1 and #3 largest crude oil net-importers (the second spot was captured by China), whereas Norway and Canada were the #9 and #18 net-exporters (Saudi Arabia, Russia and Iran were the top 3 world net exporters).

"Understanding the Decline in the Price of Oil since June 2014"

by Christiane Baumeister and Lutz Kilian

As highlighted in the introduction of this ARM, oil price suffered one of its most extreme declines over the second half of 2014; using data from Datastream, the price of Brent crude oil fell from the high levels of $112.79 on June 30th, to $55.84 on December 31st. This sharp fall and its underlying causes constitute the main focus of this recent paper by Christiane Baumeister and Lutz Kilian. Understanding these dynamics is important, especially if we consider that oil price fell even further ever since, reaching recently a multi-year low of $27.82 on January 20th, 2016.

Facts about the period between June 2014 and December 2014

The authors initiate their analysis by first describing the market dynamics during the second half of 2014 and by elaborating further on the events that could –in theory– have affected the supply and demand for crude oil:

- On a global scale, **oil production** increased in the second half of 2014, but the increase has been modest.[9] However, it is important to highlight that it is not merely the size of the production increase that matters, but instead it is how this increase compares to expectations; if the expectations were that oil production would fall, then an increase, whether modest or otherwise, constitutes a sizeable "surprise" that might cause a significant oil price shock.
- The index of **real economic activity**[10] that has been constructed by Kilian (2009) and captures the monthly changes in the world demand for industrial commodities (including oil) was negative for the entire year of 2014, even though some relative recovery was documented between June and November, partly driven by the significant oil price fall.
- The price of **other industrial commodities** (raw materials, metals) also fell during the second half of 2014 by about 5% to 15%. This might lend some support to the idea that the crude oil price fall is related to a global business cycle. However, that fact that crude oil fell by a significantly large amount (44%) shows that there exist oil-specific dynamics that should be explored.
- **Crude oil inventories** remained relatively flat during the second half of 2014. It is important to highlight, however, that the relationship between demand for storage and the oil price is not straightforward. The authors provide a detailed discussion on the dynamics between unexpected change in the demand for storage and future inventories; the reader is advised to look at the paper for further details.
- The **USD trade-weighted exchange rate** appreciated during the second half of 2014, hence one could argue that the price of oil became more expensive for non-US refineries, and therefore non-US demand for oil fell. Even though this can explain part of the oil price fall, the authors set out a list of doubts (e.g. if this was the case, then why didn't all the other USD-denominated industrial commodities suffer from such an extreme price fall?).

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[9] Here are some statistics reported in the paper:
- Saudi Arabia reduced its production by 0.23%, having a Dec-14 world share of 12.18%
- US increases its production by 1.90%, having a Dec-14 world share of 13.12%
- Former USSR countries increased their production by 3.90%, having a Dec-14 world share of 14.90%.
- Iraq, Libya and Syria combined increased their production by 18.06%; however, their percentage share of world oil production only increased marginally, reaching a Dec-14 world share of 4.59%.

[10] Data for the index of real economic activity can be found at the website of Lutz Kilian. Direct link to the data: http://www-personal.umich.edu/~lkilian/reaupdate.txt

All the above indicators of supply and demand for crude oil could, in theory, have contributed to its price decline. However, the marginal effect of each shock requires fitting a structural model for the oil price, before making any statements.

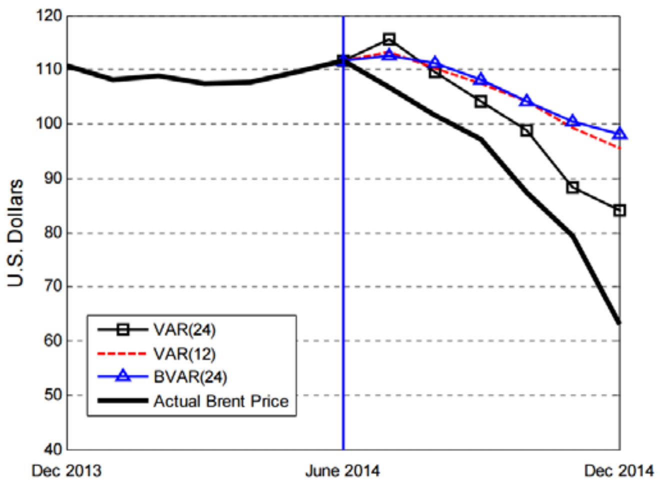
Could we have predicted the oil price decline in June 2014?

Due to data limitations at the time that the paper was written (data on inventories for the period of interest were not readily available), the authors of the paper take a different perspective and investigate whether the sharp price fall in the second half of 2014 could have been predicted, or put differently, whether economic conditions that were prevailing in June/July 2014 could have hinted towards a future oil price decline.

In order to answer this question, the authors employ a four-variable vector autoregressive (VAR) forecasting model, which has been introduced by them at an older paper of theirs (Baumeister and Kilian, 2012). The four variables of the model are (a) the **real price of oil**, estimated as the US refiners' acquisition cost of imported crude oil deflated by CPI, (b) the **percentage change in world crude oil production**, estimated using data from the US Energy Information Administration's Monthly Energy Review, (c) the **index of real economic activity** by Kilian (2009) that has already been discussed above and (d) a proxy for **changes in global oil inventories**.

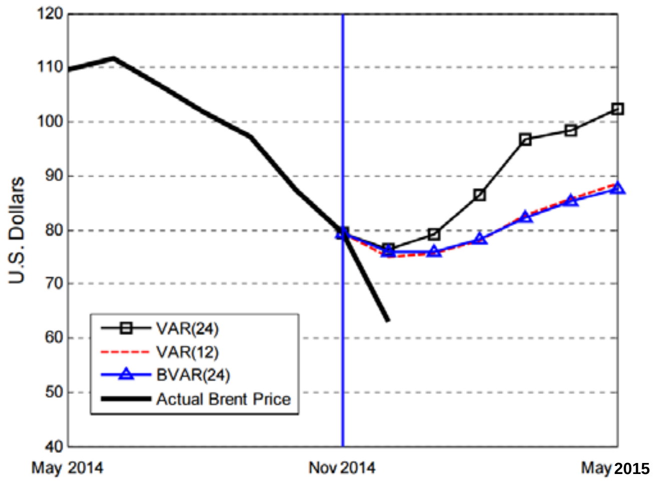
The authors estimate the baseline model using 24 lags (but also provide robustness results using either a Bayesian variant of the model, BVAR, or using just 12 lags) and provide real-time forecasts (for up to 6 months forward) for the crude oil price as they would be made available on a monthly basis from the end of June 2014 up until the end of December 2014. For illustration purposes, Figures 10 and 11 present these forecasts as of the end of June 2014 and end of November 2014 (please see the paper for the entire sequence of forecasts).

Figure 10: Real-time forecasts of crude oil price in June-14



Source: "*Understanding the Decline in the Price of Oil since June 2014*" by C. Baumeister and L. Kilian; Figure 2a, reproduced with permission. The figure presents the real-time forecasts for the crude oil price at the end of June 2014.

Figure 11: Real-time forecasts of crude oil price in Nov.-14



Source: "*Understanding the Decline in the Price of Oil since June 2014*" by C. Baumeister and L. Kilian; Figure 2d, reproduced with permission. The figure presents the real-time forecasts for the crude oil price at the end of Nov. 2014.

So, the June 2014 VAR(24) forecasts predicted that the oil price would fall to $99 by October 2014 and to $84 by December 2014, more than half (c. 57%) of the actual oil price fall during this period. Interestingly, as the authors claim, this price decline would have been impossible to be forecast using oil futures, as the futures curve at the end of June 2014 ware relatively flat. The authors attribute this poor forecasting power of futures contracts to a time-varying risk premium.

The authors conduct a number of robustness and plausibility checks of their analysis and show that the performance of the forecasting model is not due to luck. As a result, they then go on and discuss the reasons why the forecasting model would have been able to forecast such a dramatic price decline. They argue that for this to be the case, it must be that the model is capturing some structural shocks that have already occurred prior to July 2014. Using some additional analysis, the authors find that around 60% of the predicted (at the end of June 2014) price fall up until the end of December 2014 is due to the supply side of the oil market, as this is captured by the percentage change in world crude oil production variable of the model.

The model must have captured structural shocks that should have occurred prior to July 2014.

➔ The supply side appears to play an important role

If the forecast price decline has been due to structural shocks that happened prior to July 2014, then surely the part of the price decline that would have been impossible to have been predicted (at least with the given model) must be attributable to unexpected shocks that occurred post June 2014. By observing the consecutive one-month forecasts of the model, the authors conclude that there are mainly only two months when the model generated large forecast errors:

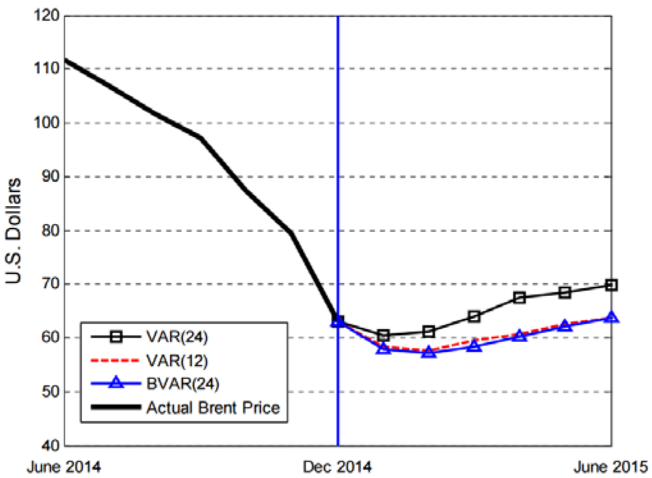
What did the model fail to predict?

- **End-of-June 2014**: as seen in Figure 10, the July 2014 forecast for the oil price is about \$9 higher than the actual price at the end of that month. The authors find that this was largely due to an unexpected fall in inventories and therefore in the demand for storage, given the simultaneous oil price drop.
- **End-of-November 2014**: as seen in Figure 11, the December 2014 forecast for the oil price is about \$13 higher than the actual price at the end of December 2014. The authors find that this was largely due to an unexpected slowdown of the global economy over that month (and in fact, not due to the OPEC announcement in November 27th against a cut in oil production).

The version of the paper that we currently review uses data up to the end of 2014 and was written around January/February 2015. The authors provide oil price forecasts as of the end of December of 2014, which, of course they weren't able to evaluate at the time (see Figure 12). However, we are now in a position to evaluate their purely out-of-sample forecasts. Figure 13 presents the actual price of Brent crude oil for the period up to the end June 2015. The data is monthly and is collected from Datastream.

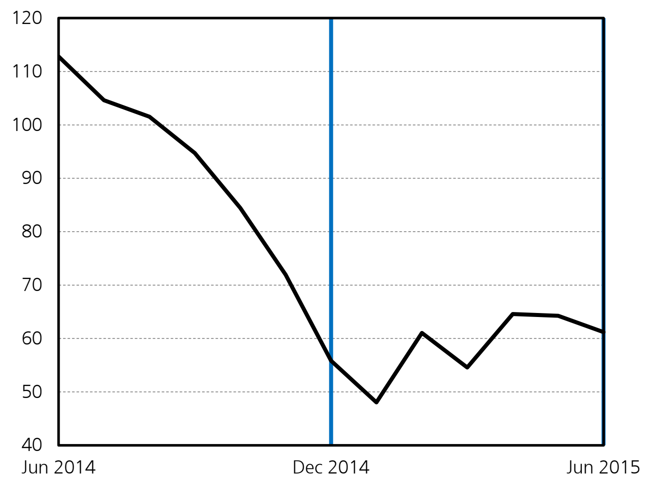
What were the out-of-sample predictions at the end of December 2014?

Figure 12: Real-Time Forecasts of Crude Oil Price in Dec-14



Source: "*Understanding the Decline in the Price of Oil since June 2014*" by C. Baumeister and L. Kilian; Figure 4, reproduced with permission. The figure presents the real-time forecasts for the crude oil price at the end of Dec. 2014.

Figure 13: Actual Brent Crude Oil Price [Datastream]



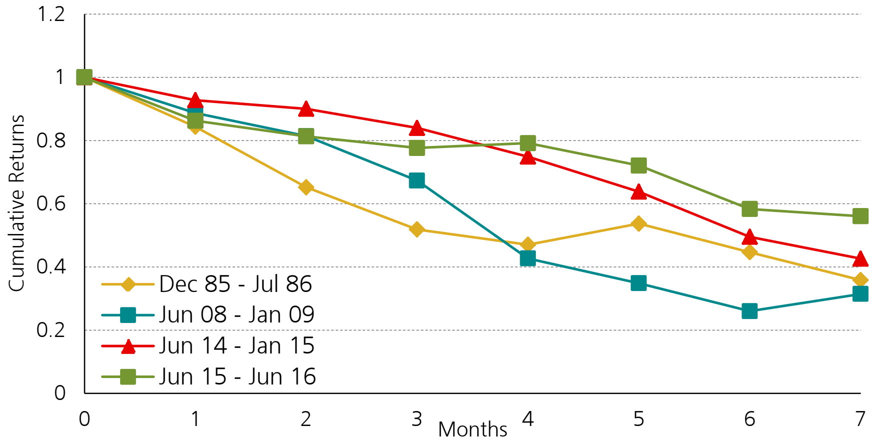
Source: Datastream. End-of-month data of Brent Crude oil price (Datastream ticker: OILBREN)

We have to admit that the results are quite impressive! After such a dramatic fall in 2014, the forecasting model in the paper manages to capture the price stabilisation and, in fact, slight increase during the first half of 2015 (before, of course, a new fall started in July 2015). As the authors stress, the predictions in Figure 12 assume no further demand or supply shocks; most importantly, they argue that if another decline realises itself (as it did since mid-2015), this should be attributed to unexpected supply or demand shocks.

Historical oil price crashes

The last part of the empirical analysis in the paper provides a brief comparison between various historical oil price crashes. In particular, the authors compare the price decline during the second half of 2014 that was studied above (during which Saudi Arabia kept its production virtually unchanged), against oil price falls in the first half of 1986 (when Saudi Arabia significantly increased its production) and in the second half of 2008 (when Saudi Arabia significantly reduced its production in response to the financial crisis). As the paper was written in January/February 2015 it did not capture the most recent price decline during the second half of 2015, but for the sake of illustration we add it in the list and present cumulative price change for Brent crude oil for all these four periods in Figure 14 below.

Figure 14: Oil Crises



Source: Datastream. End-of-month data of Brent Crude oil price (Datastream ticker: OILBREN) for four distinct historical periods. All prices series have been rescaled so to start at $1.

The main point that the authors make is that the historical evidence shows that the major oil producers of the world fail to stabilise the oil price following dramatic declines mainly due to a coordination problem. More importantly, they argue that the rise of Russia, US, Canada or even China as important contributors to global oil production the problem can only become worse.

Commentary by the UBS Head of Oil Research, Jon Rigby

Every time they say *it's different this time…* but the oil price collapse of 2014-16 does have some unique features. Firstly, it was partially prompted by the shale oil revolution, which was a largely mid and small size E&P company-driven initiative, capital intense in nature, and US focussed. Secondly, it was then catalysed by OPEC withdrawing from its traditional role on the modern oil market of supporting a price floor.

From an oil price perspective, 2014 saw a slowdown in demand – a combination of slower economic growth, especially in China, and some price effects – which meant the outturn was +800kb/d y/y versus a normal year of >1Mb/d. This plus the continued dramatic rise in US shale production (US production rose 1.8Mb/d in 2014) tipped the balance and led to Saudi Arabia's decision not to support a production cut at the November OPEC meeting. UBS' view is that this was an important event. It significantly changed the structure of the market and forced market participants to re-think the market in terms of marginal supply costs and the balance of supply and demand rather than where OPEC would provide a backstop floor. We would argue that is a structural change. This was emphasised by OPEC producers then actually raising production in the face of falling prices – up over 1Mb/d in 2015 and contributing to an over-supply of 1.5-2Mb/d or around 2% of the market. The build in inventories has been a physical manifestation of this over-supply and will likely persist even while the market repairs itself and prices likely rise.

And a word about the correlation between the oil price and equity markets. As the literature suggests demand driven positive price shocks are generally perceived as a "good news" item and vice versa. Similarly a positive supply shock (unusual historically) should be aggregate positive for the global economy and stock markets and vice versa. Hence the puzzle of why we would observe there has been a direct correlation between oil prices and the markets in recent months when the statistical work suggests that oil shocks are mixed. Firstly, the oil price fall has been considerable. The fall in the Brent price of close to $90/bbl between June 2014 and January 2016 is enormous. Why so big? This represents the distance between incentive pricing and the cash production cost of installed capacity. The scale of the fall has forced a profound change in spending and we estimate global capex 2014-17 maybe down more than $500bn of annual spend. Whatever the longer term positive impact of lower oil prices this has a major shock effect across the industrial and engineering world. Moreover, the new class of US E&P that drove the shale revolution is intrinsically tied into capital markets via both equity and especially debt. The major shortfall in cash is creating overspill into banks and capital markets.

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