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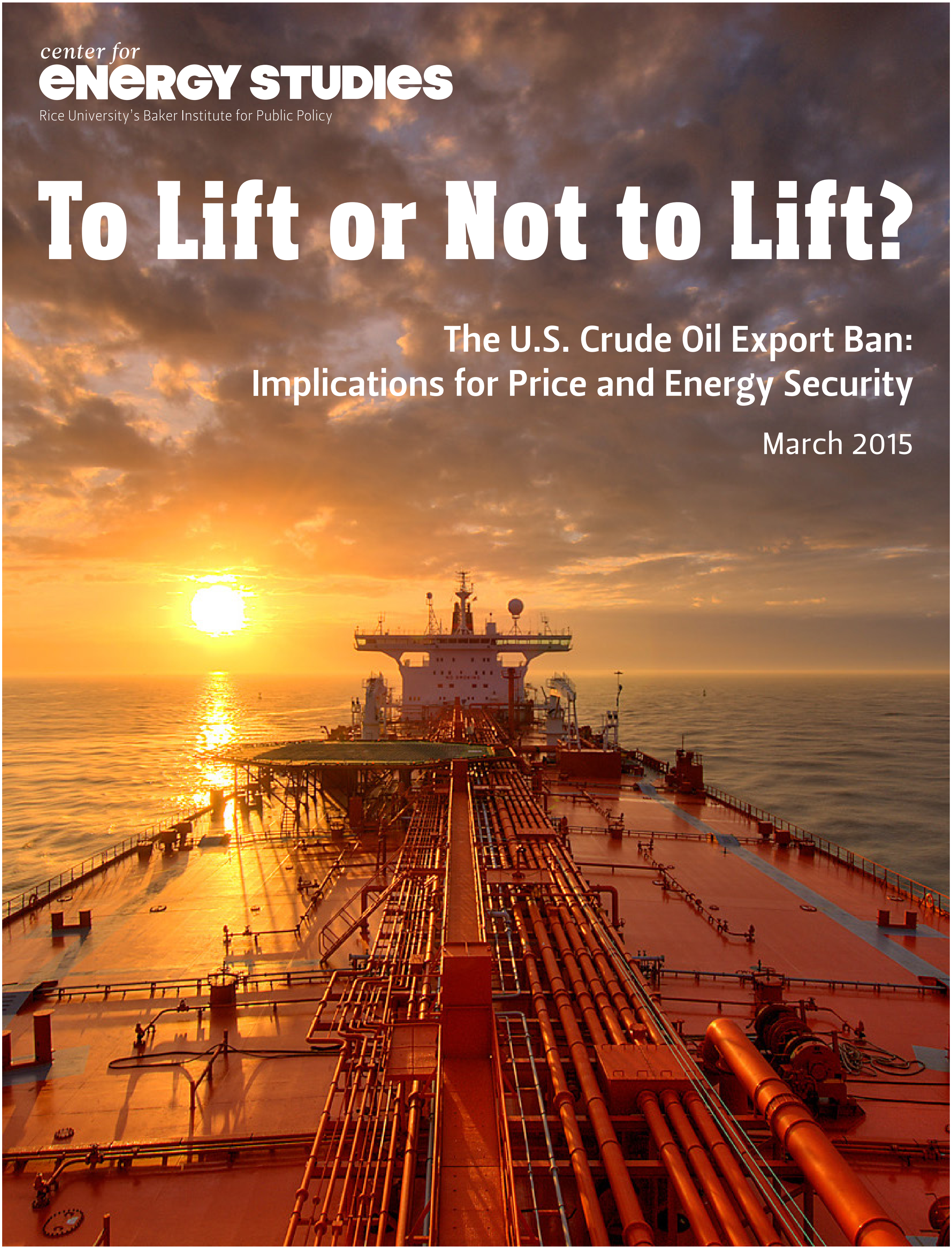

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To Lift or Not to Lift? The U.S. Crude Oil Export Ban: Implications for Price and Energy Security

By

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Medlock is currently the vice president for conferences for the United States Association for Energy Economics (USAEE), and previously served as vice president for academic affairs. In 2001, he won (joint with Ron Soligo) the International Association for Energy Economics Award for Best Paper of the Year in the *Energy Journal*. In 2011, he was given the USAEE's Senior Fellow Award, and in 2013 he accepted on behalf of the Center for Energy Studies the USAEE's Adelman-Frankel Award. In 2012, Medlock received the prestigious Haydn Williams Fellowship at Curtin University in Perth, Australia. He is also an active member of the American Economic Association, and is an academic member of the National Petroleum Council (NPC). Medlock has served as an advisor to the US Department of Energy and the California Energy Commission in their respective energy modeling efforts. He was the lead modeler of the Modeling Subgroup of the 2003 NPC study of long-term natural gas markets in North America, and was a contributing author to the recent NPC study "North American Resource Development."

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Extended Abstract

In the past few years, innovative techniques involving the use of horizontal drilling and hydraulic fracturing have triggered unprecedented increases in production of crude oil from shale in the United States. This domestic production surge has reduced US crude oil imports and led some to call for an end to the 40-year-old ban on crude oil exports. In this paper, we lay out a framework for discussing the issues germane to this debate and apply empirical tools to evaluate these matters.

We find evidence that the export ban already presents a binding constraint on the domestic market. We develop an approach based on a hedonic pricing method to evaluate the discounts being realized on West Texas Intermediate (WTI) and other domestic crude oil prices over a wide range of global crude oil price environments, ranging from $30 to $150 per barrel. The results indicate that even in a low international crude oil price environment, the importance of addressing the export ban is very high, with discounts attributable to the trade barrier erected by current policy reaching as high as $8 per barrel in a $50 world, depending on the quality of the crude oil that is being produced and marketed.

The US refining sector has already backed out imports of light crude oil and is now backing out imported crude oils that are heavier than WTI and light oils from shale. This is where the discount arises – the domestic crudes, regardless of quality, must compete with lower quality crude oils, as the only market outlet for domestic crude oil is domestic refiners, regardless of quality. As more imported oil is displaced, the competitive margin for domestic production will increasingly be established by a heavier crude oil, which will drive steeper discounts until a new arbitrage mechanism is introduced, through either new refinery capacity or a lift of the export ban. We find that lifting the ban on exports could benefit upstream producers as well as attract capital investment into midstream infrastructure development.

We also find support for the conjecture that lifting the ban on crude oil exports would not raise gasoline prices in the US. Since refined products, such as gasoline, can be freely traded in the international market, the prices of refined products sold in the US are at parity with *international* prices for refined products. Thus, the discounted prices of oil produced in the US are not

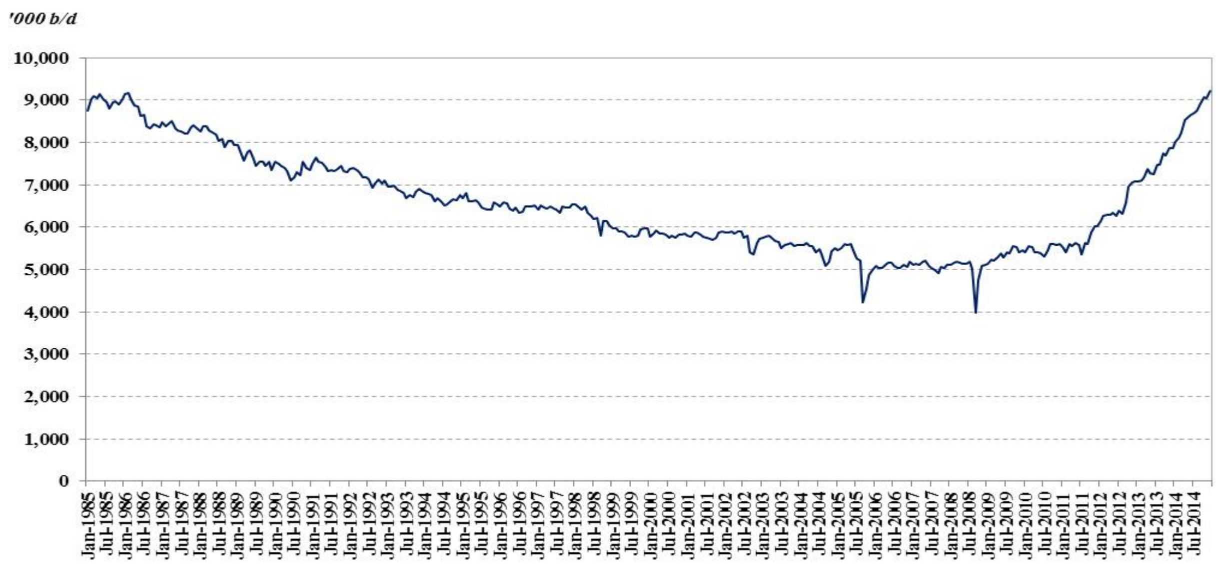
reflected in US gasoline and refined product prices. This is an important point when considering the implications of lifting the export ban for US consumers, and more generally, energy security.

Finally, we provide an in-depth analysis of the implications of lifting the crude oil export ban for US energy security. It is well-documented that heightened oil price volatility is associated with macroeconomic malaise, and the drivers of oil price volatility are *unexpected* shocks to *global* demand and/or supply. Removing the export ban generates distinct energy security benefits by providing a more stable and secure source of crude oil to a growing global market. Therefore, to the extent that US crude oil exports increase fungibility and dampen global oil price volatility, it will transmit an energy security benefit to US consumers. Indeed, we argue that in the longer term, the US can lead a transformation of the global oil market that could see North American and Western Hemisphere production capture a larger portion of the growing international market. This would carry tremendous benefits for US foreign policy endeavors in dealing with hostile oil-producing nations. It would also provide stability to the global oil market and convey benefits more broadly to the US and its allies.

I. Introduction

During the past decade in the United States, innovative techniques involving the use of horizontal drilling and hydraulic fracturing have triggered unprecedented increases in production of natural gas, crude oil, and natural gas liquids from shale. This development, the so-called “shale revolution,” has already transformed the North American gas market and, perhaps of greater significance, set the stage for a paradigm shift in the *global* gas market.

Figure 1 – US Crude Oil Production (Jan 1985-Dec 2014)



Source: US Energy Information Administration

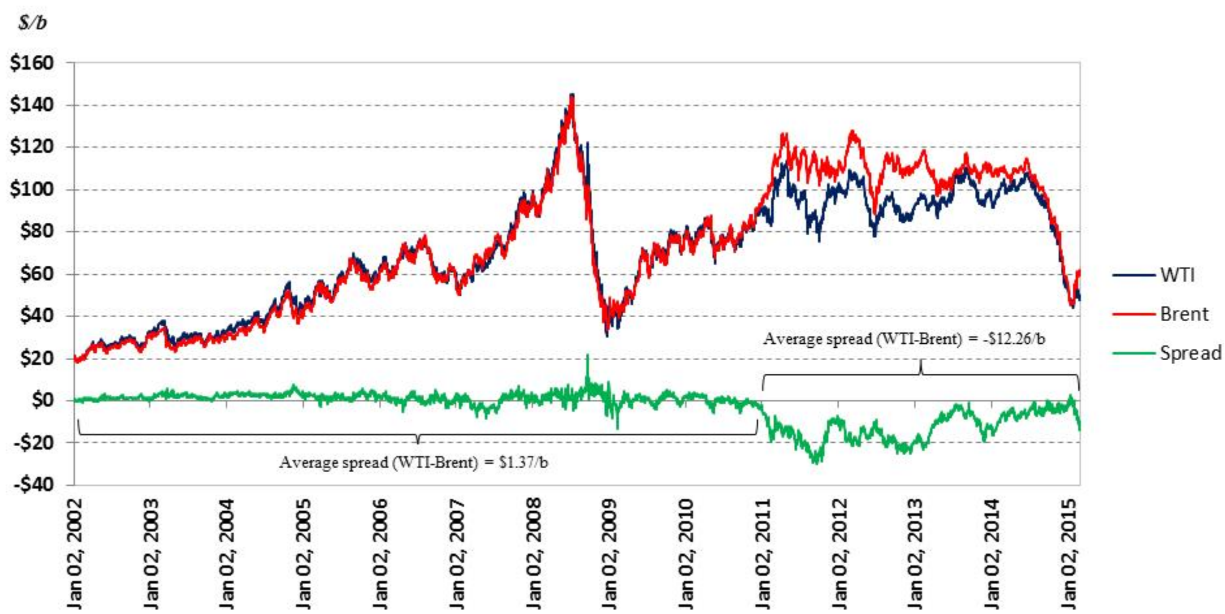
Shale resource development has also significantly impacted the US domestic crude oil market. Rapid growth in production (see Figure 1) has dramatically reversed a decades-long decline[1] and turned the US from an ever-expanding sink for global crude oil into a viable global supply province in only a few years. Of course, the global crude oil production anthology is still being written, but we have seen real supply-side responses to high prices in the last decade in the form of deep water and unconventional sources of oil. In fact, US production growth in the last five years, due in large part to new production from unconventional resources, has been the highest

[1] Note, US oil production peaked in 1970 but experienced a slight recovery in the early 1980s with rising global oil prices. Post-1985, however, the decline in US oil production was steady for over two decades until the onset of rapid increases in production of light tight oil (LTO) from shale.

seen in many decades. To date, growth in domestic production has been driven by shale oil (also known as or light tight oil (LTO)) developments in the Bakken and Eagle Ford shale plays, while other opportunities – such as in the Permian basin – have been receiving increasing attention.

Rapid growth in domestic crude oil production has also transformed regional crude oil pricing. In particular, the relatively recent discount of the benchmark US domestic crude oil price – West Texas Intermediate (WTI) – to a global benchmark for crudes – such as Brent – has occurred concomitantly with US domestic production growth (see Figure 2). While it is generally recognized that the WTI discount arose largely due to constraints on the ability to move crude oil away from Cushing, Oklahoma, it triggered concerns that broader discounts of US crude oil prices would become the norm as US domestic production continues to increase.

Figure 2 – The Evolution of WTI and Brent (Daily, 1/2/02-2/27/15)



Source: US Energy Information Administration

This begs the question, "Why would further increases in US domestic crude oil production drive discounts in domestic crude oil prices?" Moreover, and perhaps more importantly, "What bearing does this have on US petroleum product prices and energy security?" A number of studies have already attempted to address these issues. For the most part, each study to date has framed the analysis by identifying the recently emerged discount between WTI and Brent crude oil price and attributing it to transportation bottlenecks, the existing ban on crude oil exports, and the mismatch between LTO being produced domestically and the configuration of US refineries. While there have been serious attempts to address domestic transportation bottlenecks, and refineries have been receiving more LTO, thus displacing imports, little has been done regarding the decades-old ban on US oil exports. As such, studies have attempted to model the potential impacts of an end to the ban on oil exports, with an emphasis on US crude oil production, imports and exports, the implications for domestic gasoline prices, and the broader impacts on US employment, investment, and trade balance. Most studies underscore a positive economic impact of lifting the ban, while those that state opposition generally base their arguments on environmental concerns. Table 1 summarizes the principle findings of previous studies.

Regardless of the policy stance, all studies generally recognize that lifting the restriction would result in increased domestic crude oil production, as US oil producers could access international markets and the prices therein. The studies differ significantly, however, in their assessment of how large the increase in production would be. Projections range from a meager 100,000 barrels per day according to the consulting firm ICF (see Vidas et al. (2014)) to as much as 2.3 million barrels per day according to the consulting firm IHS (see Rosenfield et al. (2014)). The wide range of estimated production increases follows from different assumptions about market conditions, resource cost and abundance, and pace of productivity improvements. Bordoff and Houser (2015) attempt to understand the differences in supply responsiveness across studies, ultimately settling on an average across studies as a basis for forming expectations.

All studies, regardless of the supply responsiveness, point to a similar mechanism through which higher domestic production would be realized. Specifically, as the ban is lifted, the discount on the US crude oil prices dissipates. Hence, more plays become commercially attractive. Interestingly, the studies tend to focus on WTI, going so far as to estimate the impact of lifting the ban on WTI price and thus the WTI-Brent differential. But, as will be expounded below, that may not be the appropriate price to consider.

Table 1 – Previous Studies of the Oil Export Ban

Study Title	The Impacts of US Crude Oil Exports on Domestic Crude Production, GDP, Employment, Trade, and Consumer Costs	US Crude Oil Export Decision: Assessing the Impact of the Export Ban and Free Trade on the US Economy	Economic Benefits of Lifting the Crude Oil Export Ban	Lifting the Crude Oil Export Ban: The Impact on U.S. Manufacturing
Authors	Harry Vidas, Martin Tallett, Tom O'Connor, David Freyman, William Pepper, Briana Adams, Thu Nguyen, Robert Hugman, Alanna Bock	Jamey Rosenfield, Kurt Barrow, Hames Falllon, Jeff Marn	Robert Baron, Paul Bernstein, W. David Montgomery, Reshma Patel, Sugandha D. Tuladhar	Thomas J. Duesterberg, Donald A. Norman, and Jeffrey F. Werling
Publisher/Agency	ICF International and EnSYS Energy	IHS Energy	NERA Economic Consulting	The Aspen Institute and MAPI foundation
Publication Date	Mar-14	Mar-14	Sep-14	Oct-14
Approach	EnSYS world refining and logistics model projecting international pricing across markets based on an assumed world oil price. The model employs freight costs between markets to model global pricing and arbitrage to forecast refinery operations. This is coupled with ICF's proprietary models to estimate North American crude oil production and its impact on the world crude oil production, world oil prices, and the consumption of petroleum products.	Employs refinery models to estimate profitability of processing crude oils in different refinery capacities and configurations to calculate a domestic LTO discount.	Uses the partial equilibrium Global Petroleum Model (GPM) to assess the impact on lifting the export ban on energy markets in the US and abroad, along with the NewERA model, which is a computable general equilibrium model of the US economy, to understand how changes in the global market will ripple through the US economy. The GPM and NewEra models are linked in order to provide a consistent picture of the US crude oil and refined petroleum product markets.	Uses the Long-term Interindustry Forecasting Tool (LIFT), which is a dynamic equilibrium model that combines an interindustry input-output model with regression analysis to create a bottom-up approach to macroeconomic modeling.
Cases/Scenarios	Two scenarios: (I) Low WTI-Brent Price Differential Market Scenario in which there is rapid accommodation of light crudes and condensate in the US (by 2015) leading to a narrowing of the WTI-Brent spread, and (II) High WTI-Brent Price Differential Market Scenario in which there is slow adjustment to a new domestic crudes with the WTI-Brent spread remaining wide for several years. Two policy cases were considered in each scenario - (1) no exports and (2) export allowed	Two scenarios: (I) Base Production IHS forecast with a conservative view based on defined plays assuming limited industry improvement, and (II) Potential Production scenario that includes additional resources in less well-defined areas of existing plays with moderate improvement in industry drilling productivity and technology. For each scenario there are two trade policy variations: (1) restricted trade allowoing for then current condensate treatment as crude, and (2) free trade allowed	Considered 18 cases based on US crude oil production potential from EIA's Annual Energy Outlook 2014 reference case and high oil and gas resource case, with additional options for modifying/lifting the ban, including allowing condensate exports, lifting ban entirely in 2015, or delaying lifting the ban until 2020. The analysis also considers Asian demand response and OPEC's market response.	Considered three basic frames: (1) A baseline projection that follows EIA's Annual Energy Outlook 2014 with only trivial exports (0.13 to 0.15 million b/d) through 2025; (2) a low export case where crude exports increase by 1.3 million b/d by 2020 then levelign at 1.2 million b/d by 2025; and (3) a high export case that sees crude oil exports increase to 2.35 million b/d by 2020 and 3.12 million b/d by 2025.
Period Covered	2015-2035	2016-2030	2015-2035	2015-2025
Crude oil production	Allowing crude exports leads to an increase in US oil production of 110,000 to 500,000 b/d by 2020, with LTO production growing to 6.5 million b/d by 2020 and averaging 6.3 million b/d over 2015-2035 (representing about 59% of US oil production). Global liquids production rises to a 2015-2035 average of 103.5 million b/d if exports are allowed, but 103.4 million b/d if exports are not allowed, representing a relatively minimal impact on the global supply-demand balance.	Allowing exports sees an increase of 1.2 million b/d in the low case and 2.3 million b/d in the high case (11 to 13.3 million b/d). Due to limitations of the refining sector, domestic LTO production peaks in the Base case at 6.1 million b/d in 2024, while total US output is expected to rise from 7.4 to 11.2 million b/d by 2022. In the Potential case, domestic LTO production peaks at 9.2 million b/d in 2028, with total US crude production rising to 14.3 million b/d. If the export ban remains in place, there is a loss of between 1 and 2 million b/d, depending on the case.	If the export ban is lifted in 2015, domestic production rises by 1.5 to 2 million b/d in 2015, depending on the case, with the greatest increase seen in PADD 3 followed by PADD 2. The increase in crude oil supplies is attributable almost entirely to greater production of light tight crude oil and condensate.	In the Baseline scenario, domestic production reaches 9.8 million b/d in 2019, peaking at 9.96 million b/d in 2024-25. In the Low Exports scenarion, domestic production increases to 10.96 million b/d by 2020 and 12.13 million b/d by 2025. In the High Exports case, production reaches 11.53 million b/d and 13.21 million b/d in 2020 and 2025, respectively.

Table 1 (cont.) – Previous Studies of the Oil Export Ban

Study Title	The Impacts of US Crude Oil Exports on Domestic Crude Production, GDP, Employment, Trade, and Consumer Costs	US Crude Oil Export Decision: Assessing the Impact of the Export Ban and Free Trade on the US Economy	Economic Benefits of Lifting the Crude Oil Export Ban	Lifting the Crude Oil Export Ban: The Impact on U.S. Manufacturing
Refinery details	If exports are not allowed, refineries will struggle to digest light crudes and condensates. If exports are allowed, refinery margins are projected to average $12.75 per barrel over 2015-2035, which represents a $1.50 to $2.85 per barrel discount relative to when exports are not allowed under different scenarios.	With the export ban in place, refinery margins are higher despite a suboptimal yield on capacity. The higher margins owe to the discount that applies to LTO, which can rise to a $10 to $25 discount per barrel when sour crude refining capacity (Tier 4) is required to absorb domestic LTO. If the ban is lifted margins are lower, but domestic refiners still do well due to low cost natural gas and favorable transport differentials for domestic crude oil.	Recognizes the difficulty in predicting constraints on domestic refining capabilities due to uncertainty about how fast US production will grow, noting that EIA's projections consistently underestimate oil production growth as technology outpaces expectations. If the ban remains in place, a persistent and growing discount of up to $27/b for domestic crude oil when oil and gas production remains robust. If the export ban lifted, there will be an increase in the average cost of crude to some US refiners, domestic demand increases and exports decrease.	Argues that since refiners have already made investments ($85 billion over last 25 years) to process heavy crudes, although new investment will be needed, it will take years to fully accommodate. They see a slight reduction of refining margins if the ban is lifted. Moreover, since world crude oil prices decrease given higher global supply with exports, gasoline prices to fall.
US refined product trade	Refined product exports increase with or without the crude oil export ban in place, but are 13,000 bpd lower when the crude oil export ban is lifted.	See a significant reduction in overall crude oil and petroleum product trade deficit with or without a ban on crude oil exports, but lifting the ban bears greater benefits. For example, in the potential production case, free trade renders a surplus of $55 billion from 2016 through 2030, which represents a $93 billion improvement over a restricted trade scenario.	Lifting the ban results in a decline of refined product exports as the competitive advantage for domestic refineries is diminished, with total refinery throughput declining from 0-100,000 b/d in 2015 and 0-300,000 b/d in 2030 (representing a less than 1% and 2% decline, respectively).	Total refinery throughput grows and so do exports.
Crude oil prices and spreads	WTI prices increase by $2.25 to $4.00/b on average over 2015-2035 when exports are allowed. This is against a backdrop of near $100 per barrel global prices. Brent price declines when US exports are allowed. Even with exports, WTI remains discounted to Brent by almost $5/b, but in the case without exports the discount is closer to $10/b.	Given a Brent price of $100 per barrel, if exports are allowed WTI will converge toward Brent. Without exports, however, the discount of WTI to Brent could approach $15 per barrel. This discount would be deeper for oil plays located inland given the cost of transporting crude oil to refining centers, with Bakken crude oil being discounted up to $25.	If the crude oil export ban is lifted in 2015, the price of US crude oil rises between $2/b and $9/b depending on the scenario and year. By contrast, the international average crude oil price declines between a negligible amount up to $7/b, also depending on the scenario. Accordingly, the spread betweeen domestic and international crude decreases when the ban is lifted, but remains strong if the ban persists.	If exports are allowed, the near term domestic crude oil price increase relative to a case when exports are not allowed approaches $25/b in 2016 declining to nearer $5/b in 2025. This reflects a large near term spread if the ban remains in place that declines over time.
Other highlights	Addresses US crude oil export volumes, production impacts and implications for royalty and tax receipts, GDP impacts, employment impacts and balance of trade implications. All variable outcomes are viewed as positive for the US economy as a whole.	Addresses US crude oil export volumes and direction of traded volumes. Also details positive outcomes for investment flows, GDP, employment and the balance of trade.	Addresses US crude oil export volumes and direction of traded volumes. Also details implications for carbon emissions and, using the EPA estimates for the social cost of carbon, estimates the cost of the export ban far exceeds the environmental benefit. Outlines and discusses OPEC response.	Addresses the trade balance implications, the price of gasoline and the sector-specific impacts of lifting the ban on exports. Outlines and discusses the importance of OPEC market response, arguing the revenue concerns will ultimately drive instability in cartel cohesion.

Table 1 (cont.) – Previous Studies of the Oil Export Ban

Study Title	Navigating the Oil Export Debate	Crude Behavior: How Lifting the Export Ban Reduces Gasoline Prices in the United States	Changing Crude Oil Markets: Allowing Exports Could Reduce Consumer Fuel Prices, and the Size of Strategic Reserves Should be Reexamined
Authors	Jason Bordoff and Trevor Houser	Stephen Brown, Charles Mason, Alan Krupnick, and Jan Mares	Frank Rusco with key contributions from Christine Kehr (Assistant Director), Philip Farah, Quindi Franco, Cindy Gilbert, Taylor Kauffman, Celia Rosario Mendive, Alison O'Neill, and Barbara Timmerman
Publisher/Agency	Columbia Center on Global Energy Policy	Resources for the Future	U.S. Government Accountability Office
Publication Date	Jan-15	Mar-14	Sep-14
Approach	Used EIA's NEMS Model to run simulations using oil market assumptions from the High Oil and Gas Resource case by EIA 2014. Also assesses the output of other studies to come to an average finding across the space of analyses considered.	Used monthly panel data in a hedonic pricing approach to explain differences between regional refiner acquisition costs and average monthly spot price of crude at Brent allowing for idiosyncratic effects in PADD 4 and PADD from Jan 2004 to Oct 20132. A static simulation model (developed by Brown and Kennelly, 2013) then explicitly links the world crude market to a global refined product market via refinery operations as the demand for crude oil is derived from demand for refined products.	Reviews studies (RFF, ICF, IHS, NERA) and conducts interviews with various stakeholders on crude exports.
Cases/Scenarios	Overview and critique of scenarios from previously published studies (ICF, IHS, NERA and MAPI).	Consider the impacts on gasoline prices specifically when the export ban is lifted	N/A
Period Covered	2015-2025	long run	dependent on study reviewed by the report
Crude oil production	Lower oil prices will impact US production, but the authors are skeptical of the high supply elasticities used by NERA and IHS, with the study positing that US producers more resilient. If the export ban is lifted, domestic production rises between 0 and 1.2 million b/d, with no increase if domestic market saturation never occurs (as under EIA's Reference case) and 1.2 million b/d if global crude prices return to $100 per barrel. The report finds that the magnitude of lifting export restrictions is modest but beneficial, all else equal.	With higher crude prices in the Midwest in the wake of the export ban being lifted, production in the region and in Canada increases by an estimated 84,000 b/d. Elsewhere in the world, higher oil prices boost production by 54,000 b/d for a global total of 138,000 b/d.	Cites EIA in projecting domestic production will increase and could reach 9.6 million b/d by 2019. Removing the export ban would increase domestic production but there is a large spread in projections across the studies that were reviewed. The report cites a stakeholder that believes a rise in production will happen primarily due to higher international demand, mostly from Asia. The report also cites another stakeholder who argues that domestic production could be negatively affected if the ban remains.

Table 1 (cont.) – Previous Studies of the Oil Export Ban

Study Title	Navigating the Oil Export Debate	Crude Behavior: How Lifting the Export Ban Reduces Gasoline Prices in the United States	Changing Crude Oil Markets: Allowing Exports Could Reduce Consumer Fuel Prices, and the Size of Strategic Reserves Should be Reexamined
Refinery details	Authors requested Turner Mason to assess the cost and scale of additional capacity necessary for (1) EIA Reference and High Oil&Gas Resource scenarios, (2) an Upper Bound Scenario (IHS Potential Production Case). In the High O&G case, 3 to 4 condensate stabilizers and 13 to 15 hydro skimmers are required at a cost between $13-16 billion. In the Upper Bound Scenario, 30-35 stabilizers and/or hydro skimmers are requried costing $26 - $31 billion, which would be recouped if crude oil price is discounted at a level of $5 - $6.50 per barrel.	Assumes reduction in the cost of global refining operations of 0.5%. Perform sensitivity analyses with 0.0% cost reduction and 1.0% cost reduction.	Cites other studies as well as stakeholders who raised three key uncertainties about (1) the extent of future domestic production growth, (2) the extent to which the increase can be absorbed, and (3) whether export restrictions will change, which is a key uncertainty that limits new investment needed to relieve contracts associated with refining lighter crudes at refineries configured to process heavier grades. Somestakeholders noted that refinery margins could be reduced if the ban is lifted, leading to refinery closures in some regions, while other stakeholders disagree with this claim given low prices of natural gas that US refineries use as a feedstock.
US refined product trade	N/A	N/A	The report cites a stakeholder that believes that, if ban is lifted, increased transportation and crude costs would negatively affect the ability of US refiners to compete internationally. Another stakeholder, however, believes that this should not be the case given significant cost advantage in terms of feedstock (access to cheap natural gas). No definitive estimate is given.
Crude oil prices and spreads	Sees an increase in domestic crude prices if the crude oil export ban is eliminated. The prices of global crude oil could decline slightly with US exports. Accordingly, they agree with a discount of $5-$6.50 (per estimates provided by Turner Mason and IHS). They see the NERA study as overly pessimistic on the ability of US refiners to respond with capacity investments, especially if the discount approaches the $20 range.	As of 1Q 2014, crude oil in the Midwest was $6.34/b below the price of a comparable crude oil. The increase in oil price due to lifting the ban in the Midwest would be $6.49/b. The manner in which this matriculates into the global market and hence the price of petroleum products is contingent on OPEC response and the elasticities of supply and demand for oil and petroleum products.	Cites study projections agreeing that lifting the ban would lead to increase in domestic crude prices.
Other highlights	Reviews and notes broad agreement of other studies regarding the positive macroeconomic benefits of liftiing the ban on crude oil exports. Comments on potential role OPEC may play in understading the dynamic international response of lifting the ban.	Mentions positive gains from trade as well as the implications for US carbon dioxide emissions. Also addresses the importance of OPEC in understanding market response.	Cites result of previous studies and stakeholder views on a variety of macroeconomic and investment flow data.

In general, the increase in domestic crude oil price is the primary factor, the studies conclude, that will contribute to change in the spread between US and international crude prices. A secondary but important factor is the increased supply of crude into international markets, which has the potential to lower world oil prices. While an attempt to quantify the impact on international crude oil price that follows from lifting the ban on US exports is a laudable goal, it is fraught with uncertainty. In particular, the supply and demand responsiveness of global market participants – both OPEC and non-OPEC – are uncertain at best, meaning a precise estimate of the price impact is meaningless unless those factors are explicitly taken into account.

The various studies also report a range of estimates with regard to what will happen to the domestic crude oil price discount should the ban on exports remain in place or be lifted. For example, if global prices remain in the $100 per barrel range, the IHS study projects a WTI price discount relative to Brent of $12–15 per barrel, and an even deeper discount for crude oils extracted further inland – up to a $25 discount, for instance, to Bakken crude oils – given the cost of transportation to refining centers. If exports are allowed, however, the IHS study predicts that the differential would disappear. Importantly, the results are contingent on the international crude oil price staying in the $100 range. This is generally the case for all the studies that have been conducted over the last couple of years. At the higher end of the spectrum, Baron et al. (2014), consultants at NERA, estimate that the spread between the US and international crude prices could grow to $34 per barrel if the export ban remains in place.

The studies also examine changes in US trade patterns if the ban is lifted, noting that exported crude oils would go to Asia, Latin America, or Europe, depending on the study in question. All studies agree that even with increasing US crude oil production, the US will remain a net importer of crude. The ICF and NERA studies each indicate the largest change will come through a shift in the composition of imported crudes, as virtually all imports of light crude oil will be eliminated, while the US continues to import heavier crudes in line with the configuration of most US refineries. The extent of the impact on the overall trade balance differs across studies, but the general results are similar.

Studies also attempt to assess the impact of the ban, lifted or not, on the US refining sector. A number of outcomes are noted. In the event of the ban remaining in place, the steep discounts of domestic crude oil prices would stimulate investments in the refining sector, in particular since there are no barriers to exporting refined products. However, there are differences across studies as to the manner in which this arbitrage mechanism is employed. In the case where the ban on exports is lifted, the incentive to add refining capacity to process light crudes is dissipated, and refineries remain focused on processing heavier imported crudes that are effectively "swapped" with lighter exported crudes.

All the studies underscore that lifting the export ban will not translate into higher gasoline prices. In fact, the studies generally project that gasoline prices in the US will fall once the ban is lifted, all else equal. There are a number of anticipated declines in the price of gasoline, but the analyses generally miss an important caveat, namely, the possible response to US exports by OPEC and other producing nations. Only the NERA study gives consideration to the OPEC response, but it does so through addressing a series of possible options rather than a distinct modeling framework aimed at explicitly assessing OPEC behavior.

In sum, most studies agree that allowing exports will increase US crude oil production, provide a boost to domestic crude oil prices, lower international crude oil prices, and drive a reduction in gasoline prices. The studies also generally agree that allowing exports will provide substantial benefits to the US economy through increased employment and energy sector investment, higher local and federal tax revenues, and positive impacts on the trade balance.

Considering the above, the economic benefits of lifting the crude oil export ban are quite well documented and widely acknowledged, with the largest differences lying in various assumptions that studies hold about domestic supply responsiveness and future demand. However, the non-market impacts of lifting the ban on US crude exports are much more controversial. In fact, it is the non-market impacts – such as environmental and national/energy security concerns – that are the most common basis for opposition to allowing US crude exports.

Those who support the ban on oil exports often argue that allowing exports, thereby raising production, will negatively impact the climate and lead to local environmental damage to US land, water, and air resources (see Stockmeane (2013)). The studies by RFF and NERA recognize that allowing exports will increase carbon dioxide emissions. However, they do not advocate using trade policy to affect environmental goals. Indeed, other policy options that limit environmental damage seem to be more viable, including but not limited to those pointed out in the Columbia/SIPA study, such as performance standards for existing power plants, methane regulations, or heavy vehicle fuel standards.

Another point of disagreement across studies relates to the effect the end of the ban would have on energy security and national security. Senators Edward Markey and Robert Menendez, for example, have argued that export restrictions are vital for US national security, which should not be swapped for economic benefits. However, others argue, for example in the Columbia/SIPA report, that permitting exports has the potential to mitigate disruptions in international supply of crude and prevent oil price shocks, a result that follows from greater oil market fungibility. In general, the crude oil export ban is more and more frequently seen as distortionary, resulting in a misallocation of capital and having generally negative macroeconomic impacts.

In order to bring a new perspective to the discussion, this paper is organized as follows. First, we discuss the relevance of referencing WTI prices when considering the effects of the export ban and develop a framework utilizing a hedonic pricing method to understand the impact of trade restrictions on crude oil prices. Next, we characterize the current policy using options theory and motivate a discussion of gasoline prices. Then we turn to a discussion of energy security and how existing trade restrictions may, counterintuitive to some, compromise energy security, particularly in a world where global market balance is increasingly dependent on new and emerging supplies from non-traditional locations. We wrap up with some concluding thoughts on policy direction and areas for future research.

II. Trade Restrictions and Domestic Crude Oil Price

Much of the existing literature on the crude oil export ban has focused on the spread between WTI and Brent, largely because these are two commonly quoted benchmark prices. Indeed, the last few years have witnessed a shift in the relationship between WTI and Brent, as indicated in Figure 2 above. Strong domestic production growth coupled with a physical constraint on moving crude oil away from Cushing resulted in a discount in WTI relative to Brent. In fact, the discount has averaged over $10 per barrel since the end of 2010, which is especially remarkable given WTI priced at a *premium* of $1.37 (average) the decade prior. This provides evidence of an emerging, binding constraint on the ability to trade WTI. This is further supported by the fact that the standard deviation of the spread between Brent and WTI is 4.5 times higher after 2010. This is exactly what one should expect in the face of a binding constraint to trade – shifts in both the *average value* and *volatility* of the price difference across the trade pathway.

Over the past few years, concerns have mounted that the observed discount at WTI will spread to be more broadly representative of all US crude oil prices. This concern owes to the fact that current US policy explicitly prohibits exports of crude oil, thereby limiting arbitrage of growing domestic supply into the global market. The commercial implications are that lower domestic crude oil prices could trigger a stronger profit opportunity for refineries in the near term, and may even encourage investment in the downstream in the longer term, should the discount persist. But a persistent discount may also negatively impact US production, which has implications for the economic activity associated with upstream production and, of course, the impact that US shale will ultimately have on the global oil market. So, there are trade-offs that must be evaluated in the context of current law versus lifting the ban on crude oil exports.

Given the shift in the pricing relationship of Brent and WTI, it is useful to understand what the price of WTI and other domestic crude oil would be if no barrier to trade exists. Thus, we enter into the analysis recognizing that the history of price data for Bakken and Eagle Ford crude oils, for example, is not sufficiently long so as to predate the shift in WTI price after 2010. Therefore, the market has not revealed the prices of these domestic crude oils in an unconstrained environment. This is perhaps the reason studies focus only on WTI when discussing domestic crude oil prices. However, the crude oil being produced in the Bakken and Eagle Ford shales is lighter and sweeter than WTI, so it is important to understand how crude oils of similar quality price in the international market if we wish to fully assess the impact of the export ban. Therefore, we can more generally evaluate the effect of crude oil characteristics on the relative prices of different crude oils that are traded without constraint in the international market to inform an assessment of how domestic crude oils would price if trade were unimpeded.

To begin, no two crude oils are the same, and crude oil prices vary depending on quality. This suggests that a hedonic pricing method can be employed to evaluate how differences in crude oil characteristics drive differences in prices across different crude oils. Hedonic pricing is often employed in evaluating things such as environmental attributes and/or housing values because it stipulates that particular combinations of characteristics unique to a good or asset influence its demand and hence pricing. Crude oil assays contain important information about the physical and chemical characteristics of a crude oil, and these characteristics establish a crude oil's relative value. Thus, information in a crude assay can be used to evaluate the influences of various crude oil characteristics on pricing differences. This then allows, in principle, a revealed preference treatment for the value of each characteristic. Previous literature has identified various crude characteristics – such as API number, sulfur content, and total acid number – as being important in determining differences in prices across various crudes (see, for example, Bacon and Tordo (2005)).

We evaluate daily price data for 30 different crudes with sufficiently long time-series so that a wide range of market prices can inform the analysis. Table 2 indicates the crude oils included in the analysis along with selected characteristics of each crude oil. Next, we estimate a panel that allows the crude oil's characteristics to determine its price relative to Brent, an internationally accepted benchmark. More specifically, we estimate

$$\ln P_{i,t} = \alpha_{0,i} + \alpha_1 \ln P_{Brent,t} + \alpha_2 API_i + \alpha_3 Sulfur_i + \alpha_4 TAN_i \tag{1}$$

where $P_{i,t}$ is the price of crude oil *i* at time *t*, $P_{Brent,t}$ is the price of Brent crude oil at time *t*, and API_i, $Sulfur_i$ and TAN_i are the API number, sulfur content, and total acid number of crude oil *i*, respectively. The term $\alpha_{0,i}$ is an effect specific to crude oil i that can be treated as fixed or random.[2] We use daily data spanning from January 2, 2002, through the end of 2014.

Table 2 – Crude Oils and Characteristics in the Analysis

Crude Oil	API	Sulfur	Total Acid Number
Brent	37.5	0.400	0.010
WTI	40.8	0.340	0.100
Urals	31.3	1.250	0.080
Syrian Light	38.0	0.680	0.050
Syrian Heavy	23.1	4.200	0.280
Siberian Light	37.8	0.420	0.652
Saharan Blend	45.3	0.120	0.060
Kumkol	42.5	0.070	0.041
Kirkuk	34.3	2.280	0.090
Escravos	33.5	0.170	0.500
Brass River	37.4	0.110	0.230
Bow River Hardisty	20.3	2.960	0.690
Azeri Light	34.8	0.150	0.260
CPC Blend	45.3	0.560	0.060
Zarzatine	42.6	0.080	0.100
Forcados	30.4	0.280	0.400
Iranian Heavy	30.1	1.780	0.130
Iranian Light	33.1	1.330	0.090
Suez Blend	31.3	1.410	0.060
Es Sider	36.7	0.370	0.100
Flotta	36.2	0.980	0.150
Ekofisk	38.5	0.190	0.104
Forties	38.7	0.790	0.093
Oseberg	37.8	0.274	0.260
Cabinda	37.0	0.170	0.030
Bonny Light	35.3	0.150	0.200
Qua Iboe	36.0	0.130	0.370
Oriente	24.0	1.590	0.040
Escalante	24.1	0.190	0.560
US Poseidon	29.7	1.650	0.410
Sample Max	45.3	4.200	0.690
Sample Min	20.3	0.070	0.010
Sample Average	34.8	0.836	0.207

Source: Oil & Gas Journal and various industry websites

[2] The estimated coefficient on the price relationship is unchanged when a fixed effect specification is estimated, suggesting the crude quality variables adequately capture the differences across crudes in the sample. The Breusch-Pagan Lagrange multiplier test for random effects reveals $\chi^2(1) = 1.2 \times 10^7$ indicating with very high confidence the random effects specification is appropriate. Similarly, a Hausman specification test of the null that there is not a systematic difference in the estimated coefficients for the fixed and random effects specifications reveals $\chi^2(5) = 0.2864$, meaning we cannot reject the null hypothesis that the random effects treatment is appropriate.

The specification in equation (1) implies

$$P_{i,t} = \gamma_i P_{Brent,t}^{\alpha_1}$$

where $\gamma_i = e^{\alpha_{0,i} + \alpha_2 API_i + \alpha_3 Sulfur_i + \alpha_4 TAN_i}$. The appendix contains a graphical depiction of the above functional relationship for each of the crude oils considered in this analysis. The relationship holds very well for all but two of the crude oils in the sample – WTI and Bow River Hardisty – each North American crude oils. Indeed, there is evidence of structural breaks in the price series indicative of binding constraints on the ability to move the crudes (see Figure A1 in the appendix for more). As such, a dummy variable, denoted as D_i, is included in equation (1) and takes a value of one in periods where the breaks are identified to occur and zero otherwise.

Estimation of equation (1) reveals

$$\ln P_{i,t} = \underset{(0.0449)}{-0.2678} + \underset{(0.0003)}{1.0249} \ln P_{Brent,t} + \underset{(0.0012)}{0.0046} API_i - \underset{(0.0074)}{0.0294} Sulfur_i + \sum_j \alpha_j D_{ij} \tag{2}$$

with overall $R^2 = 0.9904$. The coefficients α_j are detailed in the appendix. Equation (2) indicates a higher API number tends to raise the price of crude oil relative to Brent, while higher sulfur content tends to lower the price of crude oil relative to Brent. The coefficient on total acid number, α_4, was negative but not significantly different from zero, so it was dropped.

Table 3 highlights the implications of equation (2). Specifically, we note that based on its qualities, WTI should price at a premium to Brent, which is consistent with the period prior to 2011. Thus, the hedonic pricing method provides additional evidence of a constraint on the ability to arbitrage WTI relative to Brent, which is consistent with observed pricing behavior after 2010 when constraints emerged on moving crude oil away from Cushing. Table 3 also indicates how the other crudes in the sample would price according to their characteristics. The only crude—aside from WTI—that deviates dramatically is the other North American crude in the sample, the Canadian crude oil Bow River Hardisty. Importantly, this crude should price below WTI and Brent, given its characteristics, but the degree of discount observed over the last 13 years has at times been far in excess of what is implied by equation (2).

Table 3 – Within-Sample Crude Oil Prices Implied by Equation (2)

Crude Oil	API	Sulfur	Price												
Brent	**37.5**	**0.40**	**$ 30.00**	**$ 40.00**	**$ 50.00**	**$ 60.00**	**$ 70.00**	**$ 80.00**	**$ 90.00**	**$ 100.00**	**$ 110.00**	**$ 120.00**	**$ 130.00**	**$ 140.00**	**$ 150.00**
WTI	40.8	0.34	$ 30.50	$ 40.68	$ 50.85	$ 61.03	$ 71.20	$ 81.38	$ 91.56	$ 101.73	$ 111.91	$ 122.09	$ 132.27	$ 142.45	$ 152.63
Urals	31.3	1.25	$ 28.47	$ 37.94	$ 47.41	$ 56.88	$ 66.34	$ 75.81	$ 85.27	$ 94.73	$ 104.19	$ 113.65	$ 123.10	$ 132.56	$ 142.01
Syrian Light	38.0	0.68	$ 29.83	$ 39.77	$ 49.71	$ 59.65	$ 69.59	$ 79.53	$ 89.46	$ 99.40	$ 109.34	$ 119.28	$ 129.22	$ 139.16	$ 149.10
Syrian Heavy	23.1	4.20	$ 25.20	$ 33.56	$ 41.90	$ 50.24	$ 58.56	$ 66.89	$ 75.21	$ 83.52	$ 91.83	$ 100.13	$ 108.43	$ 116.73	$ 125.03
Siberian Light	37.8	0.42	$ 30.02	$ 40.03	$ 50.04	$ 60.05	$ 70.06	$ 80.06	$ 90.07	$ 100.08	$ 110.09	$ 120.10	$ 130.11	$ 140.11	$ 150.12
Saharan Blend	45.3	0.12	$ 31.33	$ 41.79	$ 52.25	$ 62.71	$ 73.17	$ 83.64	$ 94.10	$ 104.57	$ 115.04	$ 125.51	$ 135.98	$ 146.45	$ 156.93
Kumkol	42.5	0.07	$ 30.98	$ 41.32	$ 51.66	$ 62.00	$ 72.34	$ 82.68	$ 93.02	$ 103.37	$ 113.71	$ 124.06	$ 134.41	$ 144.76	$ 155.10
Kirkuk	34.3	2.28	$ 28.01	$ 37.33	$ 46.64	$ 55.95	$ 65.26	$ 74.56	$ 83.87	$ 93.17	$ 102.46	$ 111.76	$ 121.06	$ 130.35	$ 139.65
Escravos	33.5	0.17	$ 29.66	$ 39.54	$ 49.42	$ 59.31	$ 69.19	$ 79.07	$ 88.95	$ 98.83	$ 108.71	$ 118.59	$ 128.47	$ 138.35	$ 148.22
Brass River	37.4	0.11	$ 30.24	$ 40.32	$ 50.40	$ 60.48	$ 70.57	$ 80.65	$ 90.73	$ 100.82	$ 110.90	$ 120.99	$ 131.07	$ 141.15	$ 151.24
Bow River Hardisty	20.3	2.96	$ 25.79	$ 34.34	$ 42.89	$ 51.43	$ 59.96	$ 68.48	$ 77.01	$ 85.53	$ 94.04	$ 102.55	$ 111.06	$ 119.57	$ 128.07
Azeri Light	34.8	0.15	$ 29.85	$ 39.80	$ 49.75	$ 59.69	$ 69.64	$ 79.59	$ 89.54	$ 99.48	$ 109.43	$ 119.38	$ 129.32	$ 139.27	$ 149.22
CPC Blend	45.3	0.56	$ 30.94	$ 41.26	$ 51.58	$ 61.90	$ 72.23	$ 82.56	$ 92.89	$ 103.21	$ 113.54	$ 123.88	$ 134.21	$ 144.54	$ 154.87
Zarzatine	42.6	0.08	$ 30.99	$ 41.32	$ 51.66	$ 62.01	$ 72.35	$ 82.69	$ 93.04	$ 103.39	$ 113.73	$ 124.08	$ 134.43	$ 144.78	$ 155.13
Forcados	30.4	0.28	$ 29.15	$ 38.86	$ 48.57	$ 58.28	$ 67.98	$ 77.69	$ 87.39	$ 97.10	$ 106.80	$ 116.50	$ 126.20	$ 135.90	$ 145.60
Iranian Heavy	30.1	1.78	$ 27.88	$ 37.16	$ 46.42	$ 55.69	$ 64.95	$ 74.21	$ 83.47	$ 92.72	$ 101.98	$ 111.23	$ 120.48	$ 129.73	$ 138.98
Iranian Light	33.1	1.33	$ 28.63	$ 38.16	$ 47.69	$ 57.21	$ 66.73	$ 76.26	$ 85.78	$ 95.29	$ 104.81	$ 114.33	$ 123.84	$ 133.36	$ 142.87
Suez Blend	31.3	1.41	$ 28.33	$ 37.76	$ 47.19	$ 56.61	$ 66.03	$ 75.45	$ 84.86	$ 94.28	$ 103.69	$ 113.10	$ 122.51	$ 131.92	$ 141.33
Es Sider	36.7	0.37	$ 29.92	$ 39.89	$ 49.86	$ 59.83	$ 69.81	$ 79.78	$ 89.75	$ 99.72	$ 109.69	$ 119.66	$ 129.63	$ 139.61	$ 149.58
Flotta	36.2	0.98	$ 29.33	$ 39.10	$ 48.87	$ 58.64	$ 68.40	$ 78.17	$ 87.93	$ 97.70	$ 107.46	$ 117.22	$ 126.99	$ 136.75	$ 146.51
Ekofisk	38.5	0.19	$ 30.32	$ 40.43	$ 50.54	$ 60.65	$ 70.76	$ 80.87	$ 90.98	$ 101.10	$ 111.21	$ 121.32	$ 131.43	$ 141.55	$ 151.66
Forties	38.7	0.79	$ 29.83	$ 39.77	$ 49.71	$ 59.65	$ 69.59	$ 79.53	$ 89.46	$ 99.40	$ 109.34	$ 119.28	$ 129.22	$ 139.16	$ 149.10
Oseberg	37.8	0.27	$ 30.15	$ 40.20	$ 50.25	$ 60.31	$ 70.36	$ 80.41	$ 90.46	$ 100.52	$ 110.57	$ 120.62	$ 130.67	$ 140.73	$ 150.78
Cabinda	37.0	0.17	$ 30.13	$ 40.18	$ 50.22	$ 60.27	$ 70.31	$ 80.36	$ 90.40	$ 100.45	$ 110.50	$ 120.54	$ 130.59	$ 140.64	$ 150.68
Bonny Light	35.3	0.15	$ 29.92	$ 39.89	$ 49.86	$ 59.83	$ 69.80	$ 79.77	$ 89.75	$ 99.72	$ 109.69	$ 119.66	$ 129.63	$ 139.60	$ 149.57
Qua Iboe	36.0	0.13	$ 30.03	$ 40.04	$ 50.05	$ 60.06	$ 70.07	$ 80.08	$ 90.09	$ 100.10	$ 110.11	$ 120.12	$ 130.13	$ 140.14	$ 150.15
Oriente	24.0	1.59	$ 27.27	$ 36.34	$ 45.40	$ 54.45	$ 63.50	$ 72.55	$ 81.59	$ 90.63	$ 99.67	$ 108.71	$ 117.74	$ 126.77	$ 135.80
Escalante	24.1	0.19	$ 28.41	$ 37.86	$ 47.31	$ 56.76	$ 66.20	$ 75.64	$ 85.09	$ 94.52	$ 103.96	$ 113.40	$ 122.84	$ 132.27	$ 141.70
US Poseidon	29.7	1.65	$ 27.94	$ 37.23	$ 46.52	$ 55.80	$ 65.08	$ 74.36	$ 83.64	$ 92.91	$ 102.18	$ 111.45	$ 120.72	$ 129.99	$ 139.26

Table 4 – Out-of-Sample Crude Prices Implied by Equation (2)

Crude Oil	API	Sulfur	Price												
Brent	**37.5**	**0.40**	**$ 30.00**	**$ 40.00**	**$ 50.00**	**$ 60.00**	**$ 70.00**	**$ 80.00**	**$ 90.00**	**$ 100.00**	**$ 110.00**	**$ 120.00**	**$ 130.00**	**$ 140.00**	**$ 150.00**
WTI	40.8	0.34	$ 30.50	$ 40.68	$ 50.85	$ 61.03	$ 71.20	$ 81.38	$ 91.56	$ 101.73	$ 111.91	$ 122.09	$ 132.27	$ 142.45	$ 152.63
LLS	38.0	0.40	$ 30.07	$ 40.09	$ 50.11	$ 60.14	$ 70.16	$ 80.19	$ 90.21	$ 100.23	$ 110.26	$ 120.28	$ 130.31	$ 140.33	$ 150.35
Eagle Ford Crude I	47.7	0.10	$ 31.69	$ 42.27	$ 52.85	$ 63.44	$ 74.03	$ 84.62	$ 95.21	$ 105.81	$ 116.40	$ 127.00	$ 137.60	$ 148.20	$ 158.80
Eagle Ford Crude II	58.8	0.04	$ 33.39	$ 44.55	$ 55.71	$ 66.89	$ 78.07	$ 89.25	$ 100.44	$ 111.63	$ 122.82	$ 134.02	$ 145.22	$ 156.42	$ 167.62
Bakken I	36.7	0.10	$ 30.15	$ 40.20	$ 50.26	$ 60.31	$ 70.36	$ 80.41	$ 90.47	$ 100.52	$ 110.57	$ 120.63	$ 130.68	$ 140.73	$ 150.79
Bakken II	46.3	0.06	$ 31.53	$ 42.05	$ 52.58	$ 63.11	$ 73.64	$ 84.18	$ 94.71	$ 105.25	$ 115.79	$ 126.33	$ 136.87	$ 147.41	$ 157.95

Indeed, Table 3 indicates the Canadian crude oil should price at a discount to Brent of $12 to $15 per barrel at prices between $90 and $110, but the actual discount was as deep as $60 per barrel in early 2013, when Brent was pricing at about $110, and had an average discount of around $40 from late 2012 through early 2014. Again, this signals a constraint on the ability to arbitrage Canadian crude oil that would under different circumstances incentivize pipeline infrastructure development. Rather, the inability to build pipeline capacity coupled with the steep discounts observed has incentivized other, more costly arbitrage mechanisms, such as transport by rail.

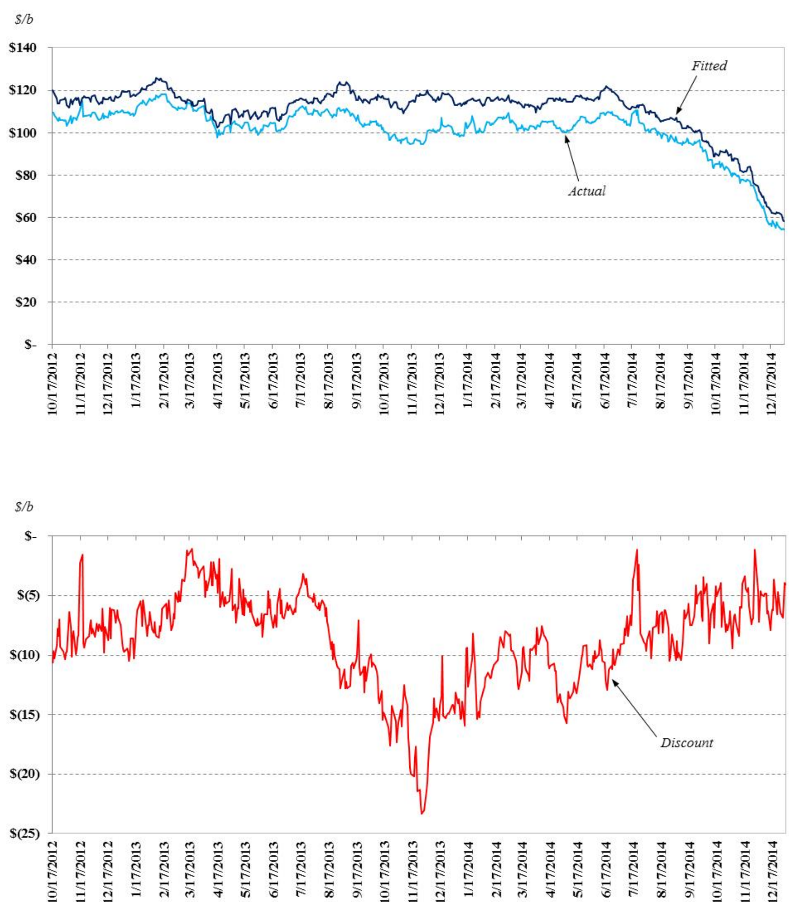
We can also use equation (2) to simulate prices for crude oil that are not included in the estimated sample. This provides an indication as to what the price of a crude oil should be given its characteristics as priced on the open water. Of course, the price differentials between any two crude oils will also reflect transportation costs. In equation (2), the crude-specific constant term provides flexibility to capture any persistent differences in the different crude oil prices relative to Brent, but these values are not known for out-of-sample crude oil prices. As noted above, estimation of equation (2) revealed the crude-specific effects are not correlated with crude oil prices, as a random effects estimator proved appropriate, so there do not appear to be any systematic crude-specific differences in the estimated sample that are not captured by the crude oil qualities and the estimated constant term. Nevertheless, it is important to recognize that there are transportation costs for inland crude oils to arrive at a port of loading, meaning the current price quote for crude oils in the Bakken or Eagle Ford shales should be below the FOB price of similar crude oils. In a market where exports are allowed the price difference would be the cost of transport.[3] However, if a binding constraint is present, the difference will generally be greater.

Assessing the prices of various crude oils out-of-sample is an important step in determining the effect of the export ban, or any constraint for that matter, on domestic crude oil price because for several of these domestic crude oils for which there is a quoted price, the crude oils are relatively new to the market, so their historical price data does not exist in an unconstrained environment. Thus, we can use the hedonic pricing method, or more specifically equation (2), to infer the prices of these crude oils in an unconstrained global market. Table 4 reveals the prices of

[3] This issue is being explored in separate CES research. Namely, the existence of an export ban discourages the construction of pipelines to the coast for export because the economies of scale cannot be captured absent access to the larger international market. Hence, transportation capacity is added in smaller increments, such as through rail capacity, resulting in a higher per unit cost of transportation.

selected domestic crude oils – WTI, two Eagle Ford crudes, two Bakken crudes, and Louisiana Light Sweet (LLS) – according to their qualities. Importantly, the price implied by equation (2) should be interpreted as the price fetched in the international crude oil market for a specific quality of crude oil. Notably, none of these crudes actually priced at these levels, which indicates an additional factor that acts to discount price. Figure 3 depicts the actual daily price, the price implied by equation (2), and the implied discount for Eagle Ford crude (API 47.7, Sulfur 0.101) from October 2012 through the end of 2014. The price indicated as "Fitted" in Figure 3 should be interpreted as the price of an Eagle Ford quality crude oil on the open water. As noted above, even in an unconstrained market the wellhead price would be lower than the price of the same quality crude on the open water by the cost of transport to a port of loading.

Figure 3 – Eagle Ford Crude Oil Price and Implied Discount



Source: Platts and Author's Calculations

The results in Table 4 and Figure 3 signal a significant incentive for infrastructure development to move crude oil from inland locations to the coasts, even at prices as low as $30 per barrel. Of course, this incentive hinges on the ability to sell the crude oil into the international market. Absent that capability, the incentive for infrastructure investment is stymied and the arbitrage will not occur. The exact amount of infrastructure investment that would occur is subject to more than just the price differential between the inland location and the point of sale; it also depends on the transport costs from wellhead to port of loading, the anticipated return to investment, the longevity of the resource play, and a host of other factors, some of which are specific to individual industry participants. Hence, a point estimate of how much investment would be forthcoming if the export ban were lifted is not prudent and is out of scope herein. However, the incentive to capture the arbitrage value that is present already exists, particularly given the price discounts implied by the analysis herein.

Next, we turn our attention to the fundamental drivers of a discount and compare selected domestic crude oils in this context to shed light on the impacts – both existing and potential – of the crude oil export ban.

Why Does a Discount Emerge in the US?

Much of the analysis that has recently been done regarding the ban on US crude oil exports has attempted to highlight the domestic price impacts of a ban on crude oil exports. In general, the arguments are couched in a discussion of the impact of trade restrictions. Figure 4 provides a graphical representation of "why" domestic crude oil prices become discounted and, more importantly, the mechanism through which such a discount operates. To begin, note that the figure represents only three different crude qualities. In practice, there are many more than this, but for the sake of exposition we keep it simple. More generally, this is an abstract, simplified, and stylized representation designed to highlight a market reality, which we will return to below.

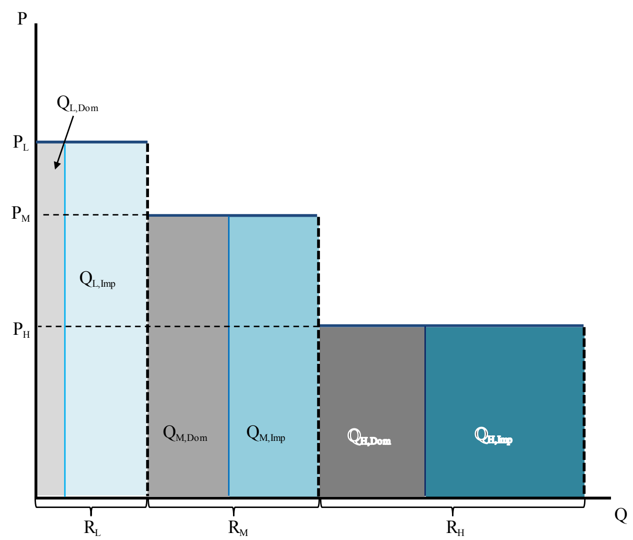
The fundamental question we must ask here is, "Since no crude is the same, how might arbitrage constraints be manifested through price?" To answer this, we must first recognize that any discount will be reflective of the competitive margin that is realized in the presence of a policy constraint. In other words, the inability to export growing light crude oil production will force an alternative arbitrage mechanism. This will be at the competitive margin that is realized by displacement of heavier, lower value crude oils. So, as the competitive margin shifts to heavier crudes, the discount on domestic light crude oil will increase, all else equal, with the countervailing force being a new arbitrage capability introduced through investment in domestic crude oil processing capacity. In general, this latter arbitrage pathway will be encouraged as the domestic price discount grows.

As established above, crude oil is priced differently in the international market according to quality. In Figure 4, we indicate three broadly defined qualities as P_L, P_M, and P_H, denoting the prices of light crude, medium crude, and heavy crude, respectively. There is also an existing set of refinery configurations associated with existing refinery capacities that are predisposed to processing different crude oils, where R_L, R_M, and R_H denote domestic crude oil refining capacity for light, medium, and heavy crude oils, respectively. A portion of the crude oil inputs come from domestic producers – denoted as $Q_{L,Dom}$, $Q_{M,Dom}$, and $Q_{H,Dom}$ for domestic light, medium, and heavy crude oil production, respectively – and a portion comes from imported sources – denoted as $Q_{L,Imp}$, $Q_{M,Imp}$, and $Q_{H,Imp}$ for imported light, medium, and heavy crude oil, respectively.

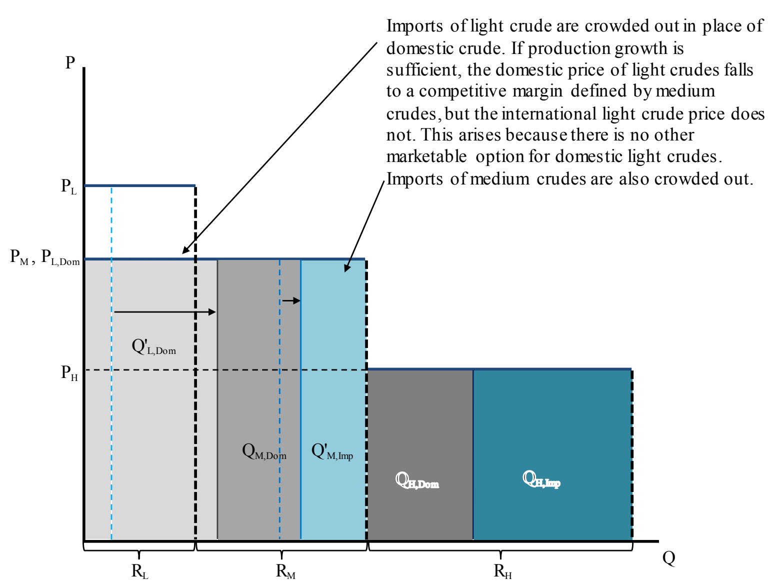
The first graphic in Figure 4 indicates the market in equilibrium prior to a rapid, unexpected growth of domestic production of light crude oil. The second graphic indicates the situation immediately after domestic production growth has occurred. As pictured, growth in domestic production outstrips available refining capacity tuned specifically to handle light crudes. Imports of light crude oils decline, as they are crowded out by domestic production. But, as domestic production continues to grow and exports are not allowed, the only available market is to refiners of medium crudes. These refiners have the option of buying domestically produced light crude oil or imported medium crude oil. Having already made investments to handle the medium crude oils, they choose to optimize their existing configurations and purchase the lower cost medium crude in the international market. However, since domestic producers of light crude oil have no other market outlet, they can either discount the price to be competitive at the margin defined by the medium crudes or shut in production. In either case, revenues are constrained, but producers will choose to sell at a discount so long as the cost of production is covered. In turn, as $P_{L,Dom} < P_L$ imports of medium crudes are crowded out.

Figure 4 – Why Does a Trade Restriction Lead to a Domestic Crude Oil Price Discount?

Initial equilibrium: domestic market harmonized with international market



After domestic LTO production growth: domestic market discounted to international market



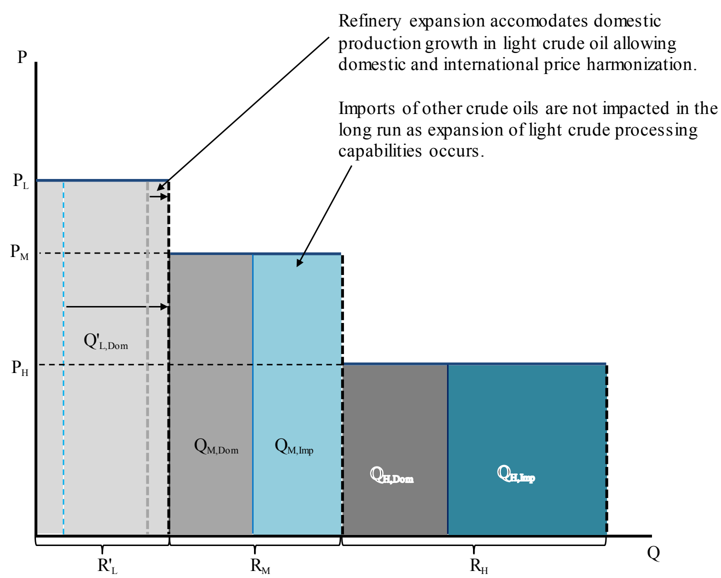
If domestic production of light crude oil continues to increase, eventually all imports of medium crudes will be displaced and the new competitive margin will be heavy crude oils. In turn, this would result in an even steeper discount of domestic crude oil. Importantly, this can only occur in the relatively short run, because should such a steep discount emerge, it would signal investment opportunities in new refining capability. As pictured in Figure 5, this would result in a reemergence of imports of medium crudes to the refineries that are tuned to process those crudes, and the total quantity of imports that are ultimately displaced is only the light crudes. Of course, this outcome depends on sufficient investment, which may be a difficult proposition given the historical uncertainty of refining margins that are needed to provide a return to such investments. The unclear future of crude oil export policy only adds to this uncertainty.

If, however, the ban on crude oil exports was lifted, then no domestic price discount would exist, and no additional refining investments would be needed (nor perhaps even incentivized); rather, as indicated in Figure 5, the excess light crude oil would be exported. Again, imports of medium and heavy crudes are not affected. In the end, each outcome – export ban remains in place versus export ban is lifted – is characterized by imports of medium and heavy crude oils. However, the case in which exports are allowed does not require investment in the domestic refining sector and it is not laden with the same degree of uncertainty.

In one sense, the conjecture in Figure 5 indicates that, in the long run, the export ban does not matter. However, there is a fallacy in such an argument. In particular, the current policy does not result in an optimal allocation of capital. Moreover, it establishes a “no-cost call option” for domestic refiners at the margin. We return to this below in more detail, but, briefly, refiners have the ability to either buy imported crude oil or domestic crude oil. If the price of domestic crude becomes discounted relative to the international market, then the refiner can opt to purchase the high quality domestic crude, thus exercising the option to buy domestically. Importantly, not all refiners benefit in such a manner. Namely, refiners that normally process light crude oil earn tremendous rents when the domestic light crude price is discounted, while refiners of heavy crudes would see little to no tangible benefit from the current policy. Thus, while the current policy secures rents for a segment of the refining industry, it does not do so for the entire industry. Moreover, it does so at the cost of domestic producers and inhibits midstream infrastructure investment by blocking an arbitrage pathway that would otherwise attract capital.

Figure 5 – Long-Run Implications for Crude Oil Imports

Markets harmonized after expansion of light crude oil processing capability



Markets harmonized as domestically produced light crude oil is exported

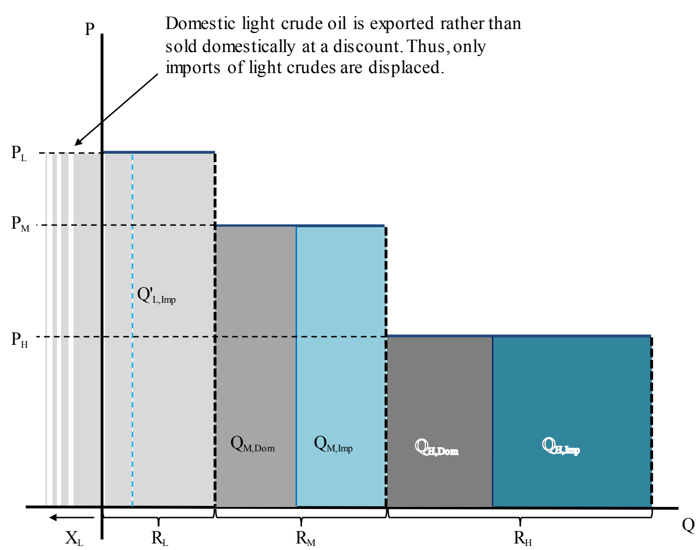
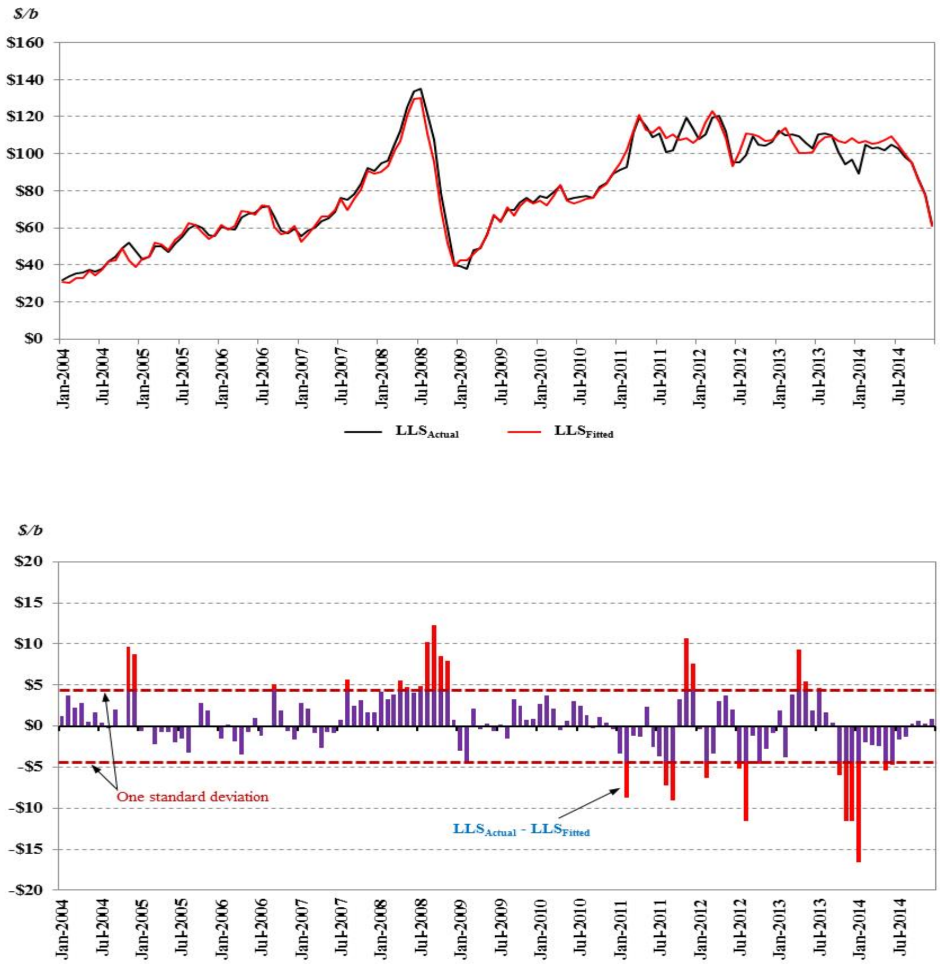


Figure 6 – LLS Actual versus LLS "Fitted"



Source: US Energy Information Administration and author calculations

As indicated in Figure 4, the price discount is not uniform across all crudes, and a discount is only realized at the margin that is binding. To this end, identifying the competitive margin is useful is we wish to understand the discounts that may already be present. As such, we can examine LLS. In particular, if we simulate daily LLS according to equation (2), then aggregate to monthly price for comparison to publicly available LLS pricing data from EIA, we see in Figure 6 that the actual and "fitted" LLS prices match very well. However, we also see in Figure 6 that an interesting pattern is revealed in the difference between the actual and fitted LLS prices. In the last 11 years, 14 of the 15 negative differences between actual and fitted LLS prices in excess of one standard deviation have occurred since January 2011.[4] Moreover, the fact that the LLS discounts are intermittent suggests the competitive margin for domestic crudes has been hovering around the price for LLS.

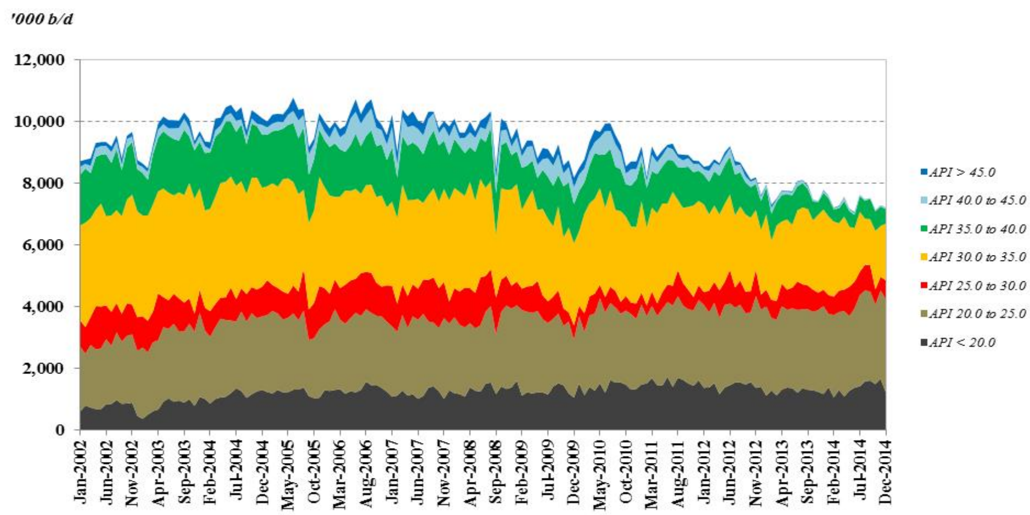
It is important to underscore that refiners of heavy crude oils do not benefit from the domestic price discount as they will continue to import heavy crude oils anyway. If LLS is indeed currently at the margin, then refiners of crude oils heavier than LLS are currently unaffected by the export ban. Moreover, domestic crude oils that are heavier than the crude oil at the margin will not see a discount. Even if domestic crude oil production grows to the point that heavy crude oil imports are crowded out, meaning a rather steep discount for domestic crude oil must emerge, the refiners of heavy crude oils will not earn rents. Rather, the refiners of lighter crude oils do. Thus, not all refiners benefit uniformly from discounted domestic crude oil prices. Only those refiners who are inframarginal see a benefit because they are able to purchase crude oil at a price lower than they would pay for imported crudes. This effectively establishes a paradigm where current policy dictates a no-cost call option for inframarginal domestic refiners. We return to this in more detail below.

How Deep Is the Implied Discount Given the Export Ban?

The framework presented above provides a theoretical argument for how price discounts might emerge when trade restrictions are present. But does evidence support theory? Figure 6 reveals monthly crude oil imports to the United States by API spanning January 2002 through December 2014. As seen in Figure 7, imports of light crude oils have been declining, with imports of the lightest crude oil imports virtually eliminated. This has been occurring lockstep with increased domestic production of light crude oils from the Bakken, Eagle Ford, Permian, and other shale formations. As argued above, in order for refiners to substitute domestic for imported crude oils, the domestic crude oils must be priced competitively. So, as the competitive margin for domestically produced crude oil is set by lower API crude oils, the discount for those light crude oils will grow. Figure 7 suggests that the competitive margin is shifting into the crudes with API in the 35-40 range. Notably, LLS is squarely in the middle of this range.

[4] Note that the positive differences are largely prior to January 2011, which indicates LLS was more likely to price significantly above its “equilibrium” value, as measured by equation (2), prior to January 2011 than after. Importantly, the significant discount observed for WTI relative Brent emerged around this time.

Figure 7 – US Crude Oil Imports by API (Monthly, Jan 2002-Dec 2014)



Source: US Energy Information Administration

Given the results from the hedonic pricing model estimated above, we can determine for particular sulfur contents what the domestic crude oil price at the competitive margin in the US will be. Then we can determine the implied discount for select domestic crude oils. Table 5 details these results. Specifically, we see the price at the competitive margin for different "representative" refineries where the designations are consistent with those in Figure 7. The sulfur contents across APIs are consistent with the US average for data on imports by API.

We see in the case where the competitive margin is established by Refinery #1 there is no implied discount for LLS, WTI and Bakken (Type I), but there is for the other crude oils. Interestingly, this reveals that even in the case where the US is still importing light crudes at API of 45, the lighter, sweeter crude produced in Eagle Ford and Bakken would still fetch a higher price internationally. Hence, there is incentive to export those crude oils even if the US is importing light crude oils. Perhaps this sheds some light on why there has been such a strong push to export condensates, which are more similar to Eagle Ford (Type II) crude oil in Table 5. In Table 5, the price reported for each crude oil is consistent with its own characteristics and a Brent price of $40, $80, and $120 per barrel, as defined by equation (2) above.

Table 5 – Implied Discounts for US Crude Oils

				Unconstrained Domestic Crude Oil Prices at Coast if Brent = $40					
				WTI	LLS	Eagle Ford I	Eagle Ford II	Bakken I	Bakken II
Representative Refinery	API	Sulfur	Competitive Margin	$ 40.68	$ 40.09	$ 42.27	$ 44.55	$ 40.20	$ 42.05
				Implied Discount					
#1	45.0	0.15	$ 41.70	$ -	$ -	$ 0.57	$ 2.85	$ -	$ 0.35
#2	40.0	0.39	$ 40.48	$ 0.20	$ -	$ 1.80	$ 4.07	$ -	$ 1.58
#3	35.0	0.98	$ 38.89	$ 1.79	$ 1.20	$ 3.38	$ 5.66	$ 1.31	$ 3.16
#4	30.0	1.15	$ 37.82	$ 2.86	$ 2.27	$ 4.45	$ 6.72	$ 2.38	$ 4.23
#5	25.0	1.54	$ 36.55	$ 4.13	$ 3.54	$ 5.72	$ 7.99	$ 3.65	$ 5.50
#6	20.0	2.02	$ 35.24	$ 5.43	$ 4.85	$ 7.03	$ 9.30	$ 4.96	$ 6.81

				Unconstrained Domestic Crude Oil Prices at Coast if Brent = $80					
				WTI	LLS	Eagle Ford I	Eagle Ford II	Bakken I	Bakken II
Representative Refinery	API	Sulfur	Competitive Margin	$ 81.38	$ 80.19	$ 84.62	$ 89.25	$ 80.41	$ 84.18
				Implied Discount					
#1	45.0	0.15	$ 83.45	$ -	$ -	$ 1.17	$ 5.80	$ -	$ 0.72
#2	40.0	0.39	$ 80.97	$ 0.41	$ -	$ 3.65	$ 8.28	$ -	$ 3.21
#3	35.0	0.98	$ 77.74	$ 3.64	$ 2.44	$ 6.88	$ 11.51	$ 2.67	$ 6.43
#4	30.0	1.15	$ 75.57	$ 5.81	$ 4.62	$ 9.05	$ 13.68	$ 4.84	$ 8.61
#5	25.0	1.54	$ 72.98	$ 8.39	$ 7.20	$ 11.64	$ 16.27	$ 7.43	$ 11.19
#6	20.0	2.02	$ 70.32	$ 11.06	$ 9.86	$ 14.30	$ 18.93	$ 10.09	$ 13.85

				Unconstrained Domestic Crude Oil Prices at Coast if Brent = $120					
				WTI	LLS	Eagle Ford I	Eagle Ford II	Bakken I	Bakken II
Representative Refinery	API	Sulfur	Competitive Margin	$ 122.09	$ 120.28	$ 127.00	$ 134.02	$ 120.63	$ 126.33
				Implied Discount					
#1	45.0	0.15	$ 125.23	$ -	$ -	$ 1.77	$ 8.78	$ -	$ 1.09
#2	40.0	0.39	$ 121.47	$ 0.62	$ -	$ 5.54	$ 12.55	$ -	$ 4.86
#3	35.0	0.98	$ 116.58	$ 5.51	$ 3.70	$ 10.43	$ 17.44	$ 4.05	$ 9.75
#4	30.0	1.15	$ 113.29	$ 8.80	$ 7.00	$ 13.72	$ 20.73	$ 7.34	$ 13.04
#5	25.0	1.54	$ 109.37	$ 12.72	$ 10.91	$ 17.63	$ 24.65	$ 11.26	$ 16.96
#6	20.0	2.02	$ 105.34	$ 16.75	$ 14.94	$ 21.67	$ 28.68	$ 15.29	$ 20.99

As imports of lighter crude oils cease, due to displacement by domestic light crude oils, the competitive margin shifts into lower crude qualities. The data in Figure 7 suggests that the competitive margin in the US is in the API 35-40 window, which is consistent with Refinery #3 in Table 5. Noting the preceding discussion, LLS also happens to fall in this window. As can be seen, as we move into this competitive margin, every US crude oil is discounted relative to what it would price in an unconstrained market, even at a Brent price environment of $40 per barrel. Of course, as previously noted the price at the wellhead will be lower than the international parity price implied by equation (2) because the cost of transportation must also be considered, but that will not affect the discount as calculated in Table 5. Specifically, $P_i = \hat{P}_i + \tau$ where P_i

denotes the sales price at the coast (or point of delivery) for crude oil i, $\hat{P}_i$ denotes the wellhead price, and τ denotes the cost of transportation (and any other cost) to deliver from the wellhead to market.[5] Since the calculated discount reported in Table 5 applies to the sales price (P_i), it will also apply to the wellhead price equally. So, the implied discounts reported in Table 5 exist as a result of the inability to trade the domestic crude oil internationally.

The results in Table 5 and as expounded above highlight a very important point. The *capability* of the US refining sector to handle light, sweet domestic crude oils is not at issue, nor is it even a relevant metric for this discussion. This follows because if domestic crude oil prices are discounted sufficiently (to the competitive margin defined by the price of a similar quality imported crude oil), then refineries have incentive to use it. To the extent that this is suboptimal for the US refining configuration, an additional discount may be necessary to incentivize the purchase, but notice we are now discussing price, not quantity. In effect, the ban on crude oil exports provides a "no-cost call option" on domestic crude oil for domestic refiners, appoint to which we now will turn.

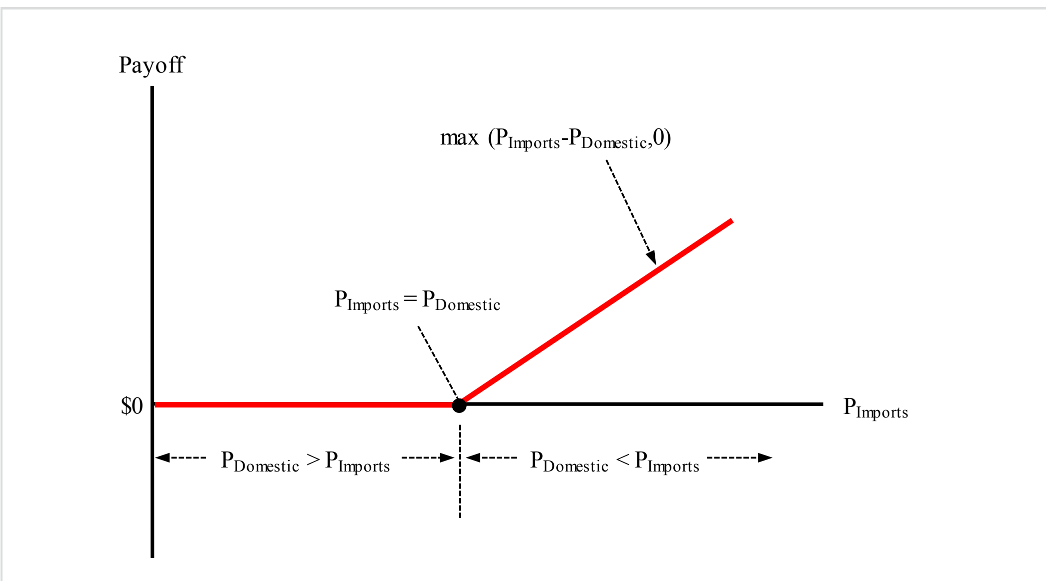
[5] The cost of transportation may indeed be higher in the current market than would be the case if the ban on exports did not exist. Specifically, the lack of an ability to aggregate volumes to access the international market will not encourage the development of pipelines, instead supporting smaller, lower capital cost options, such as rail. But, this is outside the scope of this study, and is the subject of ongoing Center for Energy Studies research.

III. The Export Ban as a "No Cost" Call Option and the Domestic Price of Gasoline

In this section, we consider the value of the constraint that the current policy on oil exports represents. We begin by using options theory in a relatively simplistic way for ease of exposition, and we focus only on the "refinery" as the consumer of domestically produced crude oil for the sake of simplicity. We then turn our analysis to the price of gasoline.

Consider Refinery X, which typically processes a medium quality crude oil, as in Figure 4 above. Refinery X has a choice. It can either (a) import a medium quality crude oil, or it can (b) buy and refine domestic light crude oil. The refiner will choose option (b) if the domestic light crude oil is a price competitive substitute, which will generally only occur if the domestic crude oil has no other marketable option. As indicated above, the abundance of domestic light crude oil relative to domestic refining capacity will determine how large a discount on domestic light crude is needed to encourage its use by Refinery X.

Figure 8 – Illustration of Payoff for a "No Cost" Call Option



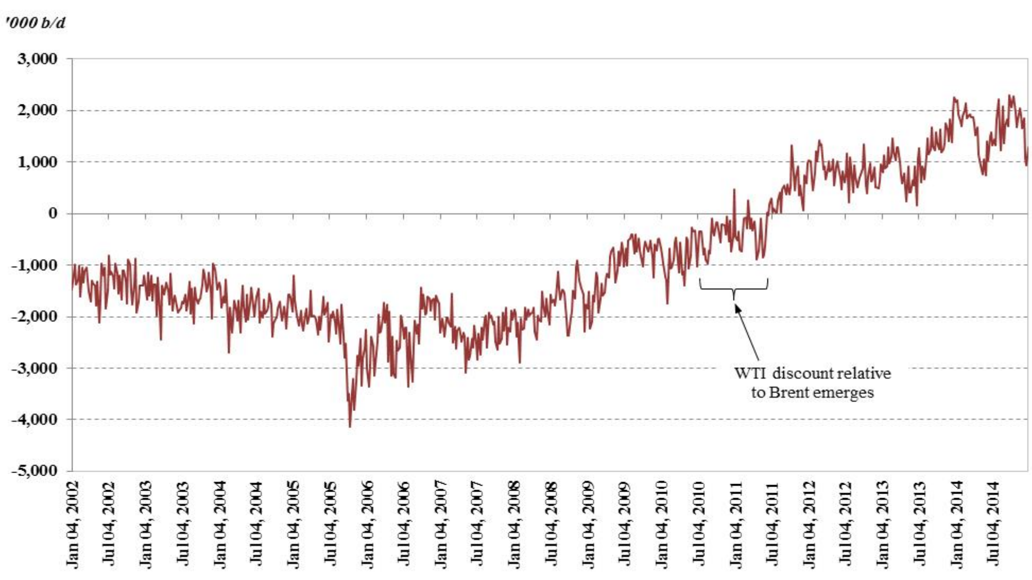
Refiner X, through policy, holds what amounts to a no cost call option on domestic crude oil (see Figure 8). If the price of domestic crude oil falls sufficiently *relative* to the price of imported crude oil of similar quality, the refiner will choose (b). But if the price of domestic crude oil rises relative to the import price, perhaps due to exports being allowed, the domestic refiner will choose (a). In either case, the refiner is maximizing profitability. Importantly, the refiner at the margin is indifferent to domestic versus imported crude oil and will operate where $P_{\text{Imports}} = P_{\text{Domestic}}$. Thus, only the refiners that are inframarginal see a positive payoff from exercising the implicit call option. In other words, the refiners of heavier crude oils who continue to import because the price discount is not sufficient to encourage use of domestic crude oils do not exercise the option (i.e.- choose (a)), and thus see no benefit.

Therefore, not all refiners benefit from the implicit call option that the current export policy creates. This raises an important point when considering the current policy; namely, the benefit accrues to a subset of refiners, but the costs accrue to all producers of light domestic crude oil. While this only considers first-order costs, ignoring the impacts on royalty payments and tax revenues paid at the local level where crude oil production occurs, it generally follows that the costs are more widely distributed. This, of course, begs the question, "How large are the first-order benefits and costs of the current policy?"

A complete accounting of the benefits and costs of the current policy is possible, but quite laborious. In particular, it requires knowledge of both the quantity and price of the crude oil purchased by each refiner. Then the value of the implicit call option could be calculated at a moment in time as well as across time to determine the accumulated value for a specific refiner as well as across the entire refining sector. Alternatively, since the accumulated industry-wide benefit of the implicit call option should be approximately equal to the cost borne by all crude oil producers, there is another approach. More specifically, the implicit call option effectively represents an income transfer mechanism across the petroleum product value chain, so we can approximate the accumulated industry-wide benefit/cost by assessing the discount (as calculated above) for each of the domestically produced crude oils multiplied by the quantity of each type of crude oil sold. Again, an exact accounting of this requires knowledge of the price and quantity of each crude oil sold by domestic producers over time. Such a precise calculation requires data that is not publicly available and thus is beyond the scope of this study. However, an options framework, assuming adequate data availability, can be used to assess the benefits/costs across the petroleum product value chain that results from the current ban on crude oil exports.

Despite the difficulty in providing a precise estimate of the accumulated benefits/costs of the implicit call option that current policy dictates, evidence is available that supports the use of such a framework. In particular, we can look at the evolution of trade in the petroleum product market to determine if there is data support for the notion that the implicit call option is being exercised by domestic refiners. We look to the petroleum product market because it faces no policy-motivated barriers to trade. As such, it is the point in the domestic petroleum product value chain where arbitrage with the international market can occur. This is also why an income transfer results across the petroleum product value chain when the implicit call option of purchases of domestic crude oil is exercised. Refiners can purchase discounted domestic crude oil, refine it, and sell petroleum products into a market with no trade restrictions, meaning exports are possible. The price in the petroleum product market, therefore, reflects international market equilibrium rather than domestic market equilibrium. This effectively enables the *inframarginal* refiners that are buying discounted domestic crude oil to buy at low price then sell their output at a higher price determined by the marginal crude oil to the international refined product market.

Figure 9 – US Net Exports of Petroleum Products

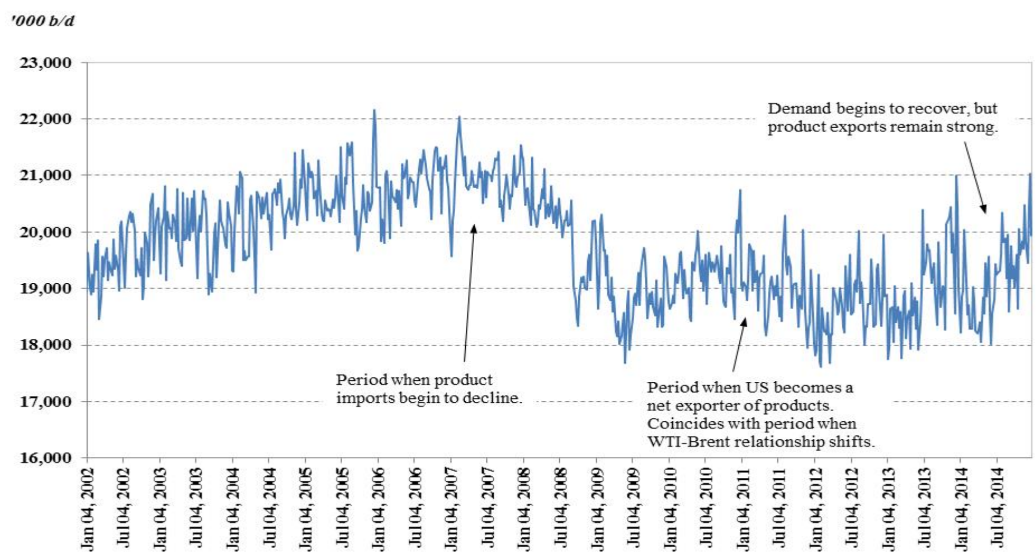


Source: US Energy Information Administration

In Figure 9, we see US net exports of petroleum products become positive in 2011. Moreover, the trend to becoming a net exporter coincides with the period in time where the relationship between Brent and WTI began to shift. This is consistent with the emergence of a strong arbitrage opportunity to the US refining sector due to domestic crude oil prices becoming discounted and domestic petroleum product demand faltering.

Importantly, the shift to becoming a net exporter of petroleum products occurred largely because demand in the US declined (see Figure 10) gradually between 2006 and 2008, then sharply in 2008/09. But the fact that there are no barriers to trade in petroleum product markets allowed domestic refiners to access international markets for product sales. Indeed, the ability to export petroleum products has been critical to the sustained health of the refining sector in the US.

Figure 10 – US Domestic Petroleum Product Demand



Source: US Energy Information Administration

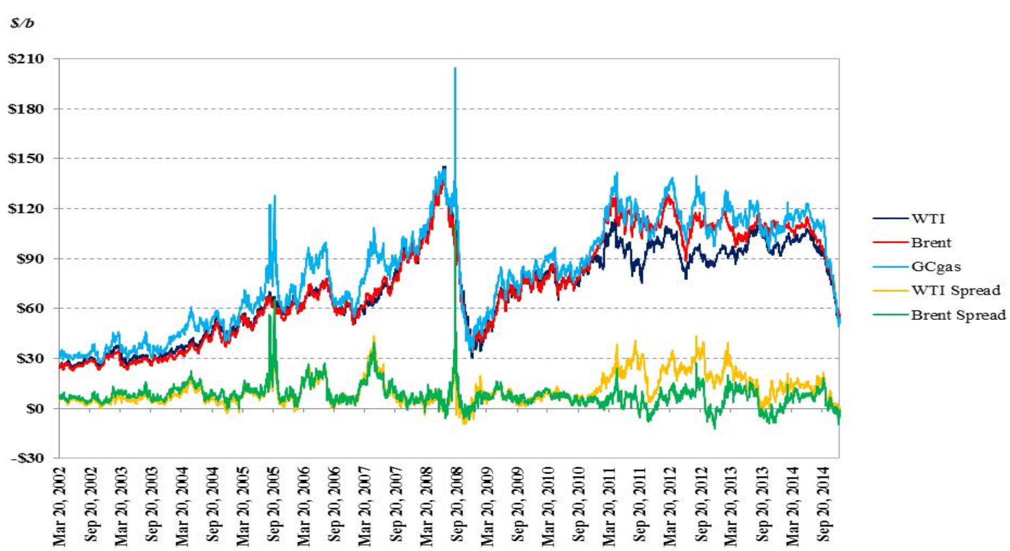
The argument that domestic petroleum product prices are determined in the international market because there are no barriers to trade is evidenced by data. We can see this in a relatively simple treatment by estimating the relationship between the price of WTI, denoted P_{WTI}, and the wholesale price of Gulf Coast gasoline, denoted P_{GC}. We can then repeat the analysis for the price of Brent and the price of Gulf Coast wholesale gasoline. So, we estimate the following

$$P_{GC,t} = \alpha_0 P_{WTI,t} + \sum_{i=1}^{12} \alpha_i D_i^{month} + \alpha_{13} D^{hur05} + \alpha_{14} D^{hur08} + \alpha_{15} D^{shift}$$

$$P_{GC,t} = \delta_0 P_{Brent,t} + \sum_{i=1}^{12} \delta_i D_i^{month} + \delta_{13} D^{hur05} + \delta_{14} D^{hur08} + \delta_{15} D^{shift}$$

where D_i^{month} is a monthly dummy variable that captures seasonal effects on the relationship between crude oil and gasoline prices, D^{hur05} and D^{hur08} are dummy variables to capture the impacts of the hurricane-related disruptions in 2005 and 2008, and D^{shift} is a dummy variable that is meant to capture any shift in the fundamental relationship between crude oil price and gasoline price taking a value of one after December 31, 2010, but is zero prior. We use daily price data nominated in $ per barrel spanning the period from January 2, 2002 through December 31, 2014. The data are plotted in Figure 11 and the estimation results are outlined in Table 6.

Figure 11 – Brent, WTI, and Gulf Coast Gasoline Prices (Daily, 1/2/2002-12/31/2014)



Source: US Energy Information Administration

There are a few things worth noting. First, the estimated coefficients α_0 and δ_0 are not statistically different, which indicates the other variables in the regression explain the differences that are visually evident in Figure 11. Second, the seasonal effects are pronounced and significant, confirming there is seasonal variation in the price of gasoline relative crude oil, with the largest effects occurring between March and September ($\alpha_3 \rightarrow \alpha_9$ and $\delta_3 \rightarrow \delta_9$, respectively), concurring with summer driving season. Third, the hurricane effects are very significant, which is consistent with observation; namely, the disruptive nature of the hurricanes of September 2005 and September 2008 are well documented and had a profound short term impact on gasoline prices relative to crude oil prices.

Table 6 – Estimation Results for Gasoline and Crude Oil Price Relationships

	Parameter	Std Err			Parameter	Std Err
α_0	1.0029	0.0052		δ_0	1.0011	0.0040
α_1	4.5948	0.4820		δ_1	6.0723	0.3773
α_2	6.9928	0.4958		δ_2	7.6168	0.3901
α_3	9.2443	0.4914		δ_3	10.5084	0.3846
α_4	10.9038	0.5013		δ_4	12.2720	0.3921
α_5	11.1245	0.4969		δ_5	12.6380	0.3883
α_6	9.3867	0.5047		δ_6	11.2683	0.3934
α_7	8.4471	0.5076		δ_7	10.2946	0.3956
α_8	9.0886	0.5031		δ_8	10.0408	0.3943
α_9	7.1557	0.5114		δ_9	8.6173	0.4001
α_{10}	4.4118	0.4898		δ_{10}	6.0762	0.3823
α_{11}	1.9164	0.4950		δ_{11}	3.6864	0.3865
α_{12}	1.6729	0.4837		δ_{12}	3.1597	0.3784
α_{13}	32.9847	1.4971		δ_{13}	34.5666	1.1883
α_{14}	63.6257	2.8886		δ_{14}	69.0974	2.2914
α_{15}	10.3829	0.3044		δ_{15}	-3.5029	0.2775
R^2	0.9946			R^2	0.9966	

Finally, and perhaps most importantly for this treatise, the shift in the prices of both Brent and WTI relative to gasoline is statistically significant in each regression, and the coefficients α_{15} and δ_{15} are statistically different from each other. The parameter estimates indicate that the price of WTI has been, on average, more than \$10 per barrel lower relative to gasoline since the end of 2010, while the price of Brent has been about \$3 per barrel higher relative to gasoline. The fact that the US is now a net exporter of petroleum products (since 2011) can explain some of this transition. In particular, as US exports of petroleum products increased since 2011, the arbitrage point for international gasoline and petroleum product prices has moved offshore. For example, to the extent that US gasoline exports are arriving in Europe, the point of arbitrage is now in Asia rather than the US gulf coast. Thus, the shift in the relative price relationship between gasoline and crude oil will reflect the cost to transport to the new point of arbitrage. Importantly, this will occur as long as the US is a net exporter of petroleum products, which is functionally tied to domestic refining capacity and domestic demand. The shift in WTI relative to gasoline cannot be explained in the same manner because WTI is not internationally fungible. Instead, WTI is landlocked, and its price must be set through arbitrage mechanisms that are farther downstream. Were the ban on exports to be lifted, it is likely that $\alpha_{15} \rightarrow \delta_{15}$, as the price of WTI would converge back into an equilibrium that reflects a full international arbitrage, similar to Brent. However, this would not equate to an increase in the price of gasoline. Rather, demand in the US is a much more important driver, all else equal, in determining the status of the US as a net exporter/importer going forward, and hence, the relationship between a fully arbitraged international crude oil price and domestic wholesale gasoline price.

In October 2014, the US Energy Information Administration (EIA) published its own analysis, "What Drives U.S. Gasoline Prices?" That research employed several techniques to evaluate the relationships between international gasoline prices and Brent and WTI. They also identified the end of 2010 as an important transition point and concluded, among other things, that Brent crude oil price is a more important determinant of US gasoline price across regions than the WTI crude oil price. In addition, the study concluded that lifting the ban on US crude oil exports would impact US gasoline prices through its effect on international crude oil prices and noted the impact of shifting trade on relative pricing. The approach taken in the EIA study is distinctly different from the approach taken herein, but the results are very similar. Thus, the result appears to be robust to methodology.

IV. Midstream Impacts

One implication of the current trade restriction is its impact on investment in the midstream – pipelines, rail, and port facilities, for example – to allow trade at the coasts into international markets. In general, when a barrier to trade exists, prices in the two markets on either side of the barrier cannot find an equilibrium that reflects quality differences and transportation costs. In fact, there is no incentive to develop capabilities to trade through the price differentials that emerge, precisely because the trade is prohibited. As such, if an assessment of the full cost of the trade restriction for the domestic economy is to be ascertained, we must understand the cost of infrastructure, the transportation cost of the trade, and the price differentials that would exist in an unconstrained environment. The last of these points, price differentials, was addressed above. Moreover, the price differentials are the signal that incentivizes, in an unconstrained market, investment in infrastructure to move to the coasts and expand port facilities to enable export. As noted above, if the US exports light crude oil, it will also import heavier crude oils as the current refinery configuration is optimized, which effectively amounts to a swap of a higher value crude oil for a lower value crude oil. Moreover, the ability to export petroleum products will not be compromised by exports of light crude oil. Rather, the primary determinant of this is domestic demand and refining capacity, while low natural gas prices – an oft underappreciated factor – have conveyed benefits for competitiveness relative to refiners abroad for virtually all refiners in the US.

So, what would lifting the export ban mean for the energy sector in the US? It would be transformative, provided the resource base has sustainable productive life. Significant investment capital would flow into pipeline and infrastructure development to aggregate to a location where transport to international markets could occur unimpeded. Investment in the midstream would eliminate the discounts for domestic crude oils, thus providing a price lift in the field for producers. Of course, the crudes would price at the wellhead in a manner that reflects international price parity less transportation costs. Nevertheless, in a market environment where profit margins are compressed due to overall lower prices, any reduction in the discount would carry significant implications for capital spending and employment in the sector. In turn, this carries positive implications for tax receipts. Any precise estimate of this is beyond the scope herein, and, quite frankly, not likely to be very accurate anyway given the uncertainties that exist in other domains, such as OPEC and general market response to greater US oil output, financial market developments and foreign investment flows, to name three. But, the qualitative implications are very clear as they follow directly from the economics of trade and investment.

In sum, the current policy carries costs for upstream participants that are quite obvious, but it also carries implications for the midstream that have not been fully internalized. Lifting the ban could invite capital flows into the upstream and midstream as a new trade opportunity is made possible. At the very least, the impacts of lifting the ban would be small, perhaps because the upstream opportunity needs higher international crude oil prices to remain viable and sustainable anyway. But, if that is the case, then lifting the ban will bear little consequence, as the US would shift back toward becoming more import dependent regardless. Thus, from the standpoint of the midstream opportunity, the cost of the current policy is clear, but any benefit is not. It is important to reconcile this with the current policy, particularly if we seek to provide domestic economic opportunity and enhance energy security.

V. The Concept of Energy Security

The concept of energy security gained prominence in public policy discourse following the oil price shocks of the 1970s. Indeed, the matter gains an even clearer focus when one notes that all but one recession since World War II has been preceded by a run up in the price of oil. This empirical revelation has prompted interest in designing policies aimed at mitigating the deleterious macroeconomic impacts of rising oil prices. In this context, “energy security” generally refers to the concept of ensuring an *adequate* and *stable* supply of energy at a *stable* and *reasonable* price. This goal is sought because there is a strong empirical correlation between macroeconomic malaise and high price/price volatility. In other words, as has been highlighted in the economic literature, recessions are highly correlated with energy market disruptions.

Note that we can capture energy security (and hence define a barometer for any policy aimed at achieving energy security) with three basic concepts: (i) adequacy of supply, (ii) stability of price, and (iii) relatively low price. First, adequacy of supply follows from the fact that energy is required for virtually all modern economic activity. Some sectors are, of course, more energy intensive than others – meaning some sectors may be more greatly impacted by changes in price or disruptions in supply – but energy input is a basic necessity for the modern economy. Second, price stability is important because irregular price volatility can be a source of uncertainty. To the extent uncertainty negatively impacts capital investment, this carries a negative macroeconomic impact. And third, the price level matters because it has a direct impact on household disposable income and industry budgetary considerations. If more financial resources are diverted to energy purchases, less is available for other activities.

Indeed, a large literature has emerged specifically investigating how energy (oil) prices impact an economy. The dramatic rise in oil prices in the 1970s and the subsequent recessions across multiple economies sparked research focused on a possible causal relationship between the two occurrences. Rasche and Tatom (1977), Darby (1982), and Bruno and Sachs (1982) found that indeed a negative relationship exists between oil price shocks and economic growth. A culmination of this early research is arguably the most famous article on the subject where Hamilton (1983) finds a connection between oil price fluctuations and business cycle, arguing that all but one post-World War II recession was preceded by a run-up in the price of crude. Since then, research has been grappling with this phenomenon.

To begin, high oil price and high oil price volatility have been attributed to higher production cost, which triggers inflation and a reduction in broad macroeconomic output indicators, such as Gross Domestic Product (GDP) or Industrial Production (IP).[6] This results in lower employment and investment levels.[7] Mork (1989) extended Hamilton's model into the late 1980s to encompass the dramatic decline in real oil price seen in the mid-1980s and noted that the relationship between oil price and the macroeconomy appears to be asymmetrical. In other words, a spike in oil price is detrimental to the economy, while a drop in the price does not necessarily lead to higher economic performance.[8] This led to a large literature on the origins of asymmetry. One pathway involves the role of uncertainty on investment. Bernanke (1983) and Ferderer (1996) showed that asymmetry could be a consequence of the uncertainty that a rapid change in oil price – up or down – can bring about. In fact, Ferderer lays out several potential "channels of transmission" from oil price to the macroeconomy that have been proposed in the literature to convey the correlation, some of which carry a causal tone.[9] These mechanisms can be summarized into

… inflationary effects:

- Increases in the price of oil (energy) lead to inflation, which lowers the quantity of real balances in an economy, thereby reducing consumption of all goods and services.

[6] See, for example, Hamilton (1983), Gisser and Godwin (1986), Burbidge and Harrison (1984), Tatom (1988), Huntington (1998), Coloni and Manera (2008), Man-Hwa Wu and Yen-Sen Ni (2011).
[7] See, for example, Carruth, Hooker and Oswald (1998) and Ferderer (1996).
[8] Evidence of asymmetry is found with respect to the impact of oil prices on a number of countries' economies, including countries in Asia (Cunado and Perez de Gracia (2005) and Abeysinghe (2001)), Europe (Cunado and Peres de Gracia (2003)), Latin America (Mendoza and Vera (2010)), and Africa (Chuku (2012)). As shown by Kang et al (2011) asymmetry is also present at the state level in the US.
[9] The literature is deep on these matters, involves many subtleties and variations on themes, and is hardly universal in its conclusions. The reader is referred to the following additional literature for more detail: Coloni and Manera (2008), Balke et al. (2002), Bjornland (2000), Esfahani et al. (2014), Cavalcanti et al. (2011), Al-Abri (2013), Kang et al. (2011), Mendoza and Vera (2010); Chuku (2012); Cunado and Peres de Gracia (2005), Abeysinghe (2001), Du et al. (2010), Baskaya et al. (2013), Hooker (1996), Barsky and Kilian (2004), Hamilton (1996), Hamilton (2011), Lee et al. (1995), Gronwald (2008), Miller and Ni (2011), Killian and Vigfusson (2011), Pinno and Serletis (2013)

- Counter-inflationary monetary policy responses to the inflationary pressures generated by oil (energy) price increases result in a decline in investment and net exports, and consumption to a lesser extent.

… trade balance effects:

- Oil (energy) price increases result in income transfers from oil (energy) importing countries to oil (energy) exporting countries. This, in turn, causes rational agents in the oil (energy) importing countries to reduce consumption, thereby depressing output. Interestingly, the literature notes that exporting regions tend to do better when prices rise, while importing regions do worse, which is consistent with the notion of income transfer through trade pathways.

… industrial influences:

- If oil (energy) and capital are complements in aggregate production, then oil (energy) price increases will induce a reduction in the utilization of capital as energy use is reduced. This, in turn, suppresses output.
- If it is costly to shift specialized labor and capital between sectors, then oil (energy) price increases can lower output by reducing factor employment in oil (energy) using sectors. If a recession is not protracted, the high costs of training will cause specialized labor to wait until conditions improve rather than seek employment in other sectors.

… and investment impacts:

- In the face of uncertainty about future price, which may arise when a price shift is unexpected, it is optimal for firms to postpone irreversible investment expenditures. Investments are irreversible when they are firm or industry specific. This, in turn, leads to a reduction in aggregate investment, a key component of macroeconomic activity.

Diversification of the overall energy supply portfolio is one means of reducing the cost of an oil market disruption, as long as oil prices and other energy commodity prices are not highly correlated. The ability to access a diversity of sources of energy supply to avoid economic dislocation is a crucial component in most energy security arguments. Notably, the energy intensity of an economy and the level of economic development have been found to bear influence on how oil price shocks are transmitted through the macroeconomy. In addition, economic structure matters, as evidence has been given that not all economic sectors are affected equally by oil prices.[10] As such, economic diversification is a critical path often raised when discussing the broader macroeconomic implications of changes in oil prices.

The concept of diversification is not limited to the overall energy supply portfolio; it can also refer to an ability to draw upon multiple sources for a single fuel. For example, any temporary market disruption can be overcome if there is an easily accessible alternative market outlet for the same fuel. This, in turn, mitigates the risk associated with uncertainty in demand (from seasonal influences, for example) or supply (due to unexpected disruptions, for instance). It follows, therefore, that diversification of supply *options* is generally viewed to be beneficial for energy security, a point that Europe has become all too familiar with over the past decade as tensions revolving around natural gas payments from Ukraine to Russia have resulted in temporary pressure reductions on pipelines providing supply to Europe from Russia traversing Ukraine. This motivates two important pathways in the energy security discussion: (1) storage and (2) fungibility through new avenues to enhance regional and international trade.

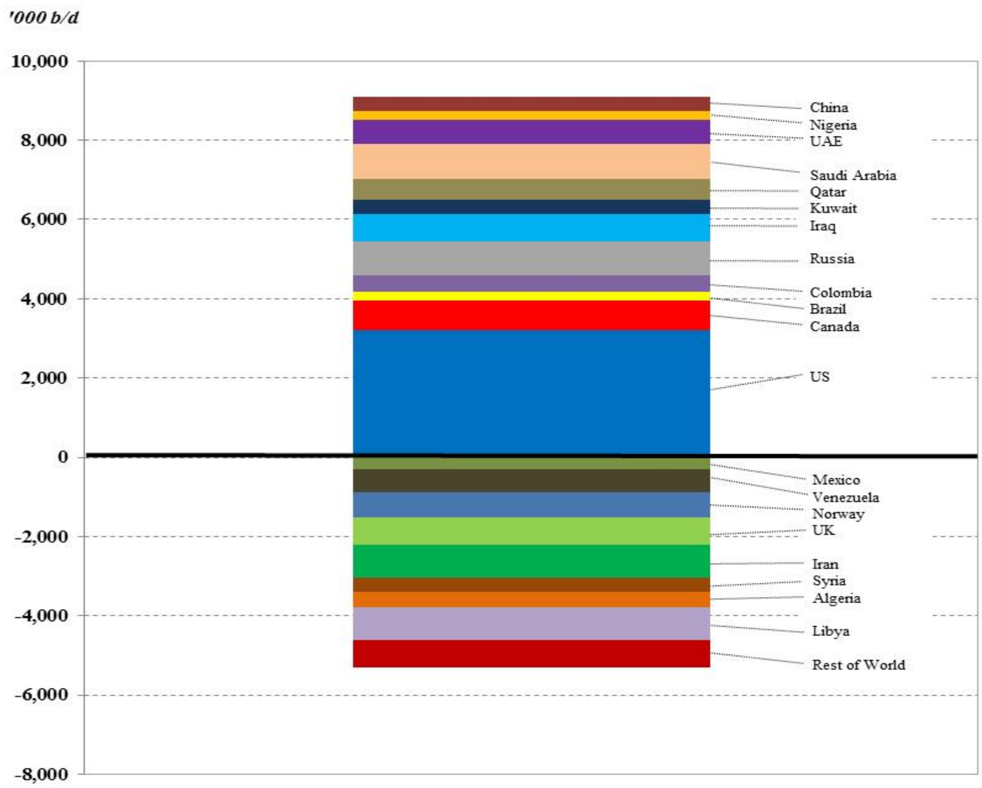
Interestingly, when the concept of energy security is raised, it has historically been, from the US-centric perspective, a discussion dominated by the need to secure supplies to sustain economic activity, or security of *supply*. However, from the producer's perspective, energy security refers to security of *demand*, or the need to ensure demand will be sufficient to support production and generate revenues. In the case of the world's oil exporters, this has often coincided with coming to grips with the balancing act of high near term prices while not encouraging demand destruction in the longer term. Recall, any temporary market disruption can be overcome if there is an easily accessible alternative market outlet for the same fuel. This principle applies to producers as well as consumers. At the time of this writing, the current US crude oil market is burgeoning with inventory, a fact that has seen WTI price drop to around $10 per barrel under Brent price, even in a sub-$60 global price environment. As noted in Table 3 above, the WTI price should be at just over $61 per barrel if Brent is at $60. Thus, the lack of ability to export is

[10] See, for example, Burbridge and Harrison (1984), Li and Ni (2002), and Huang (2008).

putting substantial pressure on domestic markets, thereby compromising domestic energy security from the standpoint of energy production.

The focus on energy *quantity* should not be the sole focus of policymakers. The literature demonstrates that *price* and *price volatility* are the mechanisms through which oil affects the macroeconomy. As such, the notion that adding US exports to the global market could add a source of supply from a relatively stable country should be considered. In fact, the last six years have borne witness to increased oil output from the US that has offset the production declines seen in countries such as Libya, Algeria, Syria, and Iran due to local strife and/or sanctions (see Figure 12).

Figure 12 – Change in Global Crude Oil Production by Country from 2008-2013



Source: BP Statistical Review

Given the above, it is apparent that growth in US domestic crude oil production over the last six years has added stability to the global oil market. In fact, absent the growth realized in US output, it is possible that prices would have reached much higher levels and been more volatile, notwithstanding supply responses in other parts of the world. Given the preponderance of findings in the energy security literature, this would have created a much more significant drag on the US economy as well as the entire global economy. As such, the impact that US exports could have on global market stability should not be understated, nor should it be disregarded in the calculus of future policy.

In the wake of the rapid growth of domestic production of light crude oil in the US, both perspectives – security of demand and supply – are now meaningful. The consumer economy that has long characterized the US is still relevant, but now the perspective of the producer should be considered if we are to meaningfully address energy security in an all-encompassing manner. A general yet simple justification of a policy-motivated constraint on trade would be that the aggregate economic impact on consumers far outweighs the aggregate economic impact on producers. However, absent a constraint on trade in derivative products, the effect of the constraint on trade becomes isolated to producers of the raw material, which renders its macroeconomic impacts to be considerably smaller.

With regard to the current ban on crude oil exports, because there is no such ban on trade in petroleum products, the primary beneficiary is domestic consumers of raw crude, such as refiners, while the consumers of petroleum products – the general public – are still subject to prices that are determined in the international market. Therefore, the energy security calculus reduces to one of comparing the economic impacts of a trade constraint on upstream producers and midstream players with the effect on refiners. While this can be interpreted as reducing the argument to being between two primary special interest groups, the *indirect* impacts must also be considered. In other words, the employment impacts, which are derivative of the relative labor intensities in the two competing sectors, are germane to the debate, as are the local and federal tax revenue implications, as well as the possible implications for petroleum product prices. All of these issues have been addressed in previous studies.

By and large, the general public and consumers of petroleum products do not see significant *direct* impacts from the existing policy, but the indirect impacts are potentially significant. While energy security is generally tied back to oil prices, it should be recognized that the general public does not directly consume oil; it consumes oil products. Therefore, given the fact that the current policy does nothing to insulate consumers from international price movements in petroleum products, it does not provide any broad energy security benefit. Indeed, as the constraint on exports becomes increasingly binding, the benefits of US production as a stable source of supply to the global market become muted. In turn, such benefits do not pass through to consumers of petroleum products because their price is determined in a fully arbitraged international market.

VI. Trade Enhances Energy Security

When discussing energy security, the focus is typically on price *level* and/or price *volatility* rather than quantity. In fact, various studies have shown that investment and consumption at the macroeconomic level is more greatly affected when prices suddenly and unexpectedly change (see, for example, Lee et al. (1995)). So, if energy security is a goal, then being able to cope with unanticipated shocks is vital. Regarding policy, pursuing measures that contribute to reasonable and relatively stable price levels will aid in achieving greater energy security.

If price changes rapidly over short periods of time, price is generally said to have high volatility.[11] Volatility can also occur in clusters, as might be the case when unexpected events create short-term stresses in the market. If this is the case, then we may have a price series that is characterized by periods of low volatility with periods of high volatility interspersed. It is generally these periods of high volatility that are of concern, particularly when they are *unexpected*. Increased uncertainty associated with elevated price volatility has been linked to changes in firm behavior, which translates to reduced investment, increased unemployment, and lower output (see Dixit and Pindyck (1994)). Since high price volatility is associated with negative economic outcomes, some have argued that artificially setting a price at a particular level would avert the consequences associated with volatility. However, such a policy intervention would mute the information carried in price movements, which can lead to inefficient levels of investment and consumption. Fortunately, it is a well-established principle that an unimpeded ability to trade a commodity, or high fungibility, reduces price volatility.

Fungibility can be enhanced through the use of inventories and/or through a greater number of trading partners. Inventories are a mechanism through which *intertemporal* arbitrage opportunities are enhanced by allowing commodities to be traded through time from low price

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[11] Price volatility is generally measured by examining the distribution of the log returns of price, defined as $R_t = \ln P_t - \ln P_{t-1}$. If price changes rapidly over short periods of time, then values of R_t will be large and price is said to have high volatility. However, if price is not changing very much, then R_t will be near zero and price is said to have low volatility. So, if the probability density function of R_t has what we call "fat tails," then it is generally said to exhibit high volatility and the price series is generally associated with greater uncertainty. If volatility occurs in clusters, a time series analysis known as GARCH (generalized autoregressive conditional heteroskedasticity) is employed for analysis. *Unexpected* shocks are then defined as price changes that move outside a particular interval (such as one standard deviation), where the interval is conditional on the estimation results.

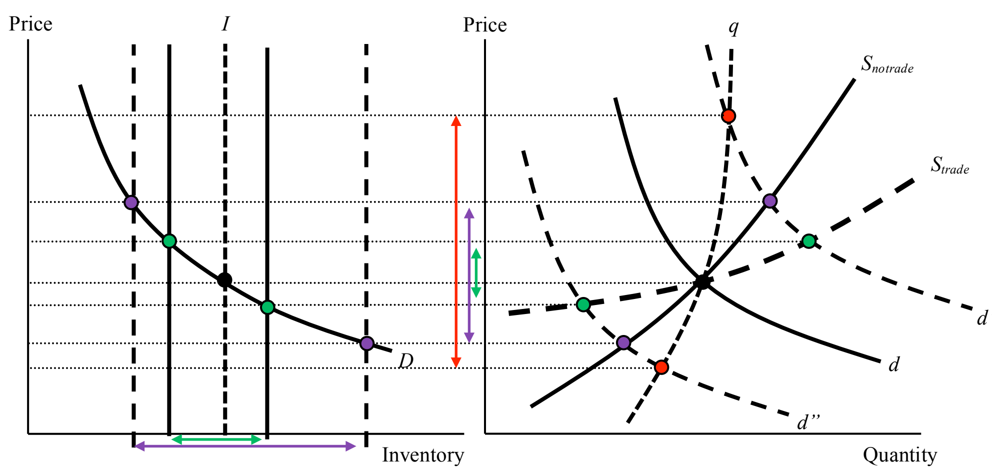
periods to high price periods. Similarly, increasing the number of trading partners enhances *spatial* arbitrage opportunities by expanding the potential trades that can be executed at any moment in time. For example, if a regional market experiences a shortage of supply relative to demand, the outcome absent additional sources of supply – through, for instance, imports from another region – would be an extreme price increase. However, if supplies from another region can be traded into the stressed region, then price will not rise as dramatically. Similarly, if supplies are bottlenecked in a particular region, the price in that region will decline until local demand increases or new demand sources are introduced – perhaps through exports to another region. In general, increased fungibility enhances the short run elasticity of supply as it allows more market mechanisms to mitigate unexpected movements in supply or demand.

The role of trade in mitigating price dislocations can be seen in many markets. For instance, there are recent examples of unanticipated events leading to the realization of constraints in natural gas markets, only to be subsequently alleviated by investment and trade. For example, the price of natural gas in Pennsylvania has recently declined due to an inability to move rapidly growing supply away from the producing areas of the Marcellus shale. This has encouraged investment in pipeline takeaway capacity as well as interest in LNG exports from the facility at Cove Point in Maryland. Another example lies in the global LNG market where Asian LNG prices jumped dramatically in the wake of an unexpected demand shock that was triggered by the nuclear disaster at Fukushima in Japan. The surprise shift in demand forced the realization of a constraint on the capability of existing supplies, but, in the wake of this, significant capital has flowed into the expansion of global LNG export capacity, including from the US. In sum, the fact that trade *can* occur incentivizes investment in new infrastructure to increase trading. This enhances fungibility, which ultimately recalibrates regional prices and mitigates price volatility. If a barrier to trade exists, as is the case with regard to US oil exports, there is no incentive for investment in infrastructure to facilitate trade, so an alternative arbitrage mechanism must emerge or a reduction in domestic production must occur.

In order to formally address these matters, we can examine the implications of trade for price formation using a class of models aimed at understanding the price stabilizing effects of storage capabilities (see, for example, Kawai (1983) and Jacks (1987)). We generalize the framework to highlight the role that trade plays in enhancing fungibility, which provides some interesting insights into understanding current US crude oil prices. Referencing Figure 13, we note three distinct outcomes defined by different market conditions:

1. We begin with the market equilibrium, defined by the equilibrium in red. Focusing only on the panel on the right, if demand, *d*, is high relative to domestic production capability, *q*, then unexpected swings in demand, denoted as *d'* to *d"*, can drive extreme price shifts.
2. When we introduce an inventory market, captured in the panel on the left, we note that storage injections and withdrawals will shift the inventory level, *I*, and result in an enhancement of short run deliverability, denoted as $S_{notrade}$. The ability to move volumes in and out of storage mitigates price volatility by facilitating *intertemporal* trade.
3. Finally, when we allow imports and exports to enter the market, we see short run deliverability, denoted as S_{trade}, is even further enhanced. This derives from the fact that imports (exports) will only occur if domestic price is high (low) relative to other regions. In this latter case, the ability to use inventories and the ability to trade further mitigates price volatility. Moreover, it reduces the need for storage injections/withdrawals.

Figure 13 – Trade, Storage, and Price Formation



There are a couple of points worth noting here that are germane to the current crude oil market. First, the ability to trade – both intertemporally via the inventory market and spatially through trade with another region – makes the deliverability curve for a commodity more elastic. Thus, unexpected movements in demand will not tend to be accompanied by large swings in price, and more stable prices due to the ability to trade through unexpected events is a desirable outcome in the quest for energy security. Second, the current WTI crude oil price is burdened by an inability to export oil from the US, which means the inventory market is the only mechanism for arbitrage to mitigate price volatility. However, should inventory capacity become stressed, then the ability to inject into storage disappears, and the deliverability curve, $S_{notrade}$, collapses to the case in Figure 13 in which there is no capability to arbitrage intertemporally or spatially. In other words, $S_{notrade}$ collapses to q. The outcome is an even more extreme decline in price. An obvious implication is that an ability to export circumvents this entire outcome. Namely, the ability to trade renders the need for storage injection/withdrawals to be lower, which conveys a lower overall risk of extreme price movements. It should be noted that the analysis above is relevant for understanding domestic price volatility *relative* to international price volatility. No restrictions on the ability to trade should render the two almost identical.

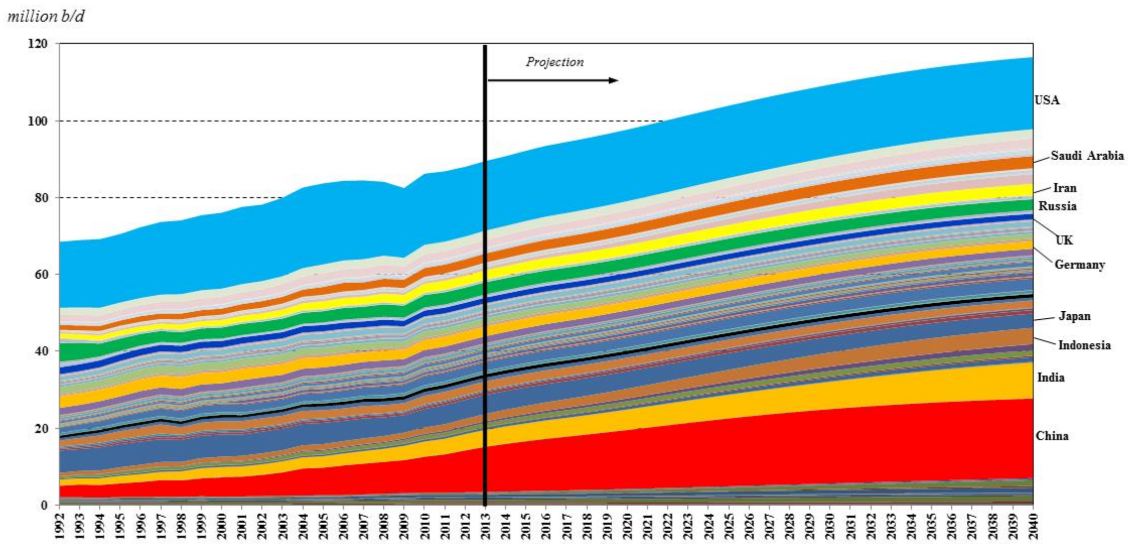
So, as seen in Figure 13, allowing exports would provide price support for domestic crude oil, which would generally be accompanied by a higher level of production. The model presented above is a relatively simple illustration of the effect of increasing fungibility. Specifically, the ability to augment domestic production capability with international trade renders the capability to deliver supply to the domestic market more elastic. This also has implications for price volatility, which, in turn, has implications for investment throughout the crude oil value chain.

Taking the above thesis one step forward, it is possible to discuss the implications for global crude oil markets if the US export ban is lifted. In the global crude oil market, new production opportunities are constantly needed to balance supply and demand at a *reasonable* and relatively *stable* price so that economic growth is not stymied. As seen in Figure 14, global crude oil demand is projected to increase to just short of 120 million barrels per day by 2040.[12] The majority of the projected growth will come from developing Asian economies, particularly China and India, but also several other Asia-Pacific countries. The ability of traditional Middle East oil producers to provide sufficient supplies to the global market may become compromised by

[12] Importantly, this is only one projection. Indeed, there are alternative outlooks that posit different growth rates, and even some that posit a peak in global demand at around 100 million b/d. According to the CES model for total primary energy demand, energy efficiency and other measures would have to drive a global reduction in energy intensity at a rate over 50% greater than witnessed historically in any single nation. Moreover, even if this does occur, the arguments herein are unaffected.

demand growth in those countries. In particular, demand in the countries of the Middle East is projected to grow among the fastest in the world, attributed to economic growth as well as heavy domestic subsidies on energy prices. Of course, a lifting of subsidies would abate the projected growth in those countries, but absent a significant shift in domestic energy pricing policy, these countries will be challenged to maintain, much less grow, exports. This, in turn, signals a need for new sources of supply from other parts of the world.

Figure 14 – Global Oil Demand Outlook by Country, 1992-2040



Source: Center for Energy Studies at Rice University's Baker Institute for Public Policy

Unconventional and deep water resources from countries such as Canada, Brazil, Argentina, Venezuela, and the US could play a major role in balancing the global oil market going forward, as could potential supplies from Mexico in the wake of energy reforms. In all, this could move the geopolitical compass toward North America and the Western Hemisphere more generally. Those countries with abundant, economically accessible resources with favorable investment climates – such as Canada and the US – could be global leaders in future supply developments. If such a future were to unfold, US foreign policy and geopolitical concerns would likely look very different in 20 years.

The importance of the US as a potential source of global oil supply over the longer term cannot be overstated. In fact, as referenced in Figure 12 above, the US has already played a critical role in balancing global oil markets in the wake of declining supplies due to economic depletion of reservoirs in the North Sea, lack of investment in Venezuela and Mexico, and regional civil strife and/or sanctions in Algeria, Libya, Syria, and Iran. Going forward, 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. In addition, energy trade policy involving Canada and Mexico will define the role of the US, and North America more generally, as a secure source of supply for the global oil market. Indeed, the US could take a leadership role in transforming global trade in crude oil, potentially redrafting the international crude oil trade map. This would carry geopolitical benefits and establish the US as a trusted partner in discussions focused on a variety of matters in international trade more generally.

VII. Concluding Remarks

Over the past decade, innovative techniques involving the use of horizontal drilling and hydraulic fracturing have triggered unprecedented increases in production of crude oil, natural gas, and natural gas liquids from shale. With regard to crude oil specifically, the domestic production surge has led to a large decline in US crude oil imports in just the last six years and opened intense discussions about exporting crude oil. We have laid out a framework for discussing the relevant issues and applied different empirical tools to evaluate these matters.

Development in the Bakken and Eagle Ford shales has driven the bulk of the increase in domestic crude oil production to date, and the crude oils coming from those locations is generally lighter and sweeter than WTI and Brent. In an unconstrained market setting, this would normally equate to those crude oils pricing at a premium when delivered to market. However, this has not been the case, as prices indicate that the export ban already presents a binding constraint on the domestic market. As such, we developed an approach based on a hedonic pricing method to evaluate the extent of the discounts being realized on domestic crude oil prices over a wide range of global crude oil price environments, ranging from $30 to $150 per barrel. The results indicate that the current export ban matters even in a relatively low oil price environment. In fact, in a low price environment the need to address the export ban is heightened, as it could eliminate the current price discount thereby supporting profit margins and upstream activity.

The benefits of lifting the ban extend beyond the price uplift it could provide to the upstream. If the ban were lifted, it would immediately allow the sale of domestic crude oils into the international market where prices reflect differences in crude quality and therefore would be higher for the light crude oils being produced from domestic shale plays. This would, in turn, incentivize investment in the midstream aimed at moving domestic crude oils to the coast – through pipelines and other means – for export through port facilities, where additional investment would also be required. Therefore, the current ban on crude oil exports is also leaving investment in infrastructure unrealized.

In the wake of the domestic supply surge, the discount that has emerged is largely due to a shifting competitive margin for sales of domestic light crude oils. In particular, the US refining sector has backed out imports of light crude oil by substitution with domestic light crude oils. In fact, with growing domestic production, refiners are now backing out imported crude oils that are heavier than WTI and light oils from shale. However, since the refineries that normally import those medium quality crude oils have already sunk the investment costs to process the heavier crudes, they will only switch to domestically sourced lighter crude oils if they are priced competitively with the heavier crudes the refiners would normally buy. Hence, the domestic light crude oils must be discounted to be sold on that competitive margin. There is strong evidence that the competitive margin is consistent with crude oils of API 35-40, and LLS sits squarely in that window. In fact, LLS has priced fairly consistent with the results implied by the hedonic pricing method, but it has recently seen episodic discounts during periods of robust domestic storage and/or refinery turnarounds. However, if domestic production continues to grow the competitive margin will shift, and LLS will become consistently discounted relative to crude oils of similar quality in the international market. Regarding the domestic refining sector's handling of domestic light crude oil, it is not a matter of *capability*; it is a matter of *price*. Moreover, as discussed above, only the refiners that are inframarginal see any benefit from discounted domestic crude oil; those that normally refine heavier crude oils are not affected.

Indeed, refiners' ability to access foreign markets has provided them with new market outlet opportunities even as domestic demand for petroleum products has declined since 2006. Domestic refiners have reduced their imports of crude oil, effectively displacing them with domestic crude oil, while increasing the sale of refined products to the international market. Indeed, refinery capacity utilization in the US has remained robust, despite lower domestic petroleum product demand, because the US has become a net exporter of petroleum products over the last few years.

Some have argued that crude oil exports would increase gasoline prices in the US. However, because refined products, such as gasoline, can be freely exported, the prices of refined products sold in the US are in a parity relationship with international prices for refined products. Thus, the discounted prices of oil produced in the US are not reflected in US gasoline and refined product prices. Thus, removing the crude export ban, although it would raise the price of domestic crude oil, would not increase the price of gasoline in the US. In fact, the results herein indicate that the biggest determinant of US gasoline price is the price of oil in the international market. But it is also influenced by the point of arbitrage in the petroleum product market. Since the US emerged as a net exporter of petroleum products a few years ago, the results herein suggest the point of arbitrage in the global product market has shifted away from the US. However, if demand were to rebound to levels not seen since 2006/07, the point of arbitrage would shift back to the US, which, by itself, would lead to an increase in gasoline price, regardless of export ban. Thus, domestic demand is a very important factor in considering the price of domestic gasoline.

We also provide an in-depth analysis of the implications of lifting the crude oil export ban on energy security. Counterintuitive to some, removing the ban generates distinct energy security benefits by providing a more stable and secure source of crude oil to a growing global market. Greater stability would lessen international market price volatility, which will affect petroleum product prices. It is well documented that heightened price volatility is associated with macroeconomic malaise. Consumers purchase petroleum products, not crude oil. So, if allowing US crude oil exports increases fungibility thus dampening oil price volatility, to the extent that it reduces petroleum product price volatility an energy security benefit will be transmitted to US consumers. More generally, the US has the opportunity to lead an oil industry transformation that would see lines of global oil trade redrawn, as North American production, and Western Hemisphere production more generally, could capture a larger portion of the growing international market. This would, should it transpire, have tremendous benefits for US foreign policy endeavors in its dealings with hostile oil producing nations. It would also lend greater stability to the global crude oil market, thereby conveying benefits more broadly to the US and its allies.

Finally, we have not addressed the role of international production disruptions – such as civil strife, sanctions, or declines due to country-specific sector mismanagement – nor have we addressed the role of OPEC or national oil companies more generally. A full treatment of these matters is forthcoming in later research. But, with regard to the research presented herein, each of these international issues affect the general US consumer base regardless of the ban on US crude oil exports because they all impact the price of petroleum products, which, as previously noted, is determined in a fully arbitraged international setting. So, to the extent that US crude oil exports could reduce the impact of such unexpected disturbances on the global oil market, benefits would accrue to US consumers.

There are a number of other policy concerns that motivate an opposition to lifting the ban on crude oil exports. Perhaps one of the most compelling arguments for a number of constituents is that lifting the ban would result in more production and carry environmental costs. However, as pointed out by Bordoff and Houser (2015), it is more efficient to use environmental policies to address environmental concerns. Consideration of the US export ban is a trade policy issue, and, in general, trade policy should be used to address international trade affairs.

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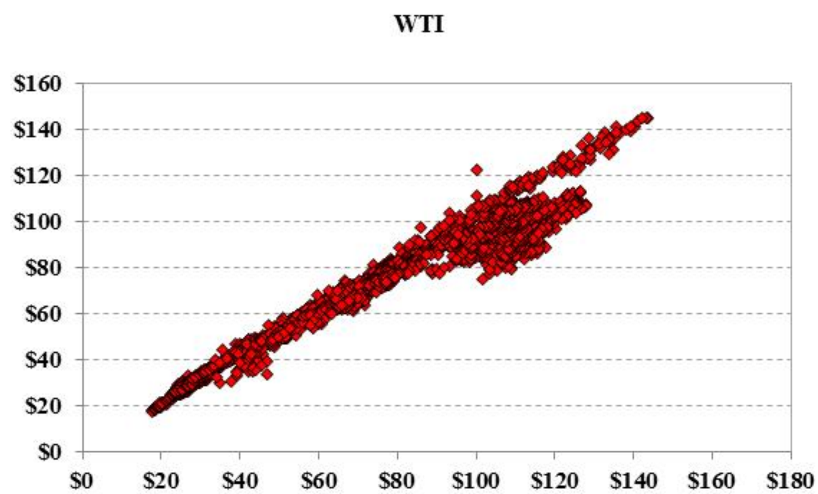
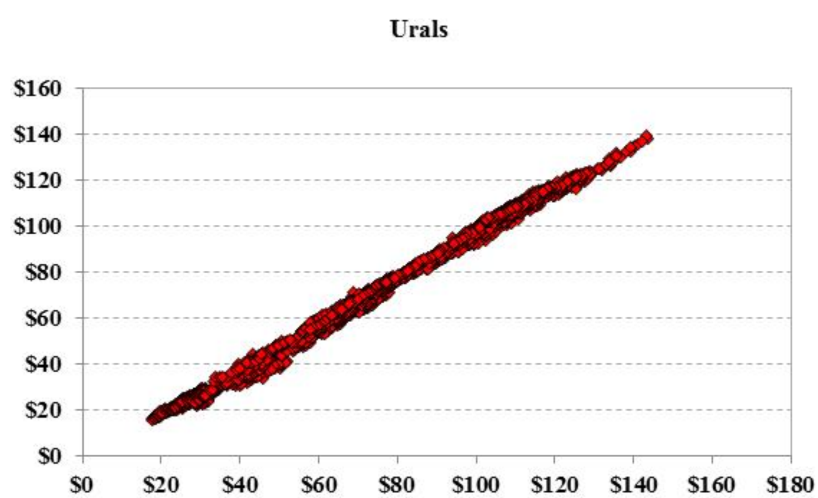
IX. Appendix

The following graphs highlight the point that every crude oil, except two, in the sample that was used in the panel analysis displays a very stable relationship to Brent crude. In fact, the North American crude oils that deviate from the linear pricing relationship demonstrated by the internationally traded crude oils only do so because of the binding constraints on trade that have impacted their prices. In each figure, the price of the respective crude oil is plotted against Brent, where Brent is on the x-axis. All time-series consist of daily data spanning the period from January 2, 2002, through December 31, 2014.

Figure A1 – Crude Oils Used in Analysis versus Brent





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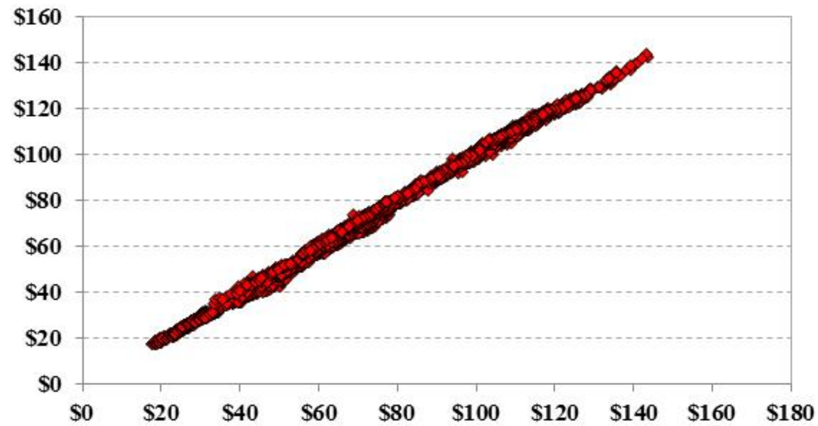

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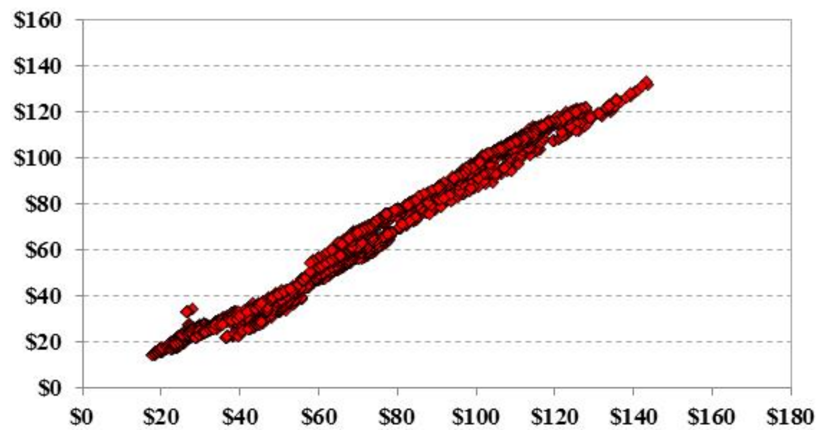
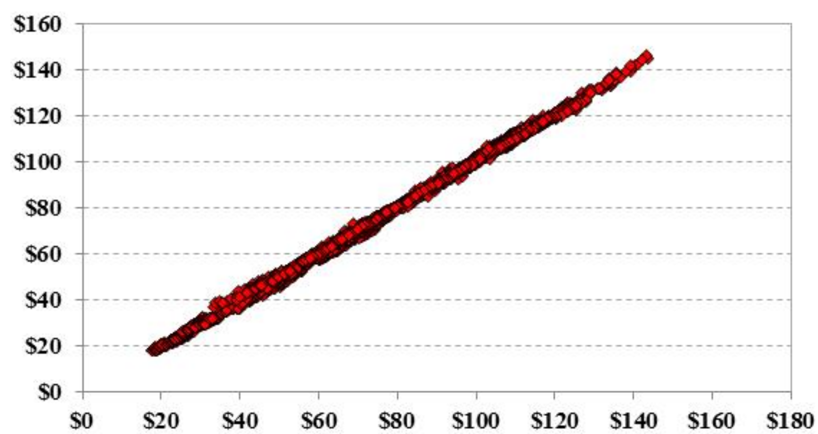
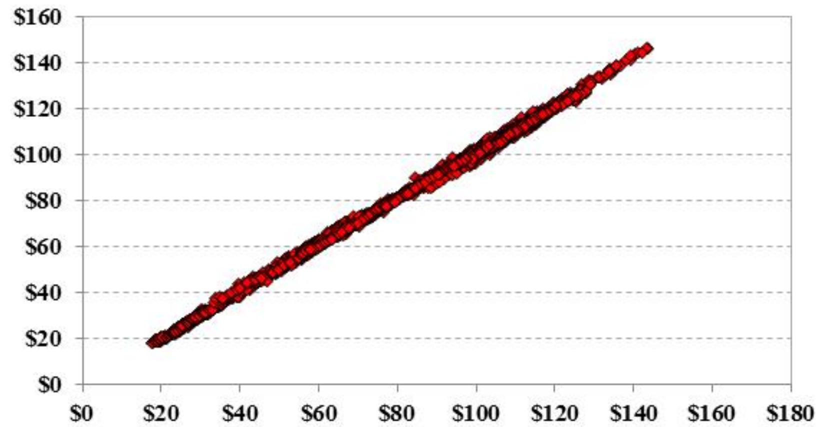


Siberian Light



Saharan Blend



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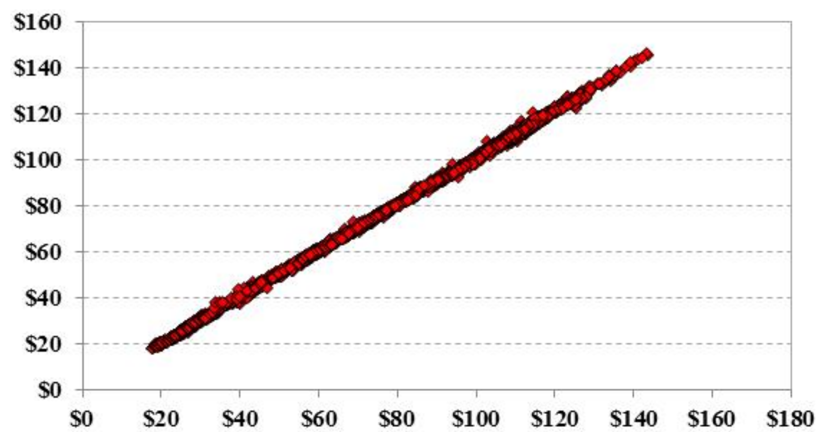

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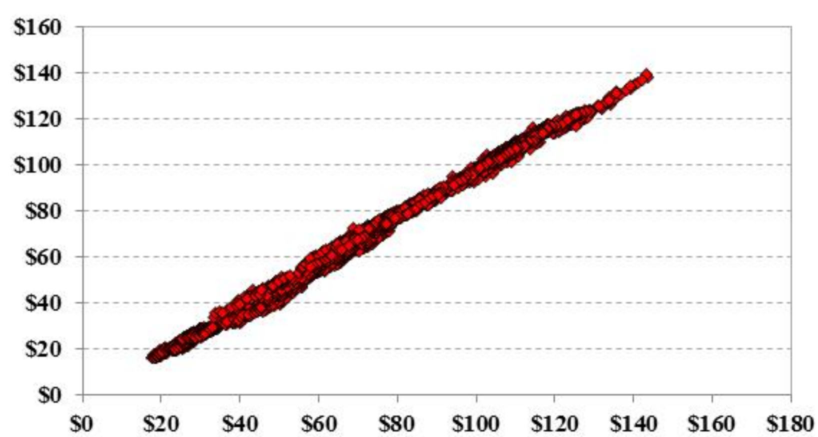
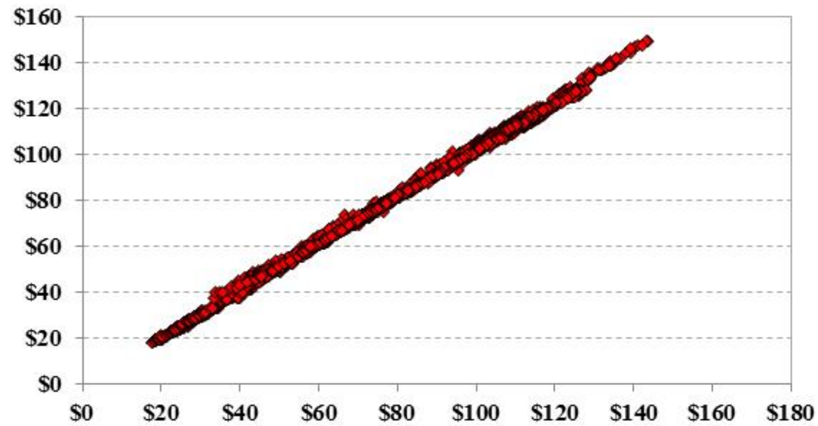
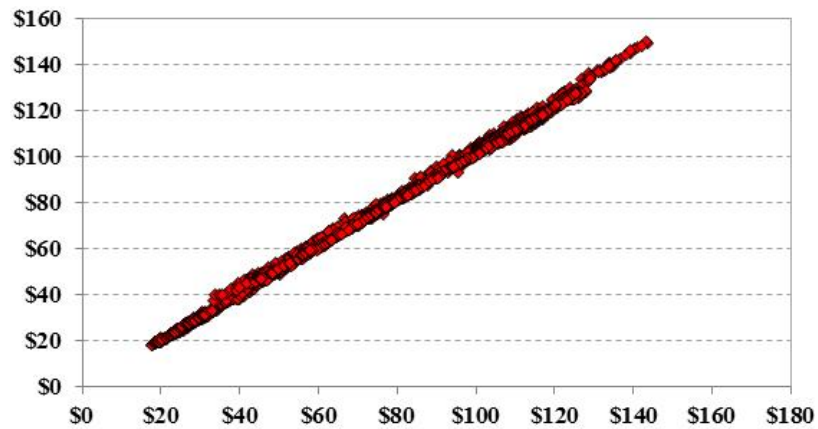


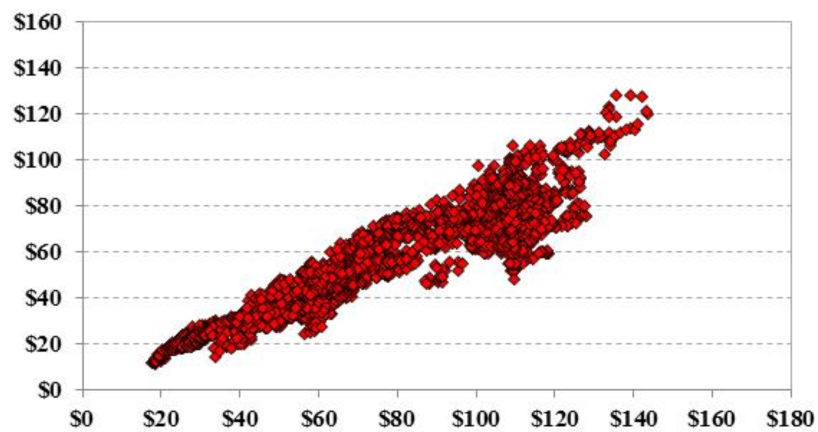
Escravos



Brass River



Bow River Hardisty



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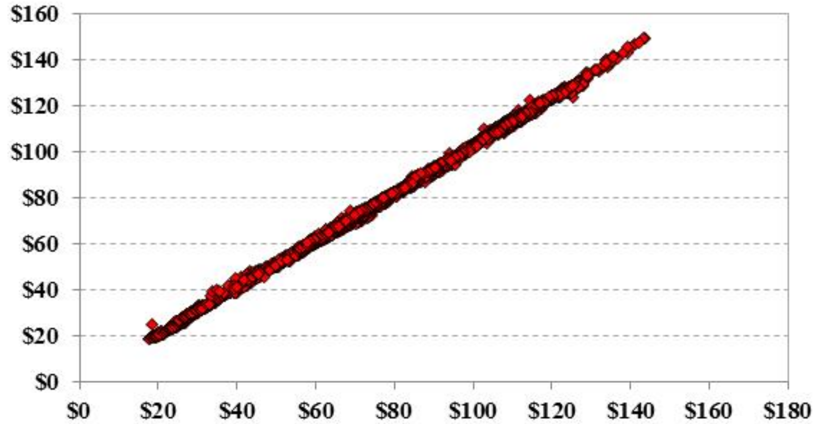

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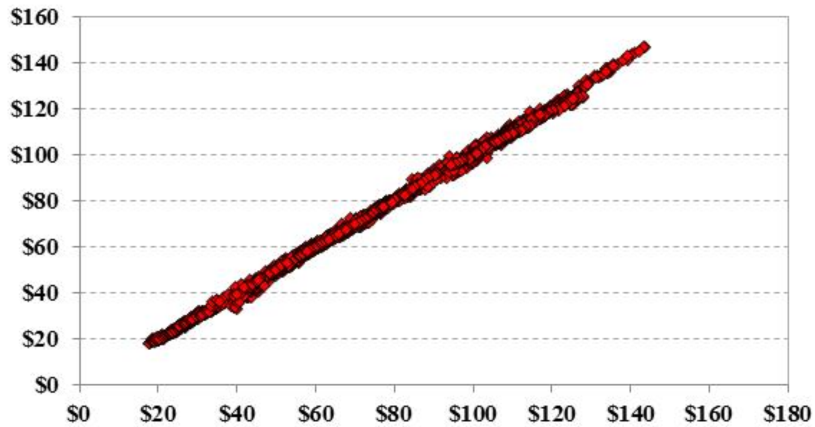

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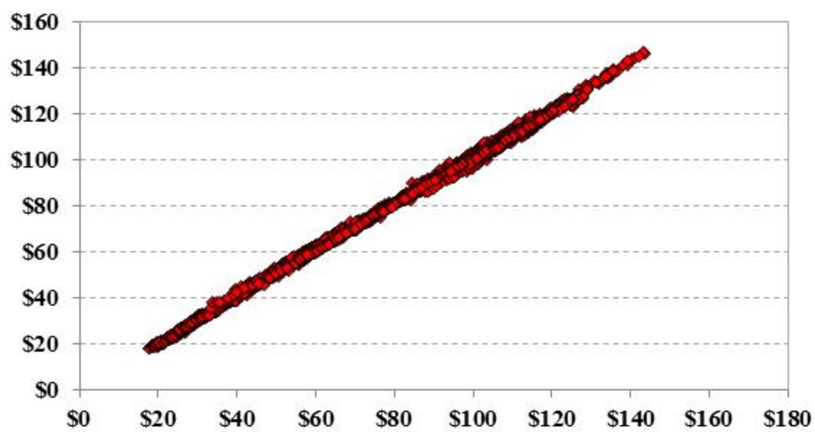

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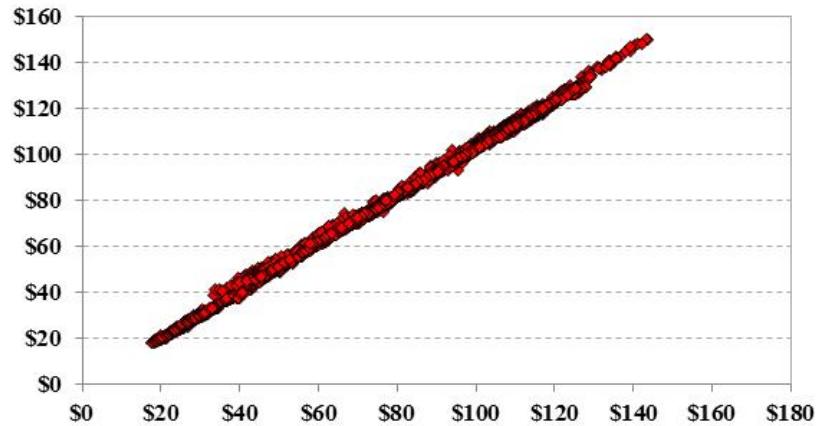
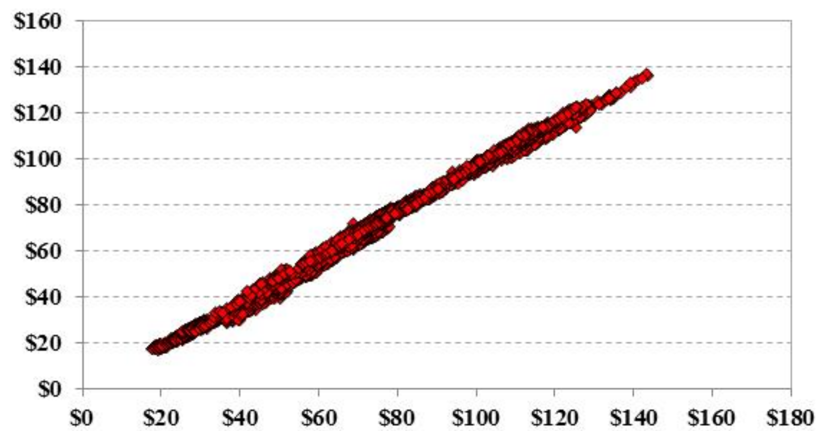


Iranian Heavy



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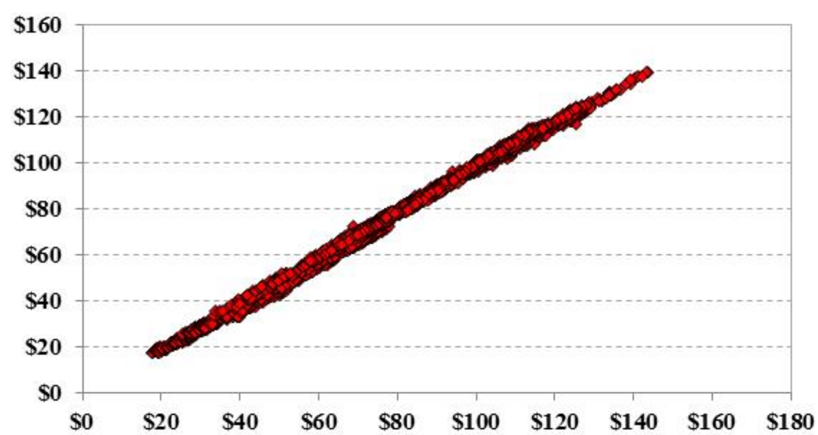

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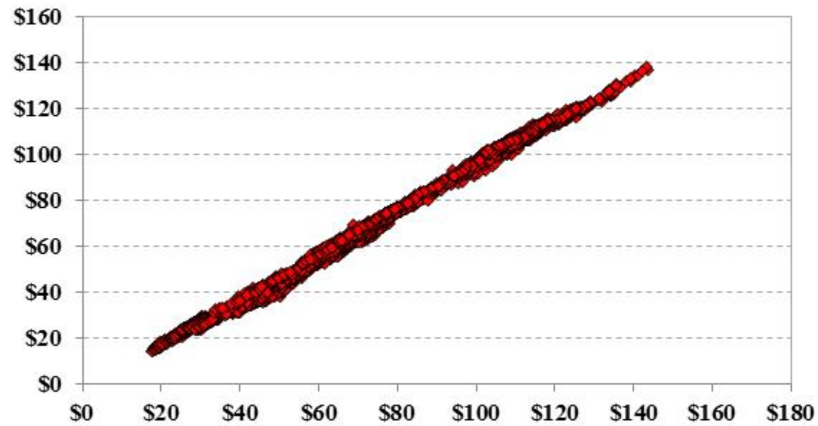

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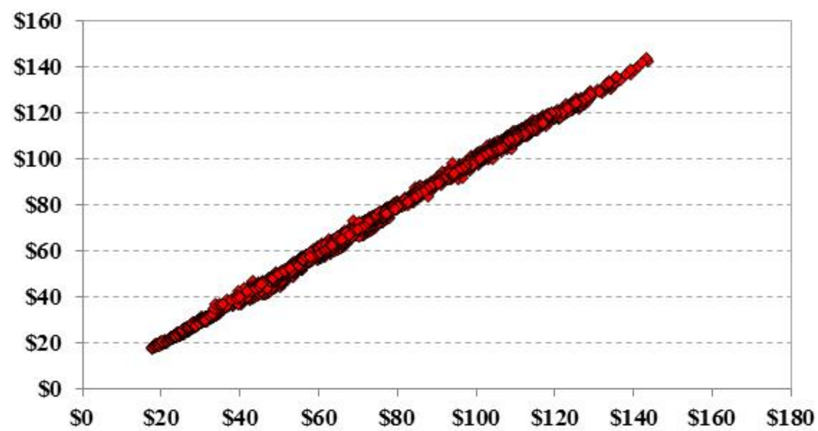

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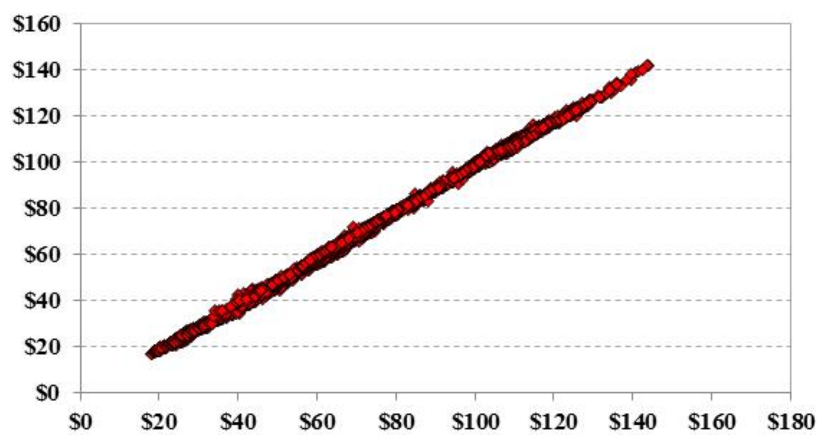

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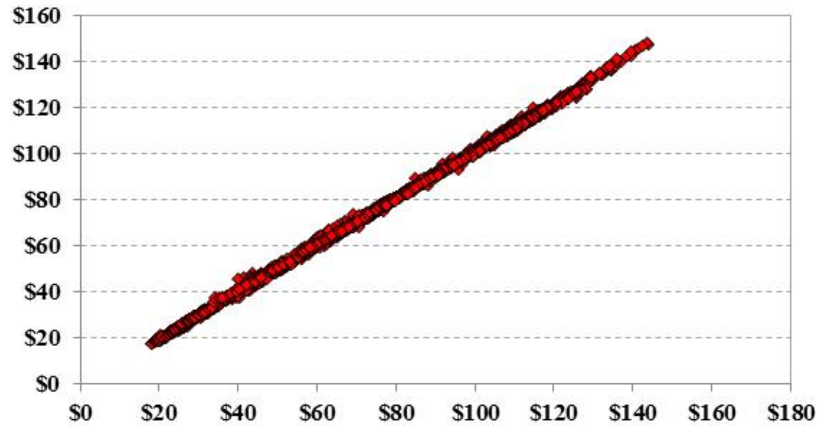

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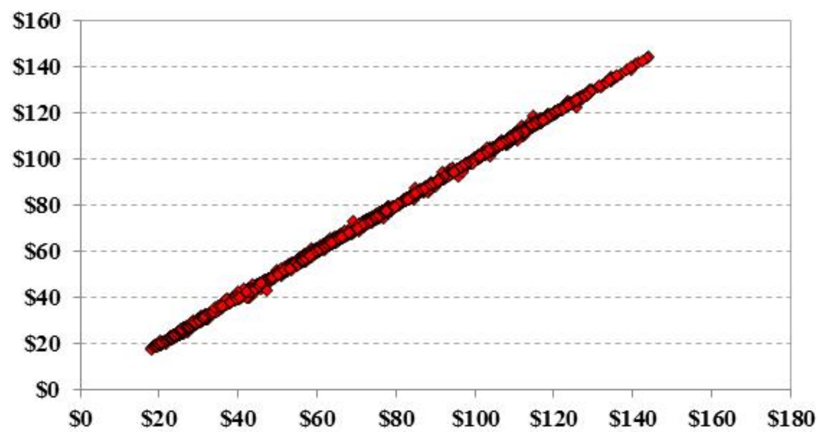

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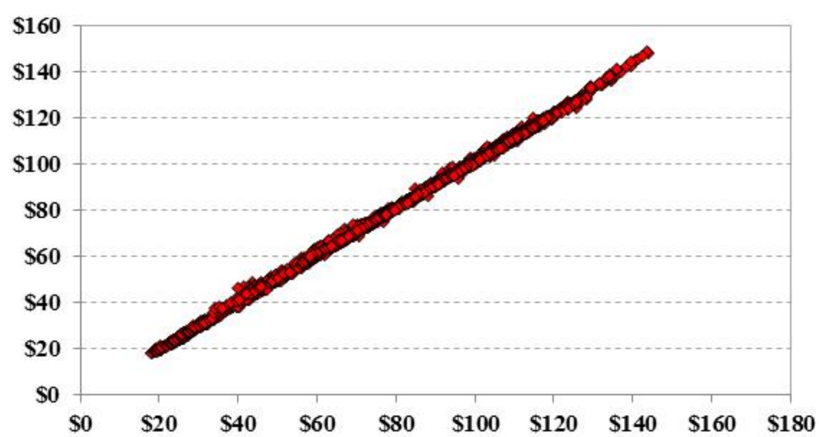

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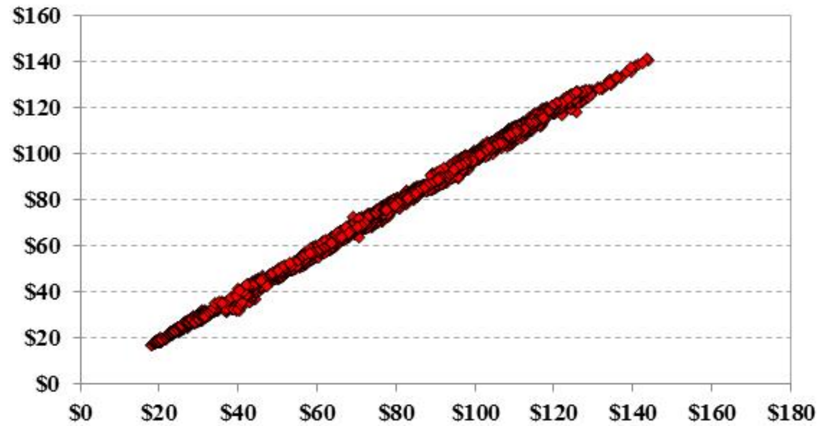

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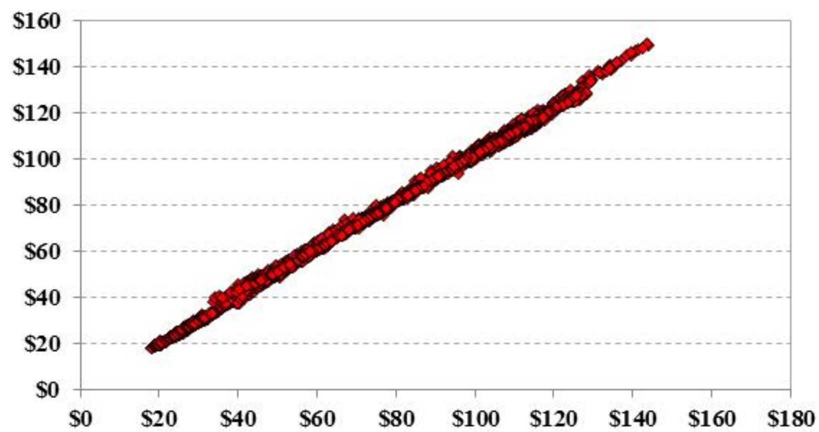

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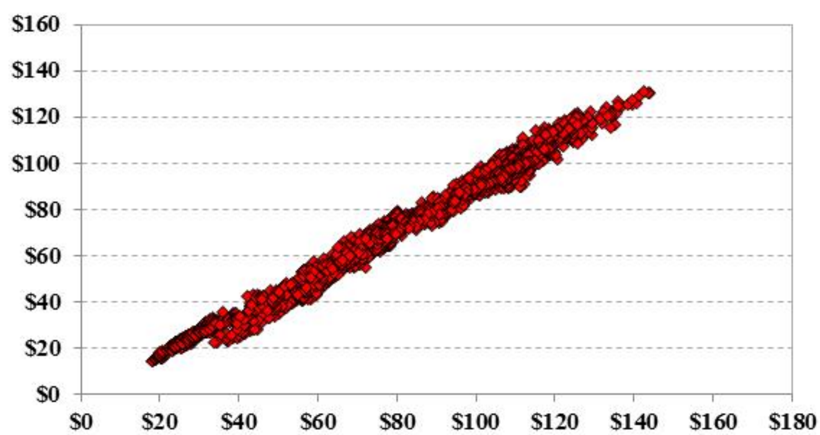

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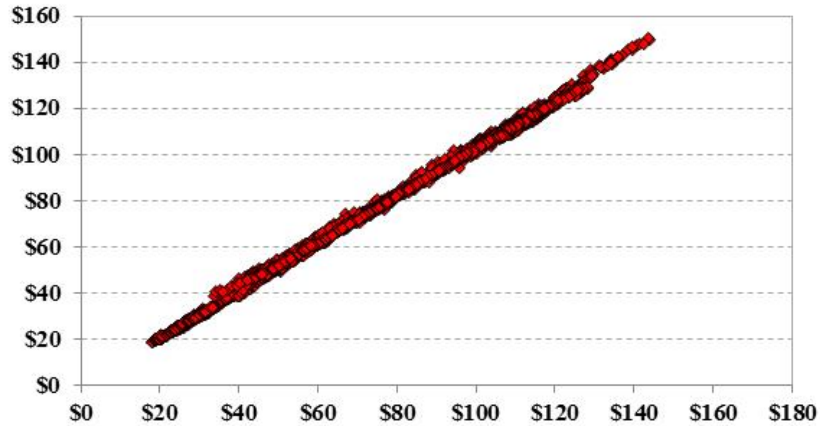

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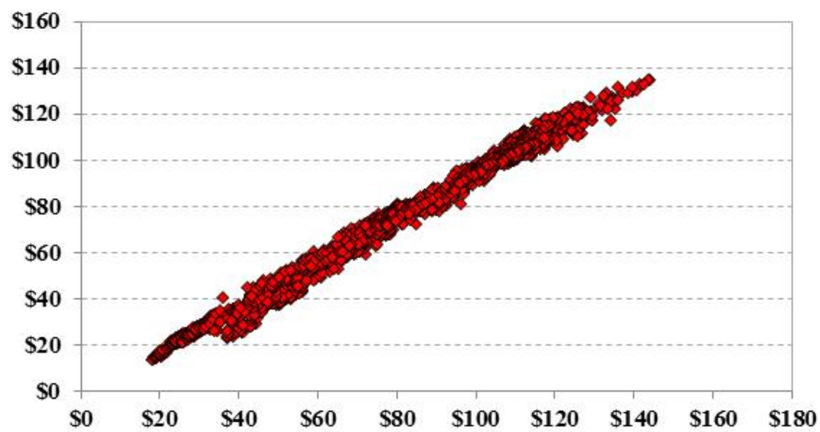

US Poseidon