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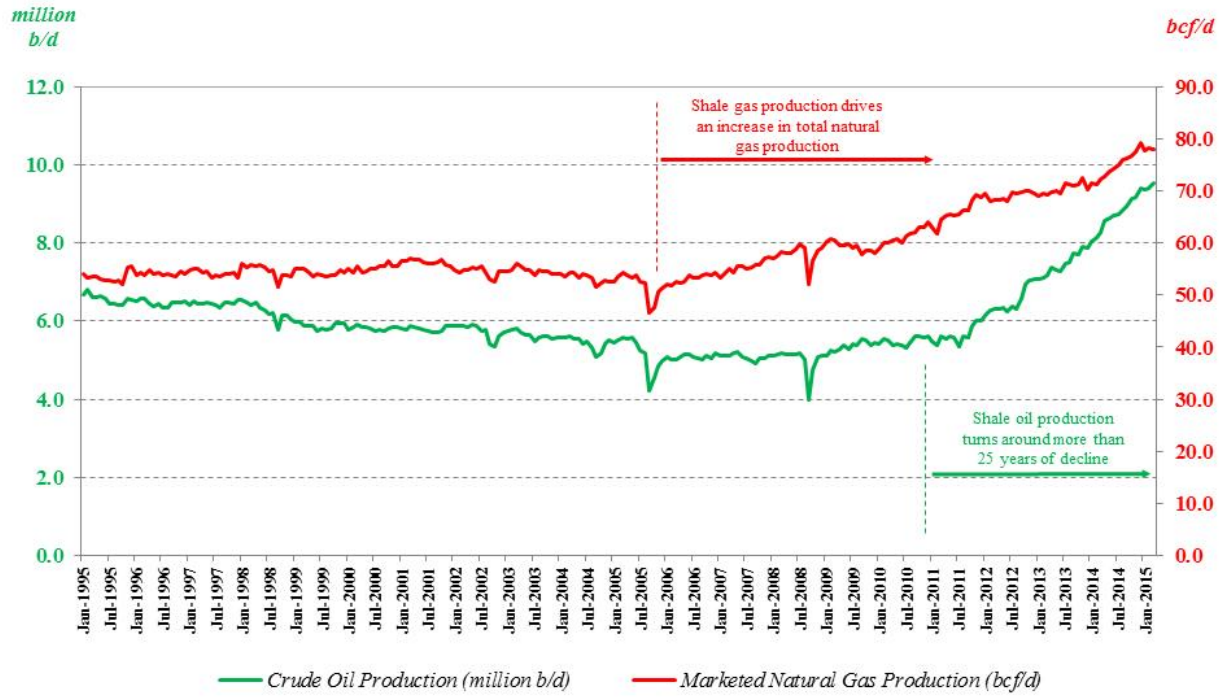
During the past decade, innovative new techniques involving the use of horizontal drilling with hydraulic fracturing have resulted in the rapid growth in production of crude oil and natural gas from shale formations in the United States. Figure 1 illustrates monthly production of both crude oil and natural gas in the US for the last 20 years. The dramatic increases in production witnessed over the last decade have transformed the energy picture in the US, and around the world. Indeed, a number of industry analysts and commentators have proclaimed that the shale revolution has positioned the US to be energy independent and will, by extension, transform how the US approaches a variety of economic and foreign policy issues. Indeed, the notion of energy independence has been in the minds of policy-makers for years, but whether or not it is actually attainable is irrelevant, as the impact that shale has had on the US is both tangible and undeniable in multiple dimensions. Therefore, central to the oil export debate is whether or not lifting the ban would help or hinder furtherance of what has already transpired.

For the purposes of this exposition, the upstream renaissance has significantly impacted the domestic crude oil market, and contributed to US domestic crude oil prices becoming substantially discounted to global benchmark crudes. West Texas Intermediate (WTI) is the most oft cited example of this phenomenon, but, as discussed in depth in the recently released Center for Energy Studies (CES) research publication "To Lift or Not to Lift? The U.S. Crude Oil Ban: Implications for Price and Energy Security," the discounts to domestic crude oils are steeper for lighter, higher quality varieties.[1] This testimony draws heavily from that study, which is much more detailed and in depth in its treatment of the issues addressed herein.

Figure 1. US Crude Oil and Natural Gas Production (Monthly, Jan1995 – Mar2015)



Source: US Energy Information Administration

Indeed, the primary conclusions of the study, which contributes a new perspective to a growing recent literature examining US oil export policy, are that lifting the 40-year-old US crude oil export ban would raise US crude oil prices back toward parity with prices for internationally traded crude oils of similar quality, increase upstream and midstream investment, and improve US energy security. Moreover, this would be accomplished without raising domestic gasoline prices. Importantly, the study exercises a different approach to characterizing and analyzing oil

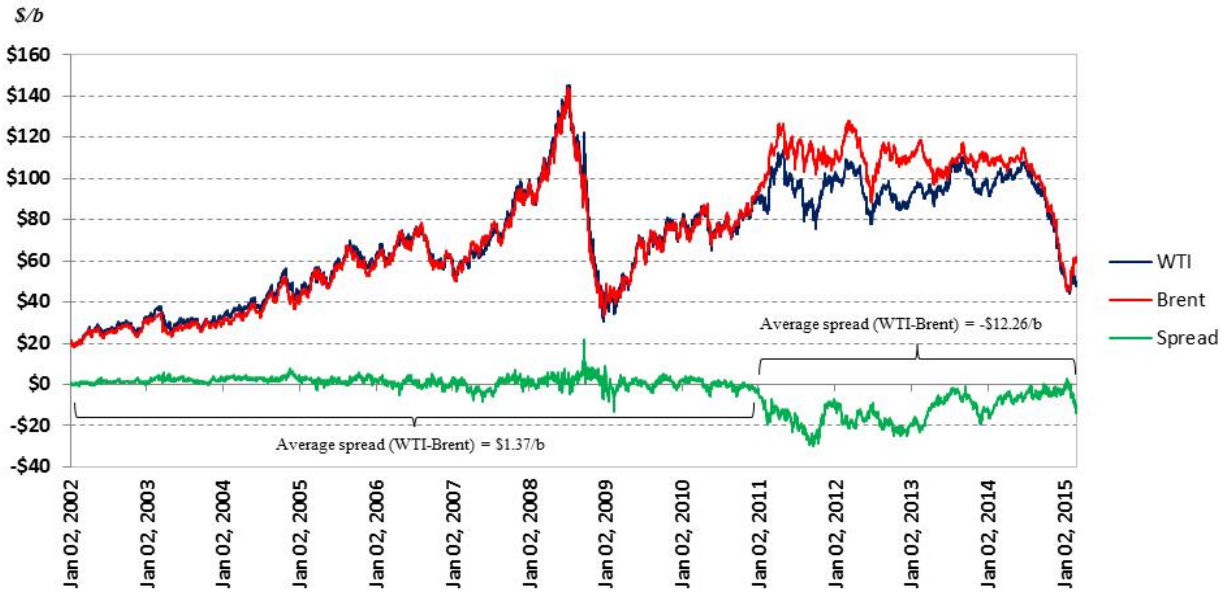
[1] The CES is at Rice University's Baker Institute, and in 2015 it was ranked 4th globally among all energy and natural resource think tanks by the Think Tanks and Civil Society Program at the University of Pennsylvania. See http://bakerinstitute.org/research/impact-analysis-us-crude-exports/ for the full study and other related research.

export policy as it is rooted in analysis of data for 30 different internationally traded crude oils. Moreover, since the research was completed after the recent collapse in oil prices, it evaluates the issue over a much wider range of potential global oil price environments, from $30 to $150 per barrel. In doing so it provides a robust view of the implications of current export policy and the impact that lifting the ban would have.

To begin, the crude oil being produced in the US from unconventional plays such as the Bakken and Eagle Ford is generally very light and of high quality. Absent the ban on exports, these crudes would compete with crudes of similar quality in the international market and would be accordingly priced. However, the export ban presents a constraint that ultimately drives the price of these domestic crude oils to be discounted. Moreover, these discounts can be expected to persist into the future as long as crude oil exports are banned. This occurs because the supply of domestic light crude oil exceeds the light crude oil processing capacity of US refiners who are backing out heavier, lower quality oils to run domestically produced light crude oils.

Most studies have almost exclusively focused on how West Texas Intermediate (WTI) has moved relative to the international marker crude, Brent. WTI, the US crude oil benchmark, priced slightly above Brent prior to 2011, but the ramp up of US and Canadian unconventional oil production and the resultant influx of crude oil to Cushing, Oklahoma has resulted in WTI being discounted relative to Brent in recent years (see Figure 2), which represents a structural shift in the pricing relationship that existed prior to 2011

Figure 2. Brent versus WTI (Daily, Jan2002 – Mar2015)



Source: US Energy Information Administration

Rather than focus exclusively on the WTI-Brent relationship, the CES study evaluates a much broader set of crude oils to better understand where domestic crude oils would price absent the export ban. To this end, the study employs a hedonic pricing method to evaluate how differences in crude oil qualities translate to pricing for 30 internationally traded crude oils. The analysis reveals that gravity (API) and sulfur content are critical determinants of a crude oil's price relative to Brent. Since data on the price of domestic light crude oils from shale is not available prior to their production, the hedonic pricing method allows the assessment of where these crude oils would price in an international market setting unconstrained by the US export ban. The analysis indicates that the export ban is already binding, thus resulting in domestic crude oil prices seeing, in some cases, fairly significant discounts, even in a low international price environment.

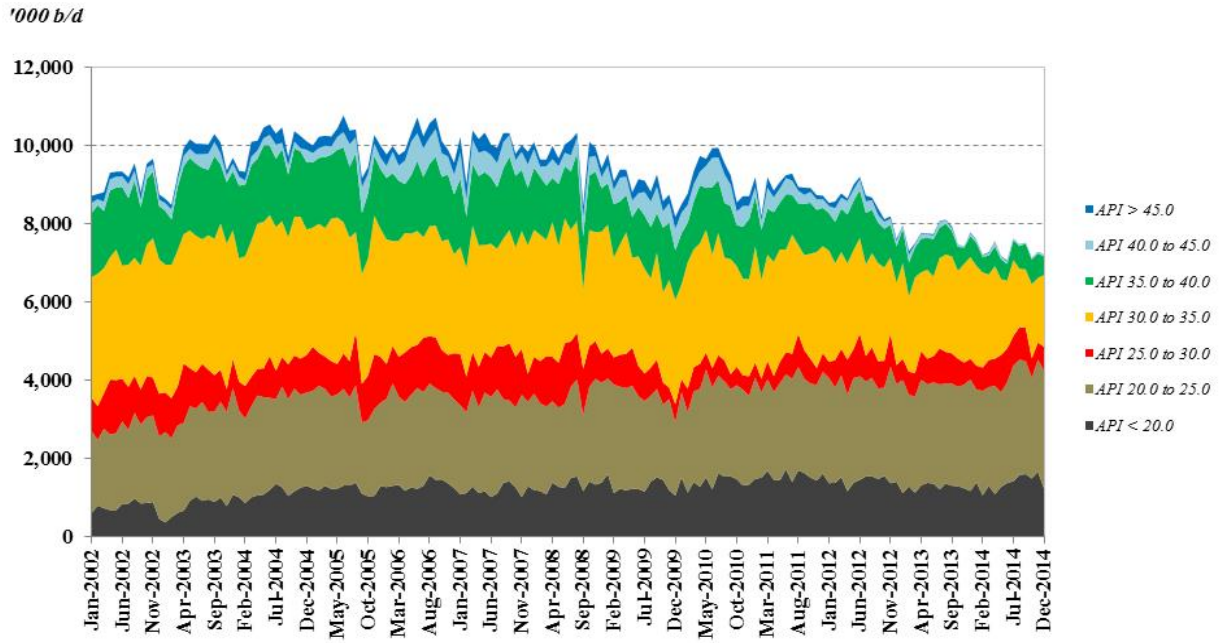
The study also explains why we should continue to expect US refineries to process substantial volumes of imported crudes, even with growing domestic production. Crude oil is not a homogenous commodity, and different crude oils are not perfect substitutes for one another. Most light crude oil being produced from shale has a higher gravity than WTI, Brent, and other international crudes and contains less sulfur than the heavier, primarily imported, crudes that US refineries have been geared to process. Due to the logistics of where crude oil has historically been sourced, US refiners have invested billions of dollars to be able to adequately handle heavy, sour crude oils rather than the more expensive light, sweet crude oils. Heavy, sour crude oils require more expensive and intensive processing to yield highly valued refined products, such as gasoline and diesel. When a refinery sinks capital into developing this capability, it has technical capability to process these heavier, lower priced crude oils. In order to provide the incentive to refine lighter crude oils, which are typically higher priced, those barrels must be discounted so that their pricing is more in line with the heavy, less expensive crude oil the refiner would otherwise purchase. Because of this dynamic, domestic refiners at the heavier end of the spectrum will continue to import heavy crude oils. Moreover, if price discounts on the domestically produced light barrels are persistent, investment in lighter processing capability will be forthcoming. In either case, the US refining sector will continue to import heavy barrels in line with its capabilities, only substituting with light domestic crudes if the price discount is sufficient to justify it.

The study provides a simple graphical explanation of what it would mean for domestic light crude oil prices if US refineries were to use additional domestically produced light crude oils to back out imports of heavy, sour crude oils. Prior to the US shale revolution, the supply of light oil to domestic refiners originated from both domestic and imported sources, and the price of US light crude was at parity with imported crude oils of similar quality. However, the rapidly growing domestic supply of light crude oil has backed out imports of light crude oil and exceeded US refinery capacity for processing light crude oil. Since the excess light crude cannot be exported, producers are faced with either shutting in some light oil production or discounting the price of their output to encourage refineries to reduce their runs of medium crude oils, instead

running additional light oil. Thus, the price of domestic light crude oil drops to parity with the lower quality oil it is replacing in refineries. As heavier and heavier crude oils are backed out by domestic production, the discount relative to the international price for light crude oil will grow in order to provide the price incentive for US refiners to substitute the light crude oil for the heavier crudes that the refineries were designed to process.

Data on crude oil imports reveal that domestic production has already backed out imported crudes of similar gravity and is now backing out heavier crudes (see Figure 3). Using the hedonic pricing method, the study assesses the resultant discount at different international oil price ($30 to $150 per barrel) environments, given the range of API gravity and sulfur contents of the heavy crude that domestic light crude oil is replacing. The analysis reveals that discounts of up to $7 per barrel are felt for some of the lighter Eagle Ford crudes even in a $60 global price environment, with the discount growing to in excess of $10 per barrel in an $80 price environment. Importantly, this result is contingent on the quantity of domestic production. Given current production levels, the crude oil at the margin appears to be Louisiana Light Sweet (LLS), meaning that price sets a virtual ceiling for domestic crude oil prices – anything of higher quality must be discounted to compete.

Figure 3. US Crude Oil Imports by Gravity (Monthly, Jan2002 – Dec2014)



Source: US Energy Information Administration

The study also assesses the impact on US gasoline prices of an end to the oil export ban. In particular, it addresses the question, "Would higher prices for domestic crude oils translate into

higher prices at the pump?" Similarly to other studies, the analysis dispels this notion. Since refined products can be traded freely on the international market, the discounted prices of US crude have not translated into discounted prices of refined products. Instead, US refiners are able to buy domestic light crude oils at a discount to the international price, then sell refined products at international prices. The lack of a restriction on trade of refined products allows domestic and international wholesale prices harmonize, meaning domestic refiners are able to retain the domestic crude oil price discount as additional margin, a point the study highlights as a "no-cost call option" that refiners hold on domestic crude oil purchases. It also notes that not all domestic refiners see this benefit, a result owing to the different configurations, and hence crude qualities, each processes. Data supports this notion. In particular, beginning in 2011, the price of WTI started diverging on a lower path relative to both Brent crude oil and US Gulf Coast (USGC) gasoline prices. Statistical analysis indicates that after 2010, WTI has been on average $10 per barrel lower relative to USGC gasoline, while the price of Brent has been about $3 per barrel higher relative to gasoline. As the US has been a net exporter of refined products since 2011, the arbitrage point for international gasoline has moved away from the Gulf Coast. The shift in the relative price relationship between international crude oils and US-produced gasoline reflects the cost to transport the gasoline to a new point of arbitrage offshore. Moreover, this transition has been driven primarily by the sharp reduction in US demand that has left the US with more than enough refining capacity to meet its domestic needs, and could easily reverse course should US demand recover significantly. The large discount of WTI relative to gasoline and Brent, however, reflects the shifting refinery dynamics driven by growth in domestic production discussed above.

The study also notes that although eliminating the export ban would compress profit margins to some (but not all) US refiners, it would be transformative for US crude oil producers (assuming that the shale resource base has a long productive life). Significant capital would flow into the upstream as well as into pipeline and other infrastructure development, which would ultimately drive a dissipation of the discount on US light oil as greater trade is facilitated. Regarding refiners, even with unrestricted oil exports, low US natural gas prices still bode well for their international competitiveness. Moreover, light crude oil imports would still be substituted by domestic production, and domestic refineries would be optimized as they would import and process the heavier, lower quality crude oils for which they were designed.

Lastly, the study reveals that removing the oil export ban would generate distinct energy security benefits for the US, a result that is counterintuitive to some. Following the voluminous literature on the subject, energy security generally refers to the concept of ensuring an adequate supply of oil at a *stable* and *reasonable* price. This goal is sought because there is a strong empirical correlation between macroeconomic malaise and unexpected and extreme movements in the price of oil. Diversification of oil supply options, especially by adding supply from stable producing countries, is one means of mitigating the risk of an oil market disruption. To this end, the US shale oil boom has already provided significant energy security benefits. Over the period

from 2008 to 2013, increased oil output from the US has offset the production declines in countries such as Libya, Algeria, Syria, and Iran that were due to local strife or sanctions. In the absence of US shale oil output, prices would have been much higher and much more volatile. However, the lack of ability for US oil producers to export is capping the extension of this benefit by leaving some domestic investment unrealized, and ultimately limiting the amount of low-risk oil supply that can reach the international market. Since oil prices transmit to consumers through the price of refined products, by not allowing US oil production to have a larger impact on global oil prices, and hence petroleum product prices, current policy is actually compromising domestic energy security. In effect, the oil export ban does nothing to insulate US consumers from unexpected movements in the international price of refined products, so it does not provide any broad energy security benefit.

The study highlights that the importance of the US as a potential source of incremental supply over the longer term cannot be overstated. However, the role of the US as a stable supplier to global markets is conditional on the ability of US production volumes to access the global market. The US could take a leadership role in transforming global trade in crude oil that would carry significant geopolitical benefits and, more generally, establish the US as a trusted partner in discussions focused on expanding international trade.