Industry Analysis

The dynamics of U.S. crude oil production

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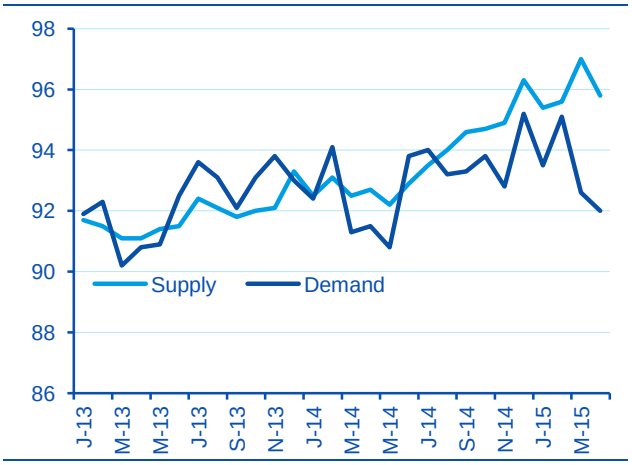
- **Hedging and debt have delayed the adjustment in production**
- **However, production will eventually slowdown as a result of lower oil prices**
- **Increasing rig productivity allows operators to mitigate risks**
- **Despite a cyclical deceleration, crude oil production will remain strong over the long-run, driven by global demand and better technology**

Introduction

Understanding the relationship between crude oil production, rig count and prices is one important step in the broader analysis of the oil and gas industry. In a context of lower prices, rig count and production should edge down. This has been the case for rigs but not for production for which the adjustment has taken longer-than-expected. Assuming no change in demand, lower prices should discourage exploration and production, forcing companies to scale back projects or accumulate inventories until prices return to profitable levels. The purpose of this brief is to discuss some of the reasons behind the observed and future dynamics of U.S. crude oil production.

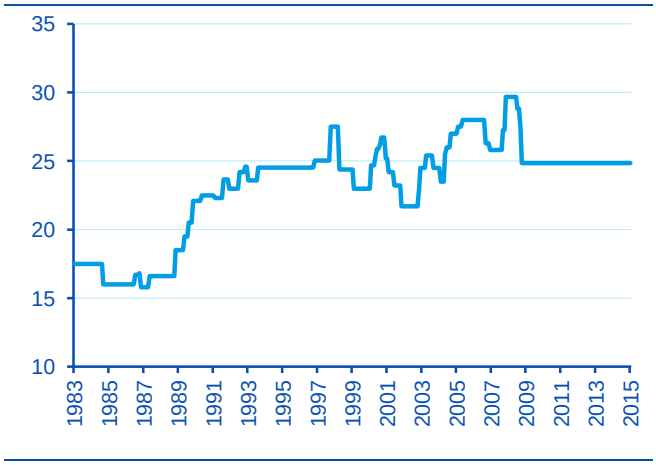
Between June 2014 and March 2015, the price of the West Texas Intermediate (WTI) crude oil barrel declined from $107 to $44. Supply and demand factors triggered the downfall. On the demand side, expectations for global economic growth were revised down due to a sluggish recovery in Europe, the impact of a stronger dollar, as well as the slowdown and re-balancing of the Chinese economy. On the supply side, the rapid increase in U.S. production along with the reluctance of OPEC to restrict supply created a surplus in the market. As we write this paper, oversupply persists. Prices have recovered although they are still far from their previous peak.

Chart 1
Global Supply and Demand for Oil (Mbbl/day)



Source: Haver Analytics

Chart 2
OPEC Pledged Production (Mbbl/day)

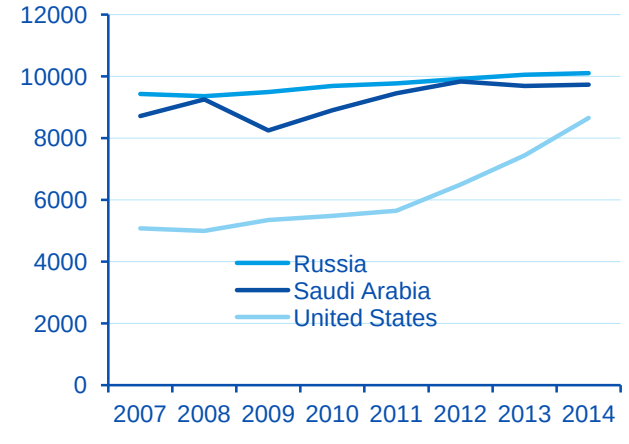


Source: Haver Analytics

Given OPEC's decision to maintain its production target unchanged, markets have turned to the U.S. as the stabilizing force. The use of hydraulic fracturing and horizontal drilling to extract oil and gas from shale formations triggered an exponential increase in crude oil production that allowed the U.S. to narrow the gap between Russia and Saudi Arabia, the two largest producers. Therefore, it has been argued that a drop in U.S. production is needed to bring back prices to higher levels, assuming that global demand remains the same and OPEC maintains current production quotas. Since the U.S. oil and gas industry is private and comprised by several companies, a substantial decline in domestic production would imply the disappearance of unprofitable firms and a significant reduction of drilling projects from the surviving companies.

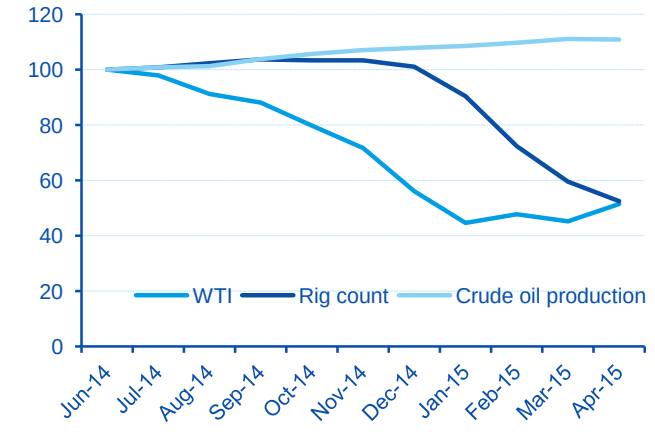
However, after nearly nine months of prices correction, domestic production has shown a significant degree of resilience, suggesting that production's reaction to oil prices occurs with some lags. From the time the WTI reached its last peak (in the week of June 20, 2014) to the time it reached a bottom (in the week of March 20, 2015), domestic output went from 8.4 million to 9.4 million barrels per day; meanwhile, the active rig count decreased from a maximum of 1,858 to 1,069. After March 20, 2015 the rig count continued to decline, even though prices went up again. Production, on the other hand, has only flattened.

Chart 3
Production of crude oil including condensate (Thous. bbl/day)



Source: BBVA Research and International Energy Agency

Chart 4
Crude oil production, rig count and prices (June 2014 = 100)



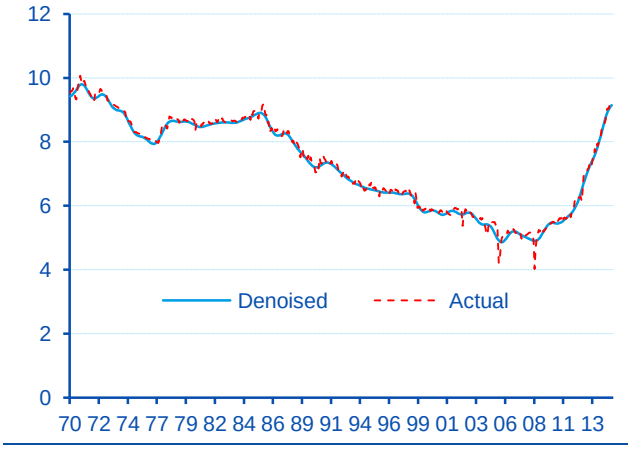
Source: BBVA Research and Haver Analytics

A time-series approach to understand the dynamics of U.S. crude oil production

Using time series analysis, we decomposed U.S. crude oil production in three parts: a long-run trend, a medium-run cycle, and a short-run noise. The long-run trend, or structural component, is determined by factors such as technology advancements and energy policies. Intuitively, changes in these factors tend to have a long-lasting impact on supply. On the other hand, the medium-run cycle, or cyclical component, is determined by companies' decisions to adjust their output based on current and historical information on demand, prices, competitive environment and financial conditions. The cyclical component is also driven by expectations of such variables. For instance, a firm may increase capital expenditures if demand is expected to increase or cut them if the latter is expected to fall. The short-run noise is purely random and has no economic rationale. Examples of short-term noise are disruptions from human errors or unanticipated natural phenomena. We obtained these three components by using the Christiano-Fitzgerald filter.[1]

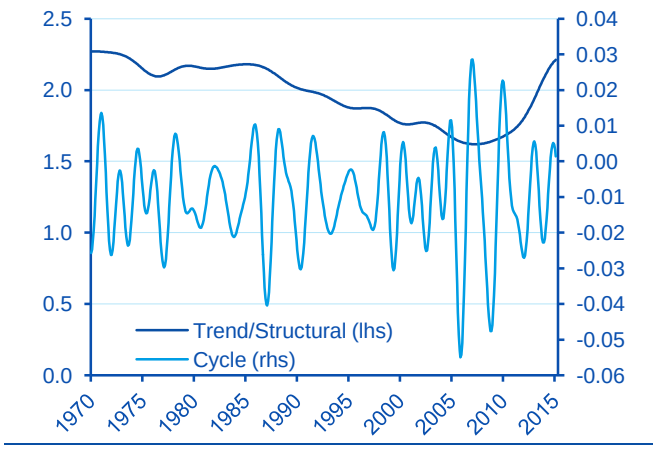
Chart 5 shows the comparison of the original series and the series without the random component or noise.

Chart 5
Crude oil production without noise, full sample (Mbbl/day)



Source: BBVA Research and Haver Analytics

Chart 6
Crude oil production decomposition (Log)



Source: BBVA Research and Haver Analytics

The structural component (Chart 6) is following an upward trend which can be explained to a large extent by technological progress. Since the early 2000s, horizontal drilling and hydraulic fracturing have allowed oil companies to tap previously inaccessible reserves located in shale formations. This technological "revolution" explains most of the upward trend in the series since 2007. Today, improvements in pad drilling (the ability to drill new wells from existing ones) or 4-D seismic technologies are examples of innovations that continue to help companies shorten cycle times and increase rig productivity at a rapid pace.

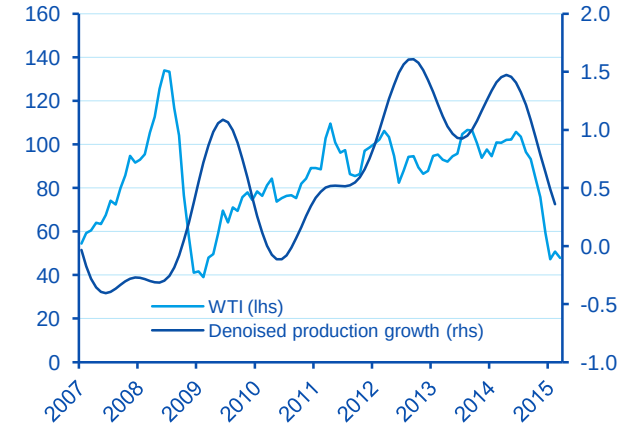
As Chart 6 illustrates, the cyclical component exhibited substantial volatility between 2004 and 2010. Two developments could explain this behavior, on the one hand, the oil and gas industry adjustment to the "shale revolution" which implied a new way to extract oil, the surge of new markets, the need for new inputs with different logistics, new and upgraded infrastructure, new regulation and environmental concerns. On the other

[1] Christiano, L., & Fitzgerald, T. (2003). The Band Pass Filter. *International Economic Review*, 44(2), 435-465.

hand, the financial crisis and the subsequent recession may have also altered the industry through a sharp drop in oil prices, tighter credit conditions and uncertainty. As prices went up again, and the global economy turned to recovery mood, the cyclical component stabilized. In 2015, the cyclical component reached a peak and has already turned down, suggesting that production will slow down in the following months.

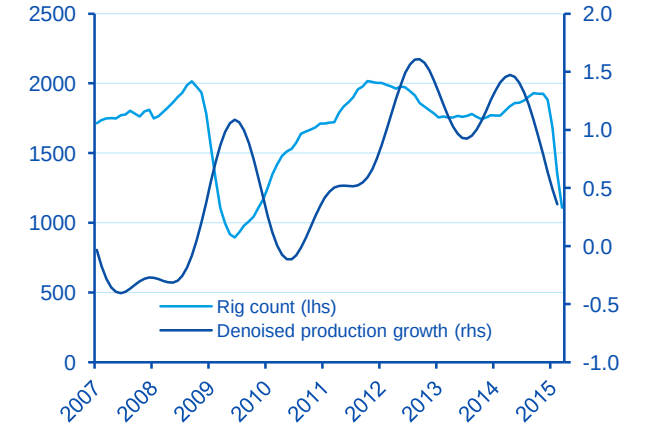
The relationship between production and prices is one of the key issues in the analysis of oil markets. Chart 7 presents a graphic version of this relationship after 2007. In general, price movements lead changes in production growth. This lagged reaction of production can be explained by factors such as contracts, cost structure and expectations.

Chart 7
Crude oil production growth and WTI



Source: BBVA Research and Haver Analytics

Chart 8
Crude oil production growth and rig count

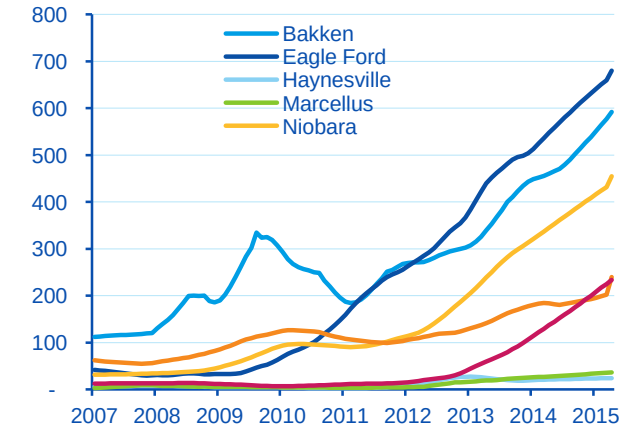


Source: BBVA Research and Haver Analytics

In addition to prices, the rig count is generally perceived as a leading indicator of future production. Chart 8 shows that the rig count leads crude production growth until 2014. However, following the price correction since mid-2014, the relationship seems less apparent. This illustrates the inter-temporal character of production-investment decisions. In an environment of low prices and tightening financial conditions, exploration and production companies (E&Ps) prioritize safe financial conditions over capital expenditures, therefore allocating more resources to existing production, which generates cash flows today, relative to investments that would yield a higher production in the future. In addition, Chart 9 shows that technological improvements have allowed operators to drill more with less, to the extent that the correlation between the rig count and oil production may have weakened.

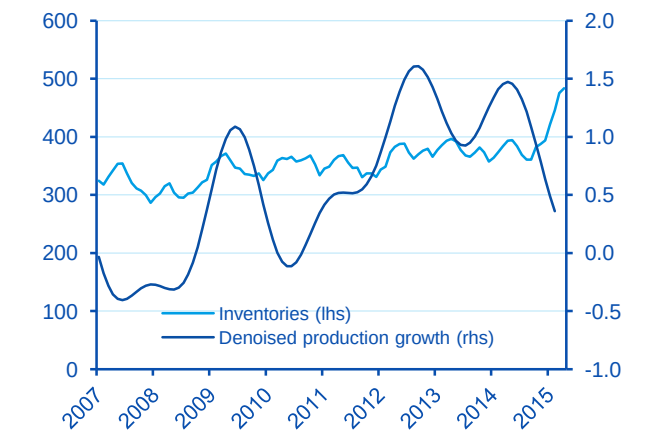
Inventories are also an important driver of production. For example, excess of inventories may deter investments and future production. Similarly, rapid inventory depletion may signal a stronger demand, which encourages production and investments. Inventories tend to be more volatile than production although they both experience the same trend. Since 2007, inventories of crude oil experienced steady growth until 2014, when their pace accelerated significantly. As of March 2015, crude oil stocks excluding strategic petroleum reserves reached 479 million barrels per day, the highest in almost 85 years.

Chart 9
Rig count productivity by shale play (bbl/day)



Source: Energy Information Administration

Chart 10
Crude oil production growth and inventories (Mbbl/day & %)



Source: BBVA Research and Haver Analytics

Quantifying the impact of prices and rig count in production

Based on the above analysis, we estimate the impact of oil prices, rig counts and inventories on oil production. Our estimations are based on the following assumptions: 1) the crude oil market in the U.S. is very competitive; 2) U.S. crude oil producers are price-takers; 3) once contracts are finalized, oil production will be very inelastic to oil prices; 4) oil rigs are for drilling and exploration, and hence actual production is behind the drilling represented by rig counts, 5) companies can hedge production.

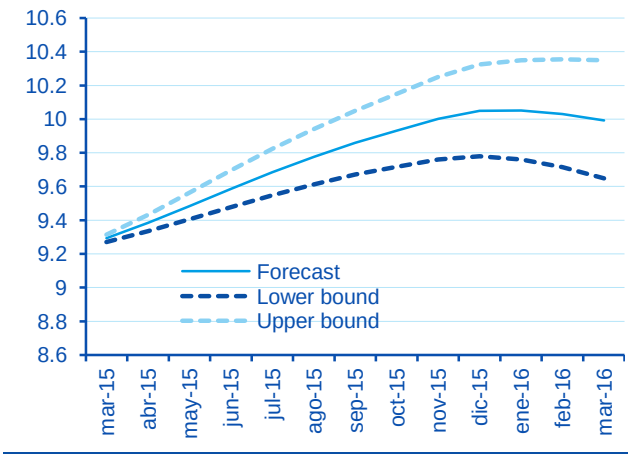
Both points 3) and 4) suggest that adjustments of oil production should be behind changes of oil prices and rig counts. Therefore, the first step in the estimation consists in identifying the optimal lag length. The correlation coefficient between contemporary oil production's growth and previous levels of WTI is the highest at the 14-month. Similarly, the optimal lag length of rig counts is 11-month, while the optimal lag length of inventory turns out to be 1-month.The estimation results of Table 1 suggest that lagged rig counts, lagged inventories and lagged WTI prices all have significant explanatory power on oil production.

Table 1. Estimation Results

Crude Oil Production	Coefficients	Std. Err.	t-value	P-value	[95% Conf.	Interval]
L1.inventory	0.01036	0.001551	6.68	0.000	0.0073	0.0134
L11.rig counts	0.000453	0.000192	2.36	0.020	0.0001	0.0008
L14.wti	0.01208	0.003135	3.85	0.000	0.0059	0.0183
_cons	-4.82713	0.556769	-8.67	0.000	-5.9326	-3.7217
R-squared	0.6998					

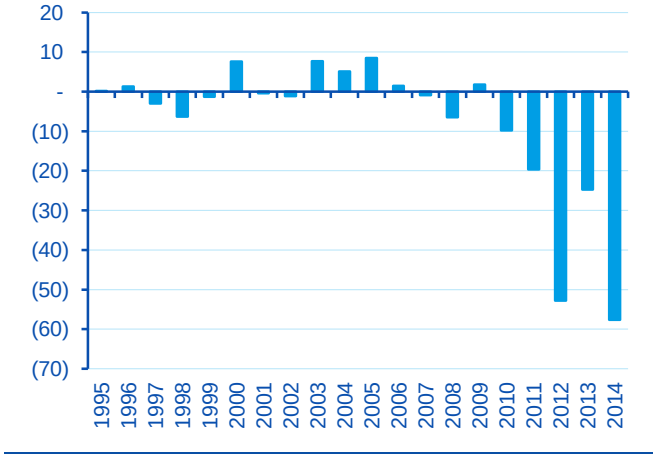
According to the results on Table 1, the negative effect from declining oil prices and rig counts will show up in the oil production in the second half of 2015, and oil production will eventually go down around January 2016.

Chart 11
Simulated crude oil production (Mbbl/day)



Source: BBVA Research

Chart 12
E&P Free Cash Flows (Billion $)



Source: BBVA Research & Bloomberg

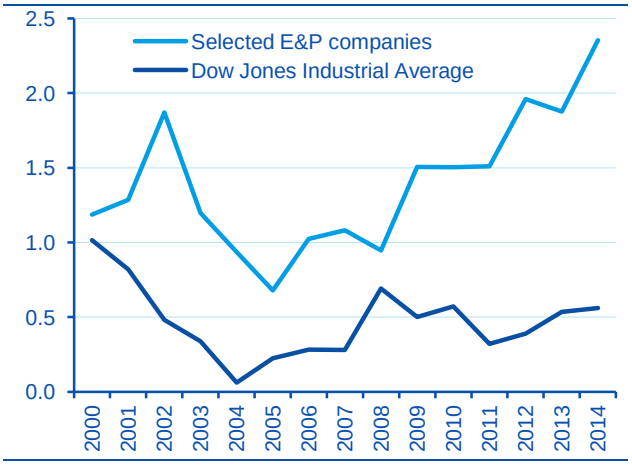
Financial factors explaining production resilience in the short run

Financial variables provide an insight on production resilience. For a sample of seventy eight independent E&P companies in North America, the gap between cash from operations and uses of cash (capital expenditures, dividends, and net share repurchases) widened significantly since 2011. This gap was filled primarily by debt and asset sales. In fact, the median net-debt to EBITDA ratio went from 0.95 in 2008 to 2.35 in 2014. In contrast, the same ratio for the thirty companies that comprise the Dow Jones industrial average went from 0.7 to 0.6 in the same period.

In the U.S., the last episode of elevated oil prices coincided with a period of very low interest rates that encouraged E&Ps to finance investment projects through debt. This was specially the case of medium and small firms. Too much debt influences the way companies allocate resources between production and investments when dealing with negative shocks in prices. Highly indebted companies have to generate enough cash flows to pay their debt even when ongoing projects may turn breakeven or unprofitable.

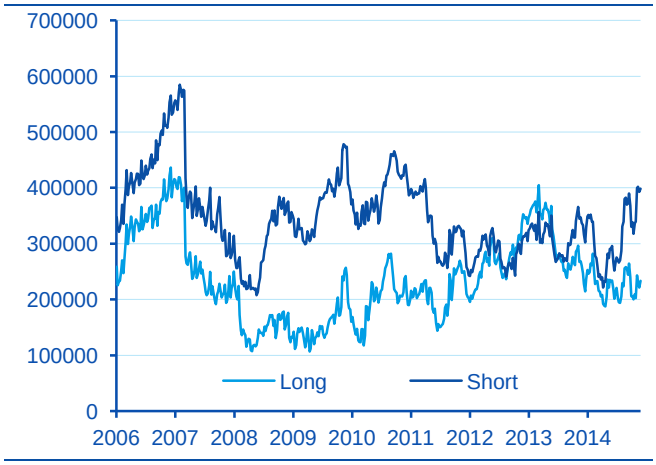
To protect cash flows, several firms hedged a portion of their 2014 and 2015 production at prices above current levels. As Chart 14 shows, the number of short positions in the futures market surged since early 2014. Hedging has allowed companies to continue producing and generate stable income in spite of price volatility. Some of these companies may have been able to cash out their hedges at a profit and use the money to shield them against further declines. Hedging is positively correlated with debt. In general, large companies with plenty of liquidity are less likely to hedge than small companies with high levels of debt. As a result, the latter most likely will continue producing, but not investing.

Chart 13
Median net-debt-to-EBITDA ratio



Source: BBVA Research and Bloomberg

Chart 14
Crude oil futures (number of contracts)



Source: BBVA Research and Bloomberg

Bottom line

The surprising resiliency of U.S. oil production is due to both cyclical and structural factors. From a cyclical point of view, the recent evolution of prices does not seem to preclude a massive default of firms. Financial stress will continue to incentivize production to the extent that highly-leveraged firms are able to services their debt. Nonetheless, the cancellation of investment projects will result in lower production going forward. From a structural perspective, market competition, financial complexity and -more importantly- recent advancements in technology have transformed the industry's production function. As a result, the relationship between prices, inventories, rig count and production has changed significantly. Ongoing technological progress will help shield the U.S. oil and gas industry against future price shocks. Productivity enhancers have lowered unit costs at an unprecedented pace. This trend can accelerate even further as prices remain low. Therefore, forecasting production and prices should account for what appears to be a regime change.