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Crude Oil Exports and the Louisiana Economy

A discussion of U.S. policy of restricting crude oil exports and its implications for Louisiana

Report prepared as a Louisiana State University Center for Energy Studies research product. No external funding was received for this project.

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November 30, 2015

EXECUTIVE SUMMARY

In 1975, President Ford signed the Energy Policy and Conservation Act (EPCA) that prohibited the export of domestically produced crude oil and natural gas as well as refined products. The "export ban" on crude oil persists to the current day. The recent shale boom has created historic increases in oil and gas production and has become the catalyst for Congress to consider whether the export ban is still in the best interest of the U.S. Spurred by this renewed interest in the decades old policy, there have been a number of recent studies that have discussed the potential implications of the removal of the export ban.

The results of these studies have been twofold. First, it has been estimated that significant economic benefits will arise if the export ban is to be repealed, primarily due to increases in domestic oil production from upstream producers. Second, studies have concluded that the removal of the export ban will not lead to increases in gasoline prices for consumers; in fact some have argued that consumers might benefit from gasoline price decreases.

This study presents a basic economic model that describes the market for a commodity under a scenario of an export ban. Next, it assesses the plausibility of the claims made by prior studies. Finally, it specifically addresses how an export ban might impact Louisiana's economy in particular by focusing on the plausible impact of the export ban on gulf-coast upstream oil producers and downstream refineries and petrochemical plants.

In sharp contrast to prior studies, results suggest that large economic benefits associated with the removal of the export ban are implausible. Simply put, most of the price differential between domestic and foreign crude prices is likely associated with shipping costs and constraints (i.e. "congestion pricing") within the U.S., not the export ban. While refineries in general are the benefactors of the export ban at the expense of producers, these transfers are transitory and likely not large in magnitude. This is especially true for Louisiana producers who were able to sell crude at prices closer to foreign market prices, unlike mid-continent crudes that traded at a significant discount, during the shale boom. The study corroborates other studies in concluding that the lifting of the ban would not likely impact gasoline prices that consumers and businesses pay at the pump.

The purpose of the study is not to make a specific recommendation on whether the ban should be lifted or not, nor does it quantify a net cost/benefit to Louisiana's economy, but it does identify specific tradeoffs that can be considered by policymakers when deciding whether the ban is in Louisiana's and/or the United States' interest. In summary, the export ban causes short-run frictions that will benefit refineries at the expense of upstream producers especially in times of large shocks—such as the recent shale boom. But these transitory shocks are short lived, as crude prices worldwide adjust quickly and trade at similar prices for which differences can be reconciled by transportation costs and quality differences. The export ban is effectively a protectionist policy for the refining and petrochemical industries. If U.S. crude production continues to rise and reaches a point for which current refining capacity is insufficient to process the domestic crude, an export ban effectively guarantees that the investment in new refining capacity will be here in the U.S.

In addition to the decades old debate over how the export ban impacts upstream producers compared to downstream refining and petrochemicals, other potential economic development opportunities are also considered in this research; and these other development opportunities are particularly pertinent to Louisiana. Lifting the export ban and allowing for free trade of all hydrocarbons can create an environment that allows for the Gulf Coast to become the epicenter for hydrocarbon trading. For instance, lifting the ban could spur investment in the expansion of the Louisiana Offshore Oil Port (LOOP) to allow for both imports and exports of crude; creating a dynamic two-way trading hub has the potential to shift the world oil market's focus from Brent to the

Louisiana Gulf Coast. In addition current investments in liquefied natural gas (LNG) could set the Gulf Coast at the epicenter for a new global market for natural gas—that has historically been traded regionally (not globally). Trade liberalization for all hydrocarbons can enhance the Gulf Coast's ability to be a global hub for oil and gas commerce.

When viewed holistically, basic economic principles alongside the data paint a very humdrum picture for both proponents and opponents of the export ban. Proponents have argued that the removal of the export ban will create large increases in domestic production and hundreds of thousands of domestic jobs while opponents have argued that the repeal of the law will significantly increase oil and gas production thus exacerbating global CO_2 emissions and climate change. Results of this research indicate that both these benefits and concerns are likely grossly overstated.

I argue that the debate over the export ban should not be decided based on net economic costs or benefits, nor should it be based on protecting one industry at the expense of another. Nor should it be based on environmentalists' concern that the removal of the ban will increase global CO_2 emissions. All of these supposed costs and benefits are highly speculative and are based on a number of overarching assumptions about the future. When a basic economic model is compared to the data, all of these benefits and concerns appear to be over-blown.

For Louisiana, the removal of the export ban will remove a long run federal protectionist policy on an industry that has served as an important component of our economy, but in return will provide the opportunity for the state to be at the center of an emerging global trading hub. Certainly, one might find solace in clinging to a decades old policy that was created for national security reasons as justification for protecting a specific Louisiana industry. But having confidence in our state and our nation's energy economy, instead we might decide to move forward and take risks that have the potential to grow Louisiana's economy into a future with a dynamic energy environment.

ACKNOWLEDGMENTS

I wish to recognize the faculty and staff assistance from the LSU Center for Energy Studies, especially David Dismukes who provided direction and feedback on this work and Marybeth Pinsonneault for her editorial expertise. In addition, I would like to thank several people from diverse backgrounds that provided invaluable thoughts and critiques of my work including:

- Karl Bartholomew, Vice President, Americas of ICIS;
- Kevin Bruce, Regional Director, State Affairs. America’s Natural Gas Alliance;
- Katie Ehly, Director, Research & Policy Analysis. America’s Natural Gas Alliance;
- John Johnson, III, Chairman, State of Louisiana Board of Professional Geoscientists;
- James Kleiss, Regional Optimization Planning Director, Valero;
- Manuel Lam, Senior Energy Analyst, Louisiana Department of Natural Resources;
- Edward O’Brien, Senior Economist, Louisiana Department of Natural Resources;
- Edward Overton, Emeritus Professor, Department of Environmental Sciences, Louisiana State University;
- Eric Smith, Associate Director, Tulane University Energy Institute.

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1 Introduction

In 1973, the Organization of Petroleum Exporting Countries (OPEC) proclaimed an embargo on oil against Canada, Japan, the Netherlands and the United States that lasted from October of 1973 to March of 1974 and sent the U.S. economy into a tailspin. In 1975, President Ford signed the Energy Policy and Conservation Act (EPCA) that prohibited the export of domestically produced crude oil and created the Strategic Petroleum Reserve. While the crude export ban—hereafter referred to as the "export ban" or more simply "the ban"—has been subject to much public scrutiny and debate since the passage of EPCA, very few gains have been made in actually removing the ban.[1] The recent shale boom has created historic increases in oil and gas production, though, and become the catalyst for Congress to consider whether the export ban is still in the best interest of the U.S. (Crude Oil Exports, 2014).[2]

Modern crude oil production began in 1859 with Drake well five miles south of Titusville, Pennsylvania, and almost instantaneously the oil industry began to take off (Yergin, 1999). For over a century, the United States experienced consistent increases in oil production. But in 1970, the age of increasing domestic production reached its end, and for the first time in U.S. history, production began to decline—a decline which continued for the next four decades. As a result, the U.S. became increasingly dependent upon foreign sources of oil. Therefore it is no wonder that the ban has received limited attention; with demand for petroleum products increasing and domestic crude supply decreasing, the ban has been of little practical relevance.

But over this last decade, the oil landscape has changed both suddenly and dramatically when a technological breakthrough allowed "shale" oil and gas to become

[1] The original EPCA also banned the export of refined products such as aviation gasoline, gasoline, jet fuel, kerosene, distillate fuel oil, residual fuel oil, butane, propane and naptha. In 1981, the export ban on these refined products was removed, but the ban on crude oil remains. In addition, the original language of the bill included an export ban on natural gas, but this has not been of practical relevance as approval processes for natural gas exports have been created. While there is currently proposed legislation aimed at the streamlining of this approval process, natural gas exports are beyond the scope of this study. See The Energy Policy Modernization Act (EPMA) for more details on natural gas exports.

[2] In fact, at the time of this writing, the U.S. House passed to repeal sections of EPCA and therefore lift the ban. Whether this bill will pass the Senate is uncertain, and it seems at this time unlikely that President Obama would sign any bill that might reach his desk.

economical for the first time in history. Because of technological breakthroughs in horizontal drilling, sequential hydraulic fracturing (informally referred to as “fracking”), and improvements in seismic tracking, the declining trend in oil production has reversed itself. For almost a decade now, oil production has continued to rise, and the U.S. is now experiencing production similar to the historic levels achieved during “peak oil” of the 1970s (EIA, 2014).

Not surprisingly, the discussion about lifting the ban has gained traction, but there are two major concerns. First, some speculate that lifting the ban could lead to increases in gasoline prices for consumers. Second, there are national security concerns.[3] Proponents of lifting the ban not only refute the concerns but also argue there will be substantial economic benefits if the ban is lifted.

The growing conventional wisdom by proponents of lifting the export ban can be summed up in two main points: First, that lifting the ban will not increase gasoline prices; if anything it will lead to a decrease in gasoline prices (Yergin et al., 2014; Ebinger and Greenley, 2014; Medlock, 2015). Second, lifting the ban will increase oil production in the U.S. and therefore create hundreds of thousands of domestic jobs (Yergin et al., 2014; Ebinger and Greenley, 2014). This paper will discuss both the plausibility of these claims in general and discuss whether they are likely to apply to Louisiana more specifically.

Conducting an empirical counterfactual-based analysis that tests what *would happen* if the ban were lifted with any degree of accuracy has proven to be infeasible. One just need look at the recent academic literature, or lack thereof, on this topic to reach this conclusion. There are two likely reasons for this lack of empirical research.

First, this policy has been in place for more than 40 years and was put in place in response to a very specific foreign policy crisis. In addition, this policy change occurred at a time of “peak oil” in the 1970s. Simply put, this was a very different time in American history and therefore empirically observing changes in crude oil prices and

[3] This research does not focus on national security concerns, as this is not within its scope. For information on the export ban and national security concerns, see Medlock (2015).

domestic production before and after EPCA was implemented is unlikely to inform us on what changes might occur today if the ban were to be removed.

Second, there are no examples of large oil producing countries with crude export restrictions that were suddenly lifted for empirical economists to study. After reviewing the literature, only one study in this vein was found. Bausell et al. (2001) empirically tested the impact of the removal of the export ban on the Alaskan North Slope in 1996, but a relatively remote market such as Alaska is systematically different than the continental U.S. market. While results suggest that the lifting of the ban did increase crude prices and production in Alaska, this was during a time of sustained price differentials between continental U.S. crude and Alaskan crude inherently constrained by refining and pipeline capacity. It is unlikely that these results generalize.

Louisiana is a unique state in that it has historically been a large onshore oil and gas producer, but times have changed. Louisiana's oil production has largely moved to federal deep waters that are primarily drilled by the "majors" such as Shell, British Petroleum, and Chevron. While production on state lands and waters has attenuated, employment associated with the oil and gas industry has continued to be important in Louisiana. But upstream oil and gas activities are not the only industries potentially impacted by an export ban. The downstream refining and petrochemical industries are also important players in Louisiana's economy, and thus must also be considered in any discussion of the impact of the ban's removal. Table 1 illustrates the importance of both upstream oil and gas production and downstream refining and petrochemicals in Louisiana's economy. About 5.4 percent of Louisiana's earnings come from upstream oil and gas activities and another 4.3 percent of earnings come from the refining and petrochemical sectors. Between these sectors, oil and gas activities make up almost 10 percent of Louisiana workers' earnings.[4] Combined, these sectors employ almost 85,000 workers statewide and account for more than 5 percent of statewide employment. In addition, jobs in these industries are high-paying jobs, paying on average over $95,000 per year. This is more than double the statewide average

[4] This number actually exceeds 10 percent when other related industries are included that are not specifically listed here.

earnings of about $45,000 per year. Thus, these industries are integral for Louisiana's economy, and any policy that impacts the oil and gas industry has the potential to greatly impact the aggregate economy.[5]

Table 1: Louisiana Employment and Annual Wages Paid in Petroleum-Related Industries (2013)

Sector	Employment		Earnings		Average Earnings
	Counts	Percent of State	Millions of Dollars	Percent of State	Dollars / Year
Oil and Gas Extraction	9,941	0.5%	$ 1,194	1.4%	$ 120,121
Support Activities for Mining	39,432	2.1%	$ 3,305	4.0%	$ 83,815
Total Upstream	**49,373**	**2.7%**	**$ 4,499**	**5.4%**	$ 91,125
Refining	12,455	1.6%	$ 1,348	1.6%	$ 108,251
Chemical Manufacturing	23,040	1.2%	$ 2,218	2.7%	$ 96,249
Total Refining and Petrochem	**35,495**	**2.9%**	**$ 3,566**	**4.3%**	$ 100,460
Total UpStream + Refining and Petrochem	**84,868**	**5.5%**	**8,065**	**9.7%**	$ 95,029

Source: U.S. Census Bureau. Quarterly Workforce Indicators.

The upstream oil and gas industry is likely impacted very differently by a policy change than refineries and petrochemical plants. Potentially, a policy that is good overall for upstream oil and gas producers might not be so beneficial for the refining and petrochemical industries, and vice versa. Because the U.S. as a whole employs more people in the upstream oil and gas industry than the refining and petrochemical industry, and because the upstream industry is historically more "boom and bust" than refining and petrochemicals that have historically been more stable, the discussion of the impact of the export ban to date has focused much more heavily on these upstream producers (Yergin et al., 2014; Ebinger and Greenley, 2014; Vidas et al., 2014; Medlock, 2015). Louisiana is a unique state in that both industries are important employers, and therefore differential impacts on both industries need to be considered in assessing whether the removal of the export ban is in the interest of Louisiana.

[5] These employment and earnings include individuals directly employed in these sectors. They do not take into account "indirect" and "induced" economic impacts associated with business activity that supports these sectors, nor do they take into account the increase in economic activity when workers spend these wages in the local economies. Thus, the actual importance of these industries is likely even more significant.

The remainder of this report is organized into four major sections. Section 2 discusses basic economic theory in a market with export restrictions on an *input* to production *but not* on the *output* from production. It then discusses the shale oil and gas boom that has occurred over the last decade and then incorporates this into the economic theory. Section 3 discusses the Louisiana economy, specifically focusing on both the upstream oil and gas producers and the refining and petrochemical industries. Section 4 considers plausibly what a world would look like without export restrictions. It focuses not only on the impact of export restrictions in general, but also specifically considers unique implications for Louisiana's economy. Finally, Section 5 discusses conclusions and likely policy implications.

2 Economic Theory of Export Restrictions

2.1 Model Assumptions

Incorporating the unique market for crude oil into a basic economic model is the first step to understanding the likely implications of lifting the ban on the domestic market for crude and more specifically on producers and consumers in Louisiana. The model should (1) take into account the fundamentals of this unique market, (2) be able to accurately describe past events and (3) be used to reasonably predict what a future might look like with and without an export ban.

I present a basic economic model to describe this market and discuss the implications of the export ban. But first, I start by discussing the basic economic principles that must be incorporated into the model. Specifically, the model will describe a globally traded commodity for which export restrictions are placed on the commodity but not the intermediate and final products derived from the commodity. Next, the model will describe a commodity that is heterogeneous but has properties that allow for substitutability (with some short-term frictions). Finally, the baseline model will assume zero transportation costs and zero transportation constraints. This assumption in particular will be informative in that subsequent analysis will consider the importance of this assumption and show how it is particularly pertinent to the current debate on the export ban, especially for Louisiana producers.

2.1.1 Export Restrictions on Crude Oil but Not Refined Product

The model describes a market for a globally traded commodity for which export restrictions are placed on the commodity but not the intermediate and final products derived from the commodity. In other words, export restrictions are placed on a commodity that is used as an *input* to production but no export restriction is placed on the *outputs* from production derived from the commodity. In this example, we will consider the supply and demand for “light sweet” crude, i.e. the type of crude found here in the U.S. and even more specifically the type of crude produced in Louisiana. Due to the export restriction set in place in the 1970s, it is not legal to sell domestically produced crude oil on the international market. Therefore domestic producers are forced to sell their product to a domestic buyer even if there is an international buyer who would be willing to purchase the same barrel of crude for a higher price.

Crude oil must be refined before consumers can use it. During the refining process, refineries take crude oil and turn it into dozens of “refined products” that can be used as either a final product, such as gasoline or diesel used to power motor vehicles, or as an input into other goods, such as plastics. While U.S. law prohibits crude oil from being exported, there is no restriction on the export of refined products. Harold Hamm, CEO of Continental Resources—an upstream oil and gas producer—summarizes this phenomenon:

> *Major oil companies are exporting refined products with no limitations. Why shouldn’t independent producers be allowed to do the same? . . . This would be equivalent to telling American farmers they can’t export their wheat, yet allowing Pillsbury to export all the processed flour they want.*

2.1.2 Heterogeneity and Substitutability

The market for crude oil is unique in that crude is heterogeneous, but different crude types can act as substitutes for one another. This substitution is not instantaneous though; refineries (demanders of crude) can adjust to different mixes of crude over time, thus adjusting the relative demand for crude with different properties. Historically, the U.S. has produced “light sweet” crude that has a relatively low density (“light”) and relatively low sulfur content (“sweet”). Louisiana crude has typically been lighter and sweeter than other domestic crudes, and thus is referred to as “Louisiana

Light Sweet," hereafter simply referred to as LLS. Thus U.S. refineries, and Louisiana refineries more specifically, were historically built to process this domestically produced light sweet crude. But since "peak oil" of the 1970s, coastal refineries have slowly substituted towards "heavier" more "sour" crudes imported from overseas to mix with declining domestic light sweet crude. Refineries can purchase an array of crudes with different properties and mix the crudes to an appropriate density for processing. This mixing gives the refinery the flexibility to change its purchases to adapt to changing relative availability and prices. For instance, if light crude is relatively inexpensive, a refinery might purchase more light crude *and* more heavy crude, causing the refinery to substitute away from a medium grade crude to take advantage of the relatively inexpensive light crude.

In addition to changing the mix of crudes purchased, refineries can also make alterations to the refinery itself to allow for a different mix of crudes to be processed. While a refinery is unlikely to make significant changes to its equipment and operations in response to a transitory shock, refineries are able to make significant changes to accommodate structural changes in crude availability. EIA (2015a) discusses the technical options for refining additional light crude in the wake of the recent shale oil boom. The economic model presented will take into account refineries' ability to alter crude inputs over time.

2.1.3 Transportation Constraints

While transportation is inherently constrained in the short-run due to both transportation costs and fixed capacity (in pipelines for instance), the model presented will assume no transportation capacity constraints and no transportation costs. Recently, Borenstein and Kellogg (2014) and Kaminski (2014) discuss the specific transportation constraints induced by shale production and how these constraints have induced price differentials within the domestic market. Discussing a baseline model with no transportation constraints is informative in that it then allows us to remove this assumption and discuss the likely importance of transportation constraints on recent systematic changes that have been observed in the market. The implications of these constraints considered in the context of the removal of the export ban will be shown to be very important, and likely overlooked and/or underestimated by prior studies. The implications of these transportation constraints will then be discussed in considering the likely implications of the lifting of the export ban.

2.2 Model Overview

Figure 2.1 illustrates the basic economic model that describes this unique market. I start with a short-run supply curve for domestic light sweet crude oil. The supply curve is upward sloped, as increases in price will spur new supply into the market. There are three mechanisms that allow for an upward sloped supply curve. First, oil producers are able to store crude in the short run due to price drops and sell that crude to the market when the price rebounds. Second, as illustrated in Figure 2.2, historically U.S. rig counts have been positively related to crude oil prices, typically with a lag. Third, it has recently been documented that companies are drilling wells but defer stimulation until the price increases to an acceptable level (Levine, 2015). Thus price is positively related to supply in the short-run.

Unlike crude oil production that can increase and decrease relatively quickly in response to price shocks, the demand for light sweet crude is relatively fixed in the short run, as refineries are configured to handle a specific mix of crude. This is illustrated in Figure 2.3, which shows two properties of crude used by U.S. refineries: API gravity and sulfur content. Since the 1980s, U.S. refineries have seen gradual decreases in API gravity.[6] This means that crudes utilized in U.S. refineries have gotten "heavier" (note: light crude means a high API gravity). Crude inputs have also seen increases in sulfur content over this this time period, meaning that refineries have adapted to more "sour" (as opposed to "sweet") crude inputs over the last several decades. While refineries can change the composition of the crude inputs, this happens over an intermediate time period, and therefore demand for crude is modeled as a vertical inelastic demand curve in the short run.[7]

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[6] Over the last few years, this trend has reversed. This reversal will be discussed subsequently in this research.

[7] While the model is presented with a vertical—completely inelastic—demand curve, the basic conclusions of the model are unchanged if this demand curve is modeled with a short run elasticity not equal to zero. The actual short run price elasticity is an empirical question that is not addressed directly in

As shown in Figure 2.1(a), domestic supply and demand come together to reach an equilibrium price and quantity, P^*, Q^*. This represents the domestic equilibrium price for an American style, light sweet, crude purchased by a domestic refinery. Because it is not legal for domestic producers to export these domestically produced crudes, it is possible that the world price for crude oil could be different than the domestic price. This is illustrated in Figure 2.1(b) where $P_w^* > P_D^*$. In this situation, domestic producers will want to sell their product on the global market (as they will receive a higher price), but will be unable to do so because of the export ban. Crude producers will either have to sell their crude at the lower domestic price or store their crude until they think they will be able to receive a higher price.

Because of this price differential, foreign refineries will have a higher cost feedstock relative to domestic refiners, thus they will be at a disadvantage. Therefore, domestic refiners get the best of both worlds—they are able to purchase their crude at a low price and sell the final product at a higher global price. This basic economic theory explains why historically upstream oil and gas producers have been opponents of export restrictions while refiners have been proponents of these restrictions.

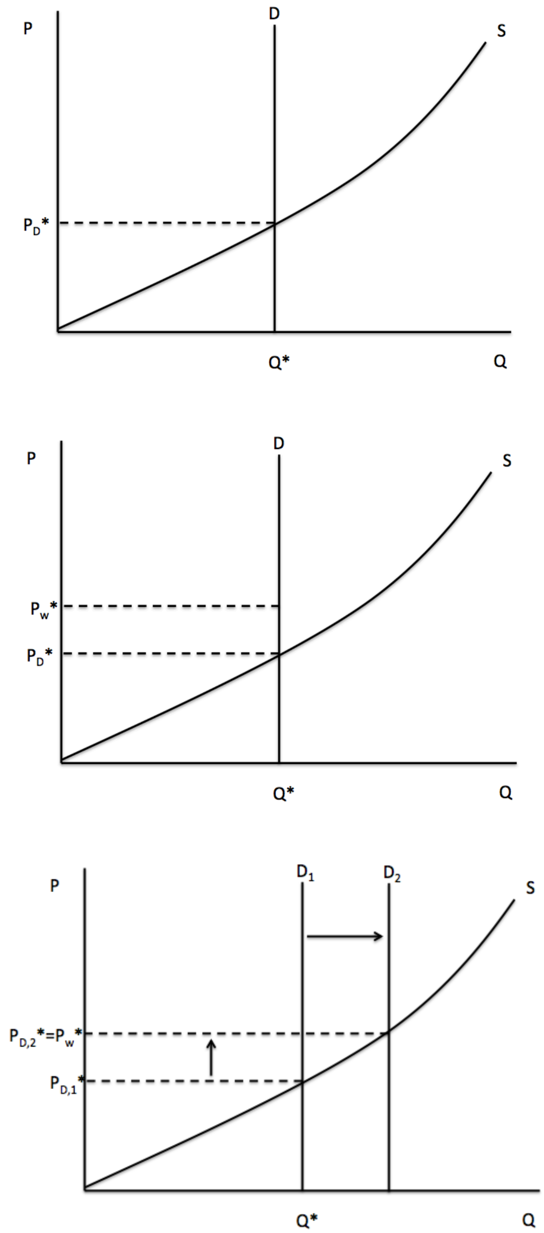
While refiners are the beneficiaries of this scenario, theory predicts that this differential will not sustain itself, as refiners will begin to make changes to fully capitalize on this price differential. They will start making modifications to existing refining operations to utilize a relatively larger share of the lower priced domestic light sweet crude in order to increase margins between the feedstock and final products produced. Some of these changes will require simple alterations to the mix of crude input into the refinery (such as substituting heavier crudes for medium grade crudes to mix with the domestic light crude) while others will require making changes to the refinery operations itself (EIA, 2015a). In addition, recently companies have been accused of creating “mini-refineries” that process the crude just enough to get around the export restriction (Nussbaum and Olson, 2014) and further increasing the domestic demand for crude. If

this research. Empirical estimates for the U.S. suggest that the short run elasticity is very inelastic: An average of a half dozen studies yield an average short run elasticity of about -0.2 (Hamilton, 2008) with individual estimates ranging from almost zero to -0.34. Hamilton argues that these estimates are likely upward biased on average, and that the actual short run price elasticity is very small.

a sustained price differential is observed, this could spur large capital-intensive infrastructure projects in the refining sector.[8]

This phenomenon is illustrated in Figure 2.1(c) where domestic demand for crude shifts from D_1 to D_2 thus driving the domestic price up until it reaches the world price. Once $P_w^* = P_D^*$, there will no longer be an incentive for refiners to make changes to their operations to utilize the light sweet crude, and therefore the domestic market will return to its long run equilibrium.

[8] The speed at which this adjustment takes place is an empirical question that is not directly addressed in this research. Potentially, some refinery alterations can be made relatively quickly and inexpensively, but at some point refineries that were built to process a heavy crude might only be able to process a certain share of lights regardless of the changes made to the particular refinery. Thus, while in the long run the market will move back into equilibrium with world and domestic prices being approximately equal, the speed of this adjustment relative to the size of the shock is ambiguous. This speed of adjustment will be addressed subsequently in the report.



(a) The short run supply curve is upward sloping, while demand (i.e. refinery demand) is fixed in the short run.

(b) Because of crude export restrictions, the domestic price will not necessarily be equal to the world price in the short run. In this instance $P_w > P_D$.

(c) Domestic refineries receive a discount on domestic crude relative to the world price, so they adjust refining operations to take advantage of this differential and drive up the price until $P_w = P_{2,D}$.

Figure 2.1: Economic Theory of Export Restrictions: Supply and Demand for Light Sweet Crude.

Source: Author's Theoretical Model

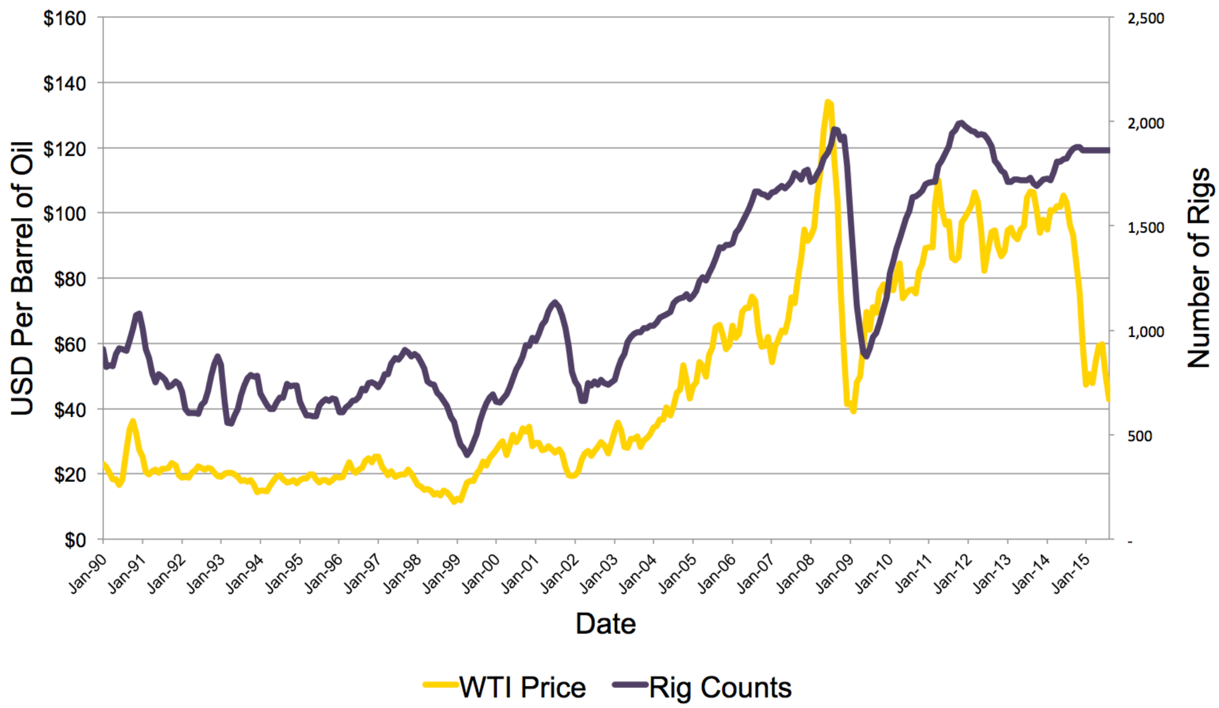


Figure 2.2: Supplier Response to Oil Price Shocks

Source: Energy Information Administration, U.S. Department of Energy; and Baker Hughes.

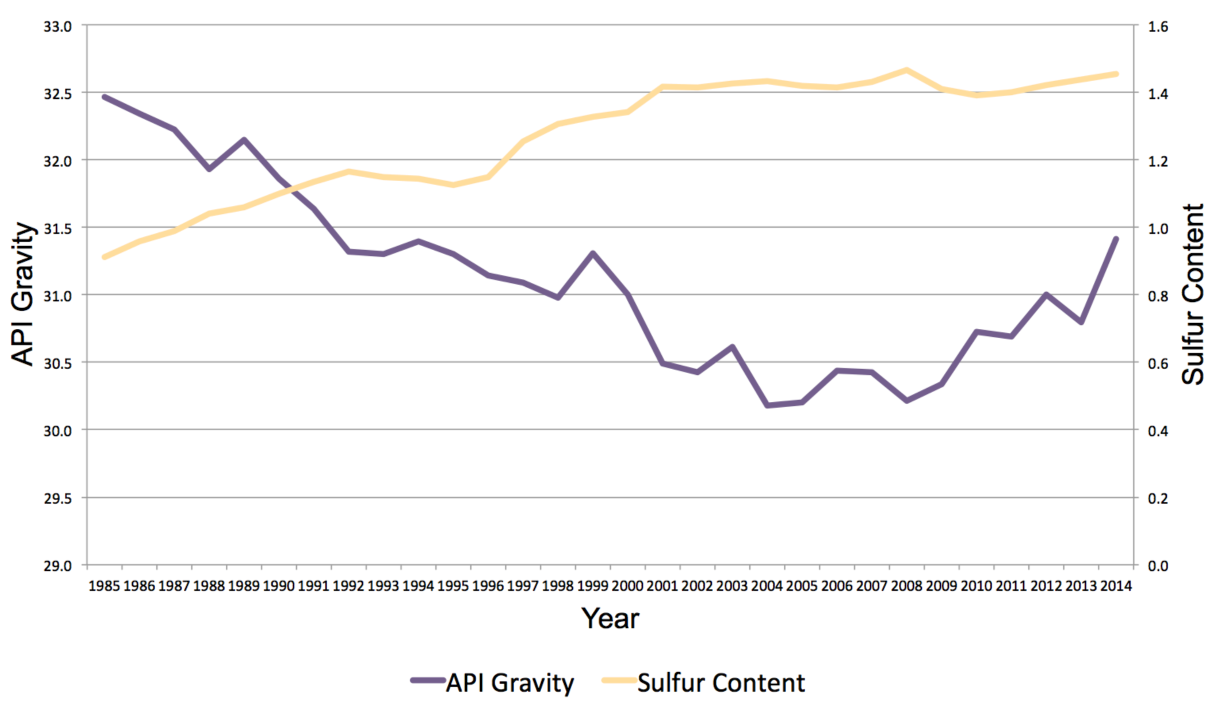


Figure 2.3: U.S. Refinery Crude Input Properties

Source: Energy Information Administration, U.S. Department of Energy.

This basic economic model suggests the following. First, it is possible for the world price to differ from the domestic price in the short run due to the relatively slow movement of refineries to adjust to sudden changes in the supply side of the market. Second, domestic refineries will likely be the beneficiary in the short run at the expense of upstream oil producers and foreign refineries. Finally, the model predicts that the world price and domestic price will converge in the long run.

Specifically, these conclusions can be summarized as follows:

> *Prediction 1: The domestic price of crude is determined by the domestic supply and domestic demand, i.e. refining demand.*
>
> *Prediction 2: In the short run, it is possible for the domestic price to deviate from the world price; specifically it is possible for the domestic price to decrease relative to the world price.*[9]
>
> *Prediction 3: If the domestic price is less than the world price, in the short run refiners will benefit at the expense of producers.*
>
> *Prediction 4: In the long run, the market will move back into equilibrium, where the global price is equal to the domestic price.*

2.3 Shale Oil and Gas in the United States

Technological change is the driver of economic growth. A tipping point for the industrial revolution, and therefore modern society, came about when humans learned to utilize energy stored in fossil fuels to power production of an almost limitless number of goods and services. While humanity has come a long way since the industrial revolution, technological progress still has the ability to fundamentally transform the modern global economy as well as the economy here in Louisiana.

Over the past decade, the landscape for oil and gas development has been fundamentally shifted in the U.S. again due to technological change. As the combining

[9] While it is possible for the domestic price to be lower than the world price, the inverse is not possible. This is because if the world price is *lower* than the domestic price, then refineries will choose to purchase crude from the world market instead of from domestic producers, therefore driving down the price of domestic crude.

of horizontal drilling and sequential hydraulic fracturing has become economical in "tight" shale oil plays, the historic trend of declining oil and gas production has reversed itself and created a glut of light sweet crude that has fundamentally changed the trajectory for the future of energy both here in the U.S. and across the world. This fundamental change in global oil and gas markets has also brought attention, once again, to the possibility of exporting crude oil and natural gas.

Figure 2.4 shows a map of shale plays in the United States. While these different plays vary from containing mostly gas (i.e. Haynesville in Louisiana) to having a mix of both oil and gas (i.e. Marcellus in Pennsylvania) to having mostly oil (i.e. Bakken in North Dakota), the same technique of combining hydraulic fracturing and horizontal drilling in these specific geological formations has changed the global energy landscape. Figure 2.5 illustrates this, showing total U.S. crude oil production from 1980 to 2013. From 1980 until 2005, the U.S. experienced a steady decrease in crude production. This is due to the fact that both individual wells and entire basins (comprised of many wells) experience natural declines in production over time. Because the United States was a pioneer of oil and gas activity at the beginning of the twentieth century, it is not surprising that our conventional crude production, and share of world production, has attenuated over time.

Figure 2.5 also highlights the fact that this new shale revolution has been concentrated primarily in the United States. While other shale formations are now being discovered in other parts of the world, to date, essentially all of the commercial shale production has come from within the U.S. For this reason, not only has U.S. crude production increased in absolute terms, but it has also increased as a percent of total world production.

Now that we have established a background of recent trends in world crude markets, next we will incorporate this new information into the theoretical model.

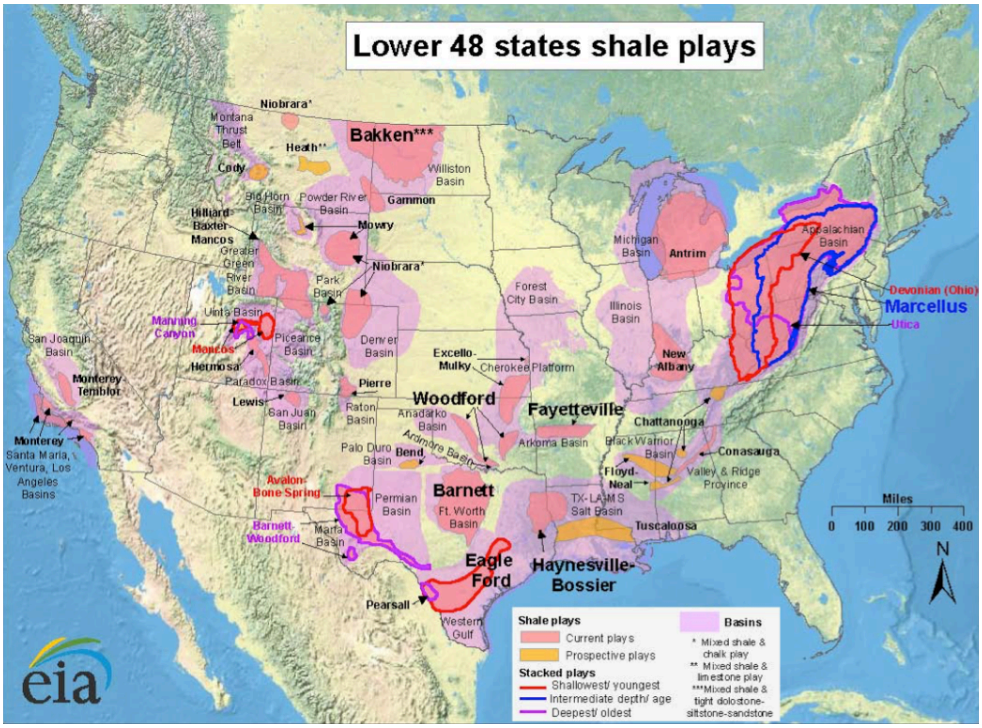


Figure 2.4: **Map of U.S. Shale Oil and Gas Plays**

Source: Energy Information Administration, U.S. Department of Energy.

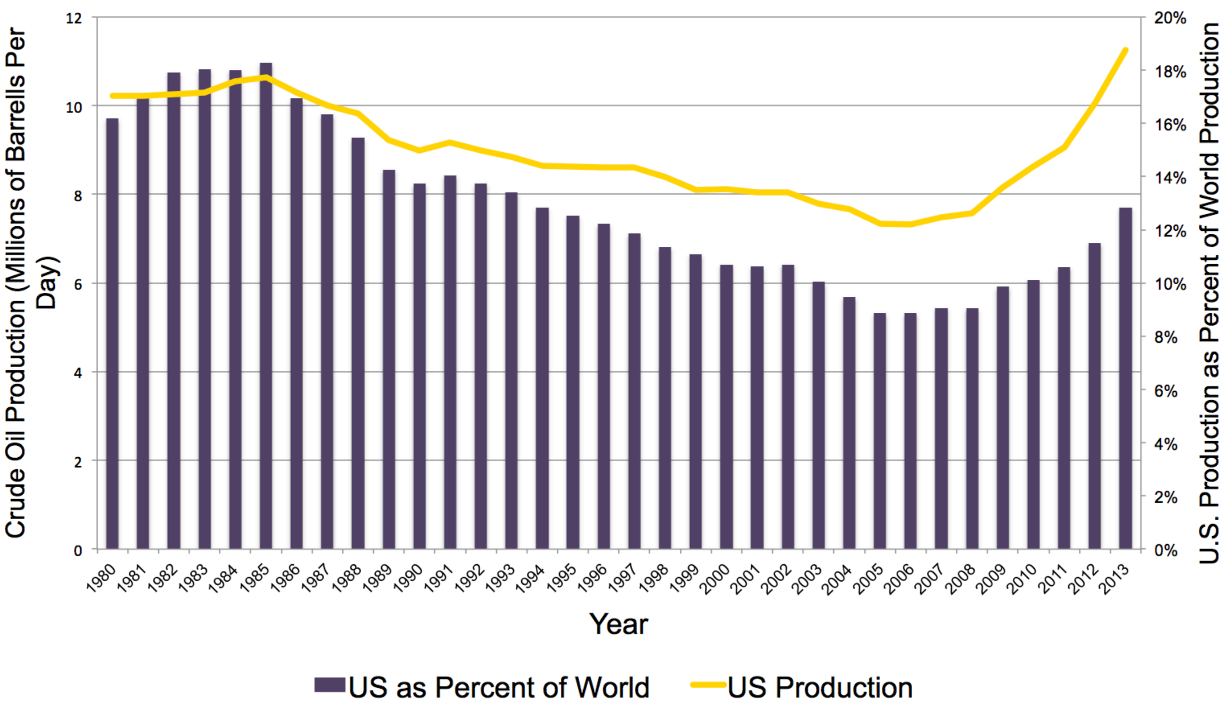


Figure 2.5: U.S. Crude Production

Source: Energy Information Administration, U.S. Department of Energy.

2.4 Predictions with Shale Oil Shock

Now that we have established a basic economic model to describe the domestic market for crude oil and discussed the recent trends in U.S. crude production, this next section will incorporate these changes in crude markets over the past decade into the economic model and discuss potential ramifications. This will be the starting point for a discussion of the potential economic costs and benefits of lifting the ban of crude exports to the state of Louisiana.

As illustrated in Figure 2.6, we start with the market for light sweet crude in long run equilibrium, where the world price of oil is equal to the equilibrium price in the domestic market, or $P_w = P^*_{D,1}$. But with the advent of shale in the United States, there is rightward shift in the domestic supply curve for light sweet crude. The model predicts that this supply shock will cause the domestic price to decrease from $P_{D,1}$ to $P_{D,2}$ relative to the world price.[10]

This price differential will create arbitrage opportunities for refiners, as they will now be able to purchase crude at a lower price than foreign competitors but still sell their refined products on the world market. But this advantage will only be temporary, as this increased price differential will incentivize refineries to increase the share of light sweet crude into their refining process. These changes will cause an increase in refining capacity of light sweet crude that will drive up the domestic price until once again the world price and domestic price are equal; $P_w = P^*_D$.

[10] It should be noted, that this supply shift occurs only domestically here in the U.S as noted in the previous section. Had another supply shift impacted foreign supply as well, this would need to also be incorporated into the model and the implications would potentially be different.

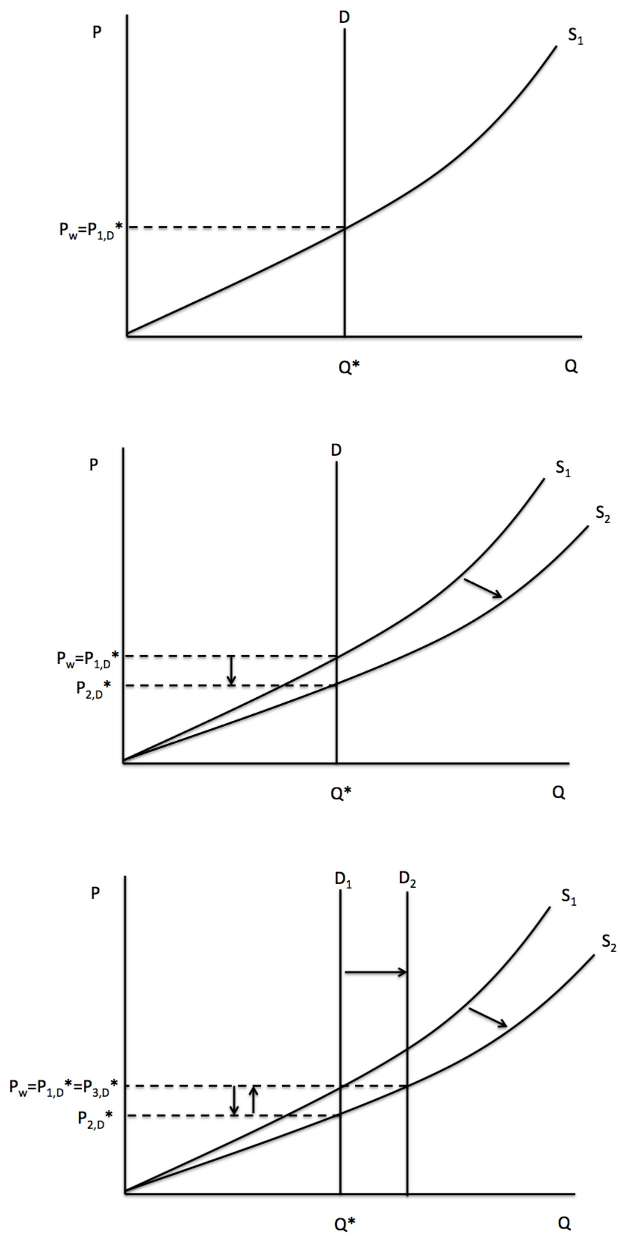
Specifically, the model makes the following predictions given the recent advent of shale oil production in the U.S.

Prediction 1: The advent of shale oil production creates an increase in domestic supply, which drives down the domestic price relative to the world price.

Prediction 2: In the short run, this will create increased crack spreads for refiners that process light sweet crudes, and therefore refineries will substitute away from other medium grade or heavy grade crudes towards light crude.[11]

Prediction 3: In the long run, the market will move back into equilibrium where the global price is equal to the domestic price.

[11] "Crack spreads" are the differential between the refineries' inputs and outputs. Higher crack spreads, in general, indicate higher refinery profits.



(a) Before the shock, the market for light sweet crude in Louisiana is in equilibrium with the domestic price $P_{1,D}$ equal to the world price P_w.

(b) New shale shifts supply outward. This creates a price differential between the world price and domestic price such that domestic crude is traded at a discount to the world price. $P_w > P_{2,D}$

(c) Refineries adjust operations to better utilize this new influx of domestic crude. This increases demand until the domestic price once again reaches the global price. $P_w = P_{3,D}$

Figure 2.6: Theoretical Predictions of Shale Oil Shock on Supply and Demand of Light Sweet Crude

Source: Author's Theoretical Model

2.5 *Matching Theory with Data*

Economic theories are just that, theories, and provide little relevance if they cannot be corroborated with real world observations. Thus, in order to see if predictions based on the economic theory are reasonable, we must first see if the theory has sufficiently described past occurrences. In this section, we discuss recent trends and apply these to the predictions discussed in Sections 2.2 and 2.4.

First, our theory predicts that, in the long run, the world price and domestic price of crude move in tandem with one another and are approximately equal to one another. In practice, any differences in prices should be attributed to quality differences and transportation costs. In order to see if this theory holds, Figure 2.7 shows a comparison of the West Texas Intermediate (WTI) spot price located in Cushing Oklahoma to Brent crude oil that is traded on the Intercontinental Exchange (ICE) for delivery in Scotland. For purposes of this comparison, we will consider the WTI spot price as the “domestic price” and the Brent spot price as the “world price.” As can be seen, historically, WTI and Brent prices have tracked one another very closely. WTI has traded at a slight premium due to quality differences, but this premium has been relatively stable over time.

Next, the model predicts that the advent of shale oil will lead to a decrease in the domestic WTI spot price relative to Brent. As shown in Figure 2.8, starting in 2009, around the time when shale oil began to flood the market, a structural shift occurred with the price of WTI relative to Brent. Historically, WTI has traded at a premium to Brent, but this systematically changed as shale came on line, and for the first time in history, Brent began to trade at a premium to WTI for a sustained period of time. This is precisely what is predicted by the theoretical model.

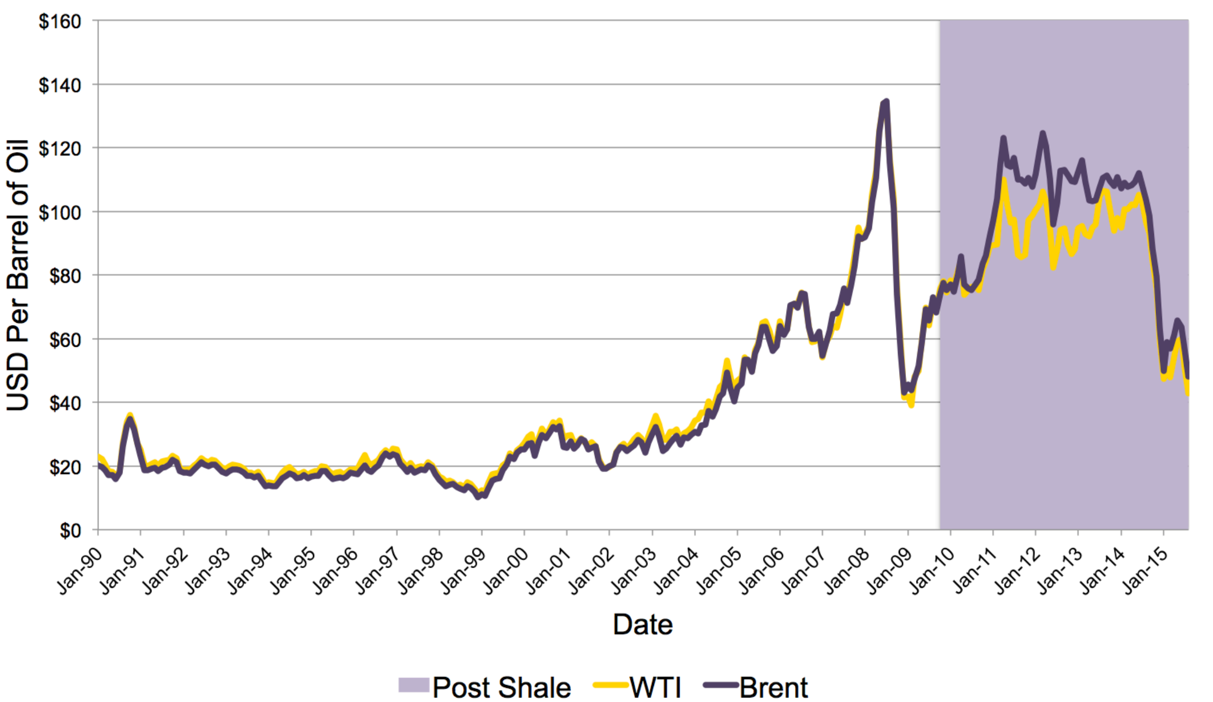


Figure 2.7: Comparison of WTI and Brent Spot Prices
Source: Bloomberg and Author's Calculations

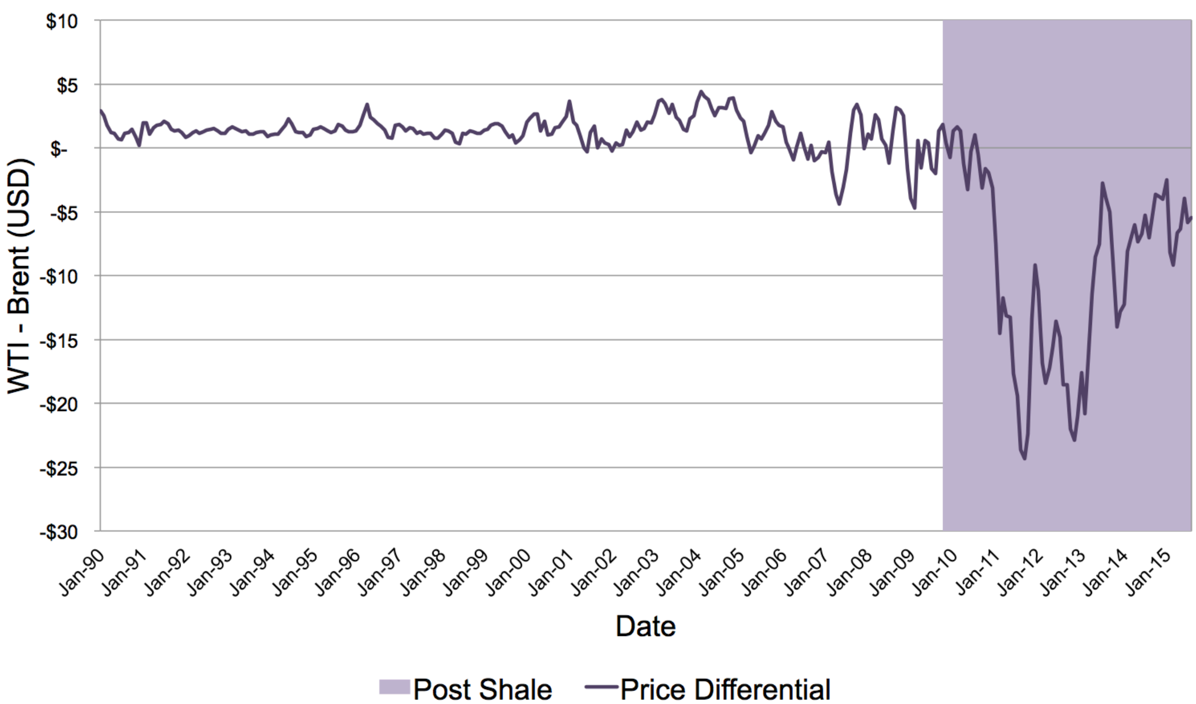


Figure 2.8: Price Differential between WTI and Brent
Source: Bloomberg and Author's Calculations

As discussed previously, over the past several decades, as U.S. crude production declined both in absolute terms and relative to total global production, refineries reacted by importing heavier crudes from around the world. In order to be able to process these heavier crudes, gradual modifications were made to refineries. This process reversed itself when light crude began to flood the U.S. market (See Figure 2.3). The API gravity of crude feedstock to refineries had been declining since the 1980s (i.e. crudes were getting heavier) until shale oil flooded the market, and caused a reversal in this trend. The feedstock has been gradually getting lighter (i.e. higher API gravity) since.

This change in the gravity of feedstock is due to the ratio of heavy sour crude being imported to meet refinery demand relative to light sweet domestic crude. Because U.S. crudes are lighter than foreign crudes on average, historically the amount of crude imports and API gravity of feedstock have moved in tandem. As crude imports increased over the past several decades to meet refinery demand, the crude feedstock became heavier and heavier. Thus, the advent of shale crude in the U.S. also caused a reversal of the decades-old trend of increasing crude imports. This is illustrated in Figure 2.9.

Not only did the imports of crude decline in the U.S. after the shale boom, but so too did the composition change. As shown in Figure 2.10, during the 1990s and until the mid-2000s, imports of light crude increased gradually with total increases. But since the shale boom, light crude has seen the largest reduction (in terms of its total share), and today the U.S. is importing almost zero light crude. On the other hand, the relative share of heavy crude being imported has actually increased. This can be explained in that refineries are choosing to purchase discounted domestic light crudes and mix with heavier foreign crudes in order to decrease the aggregate cost of its feedstock.

Refineries' ability to substitute towards a lower cost feedstock has also translated into an increase in the crack spread.

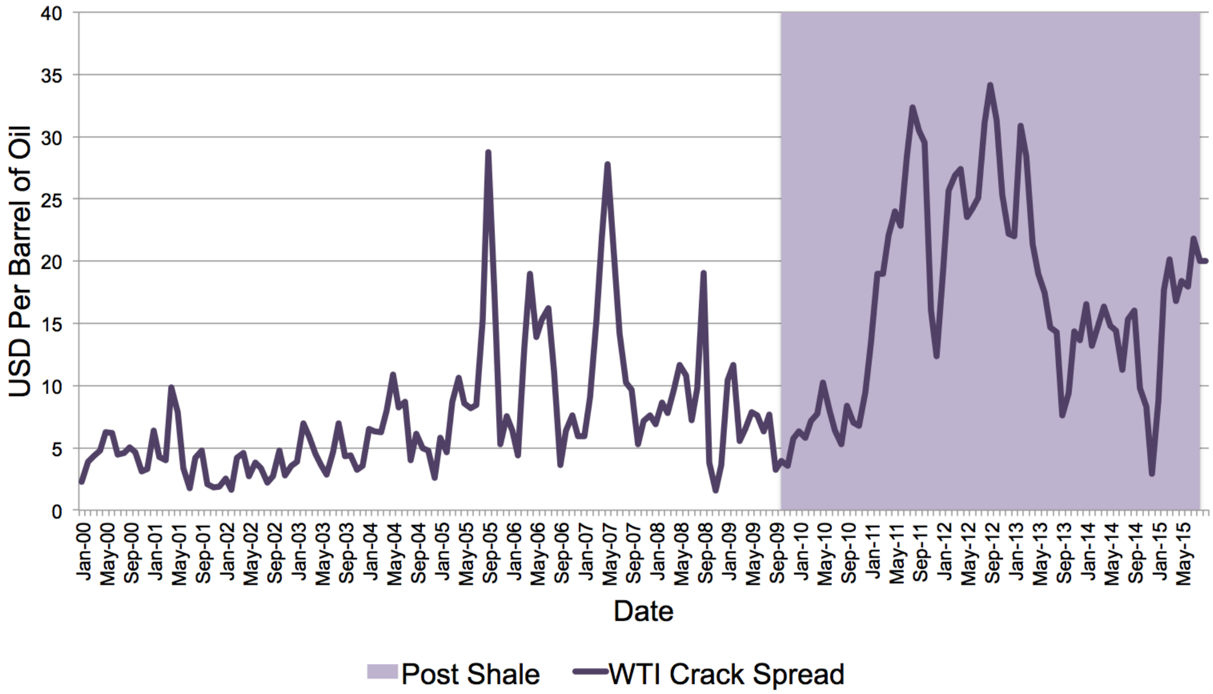


Figure 2.11 shows a crack spread that has primarily oscillated between \$5 and \$10 per barrel in the pre-shale boom period. Around 2005 and 2006 shale gas began to hit the market for the first time, and this did create large spikes in the crack spread, but these spikes were short lived as the price quickly returned to levels similar to the pre-boom period.[12] But around 2009, when shale oil began to hit the market in a big way, these crack spreads were exacerbated; at the peak, spreads were more than \$30 per barrel. These spreads eventually did return to recent historical levels in early 2015, but have since increased likely due to the global depression of oil prices.

Due to the decrease in crude imports, and therefore the move to a "lighter" feedstock for refineries, this has caused technical challenges for refineries in the U.S. As the process of reversing a decades-long trend of moving towards heavier feedstock continues, the theory predicts that the demand for light sweet crude (i.e. refineries' ability to utilize this new glut) will increase and therefore remove the price differential between Brent and WTI. This is indeed what is observed. While a systematic change in the relative price in Brent and WTI was observed after the market was flooded with

[12] Shale gas preceded shale oil.

shale oil, these prices have once again converged, and today, these two crudes are trading within a few dollars of one another.

Therefore, the main predictions of the economic theory are shown to be supported by the data. Next, an overview of the Louisiana economy and the importance of both upstream production and downstream refining and petrochemicals are discussed.

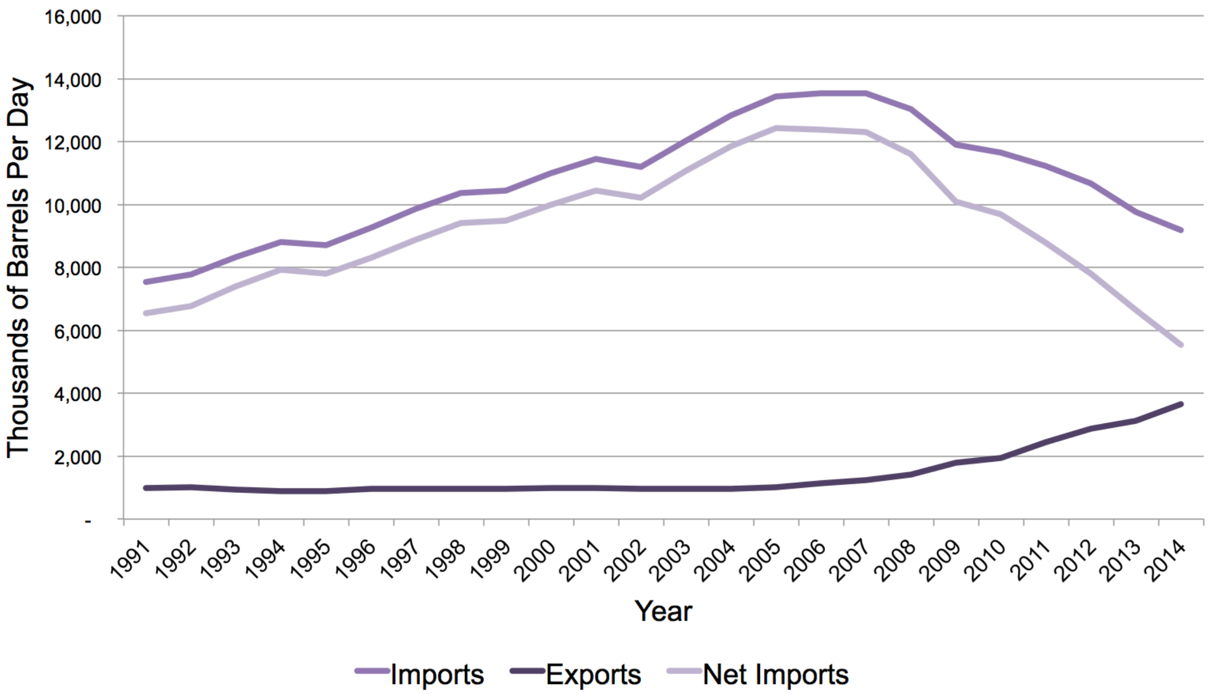


Figure 2.9: U.S. Crude Exports
Source: Energy Information Administration, U.S. Department of Energy.

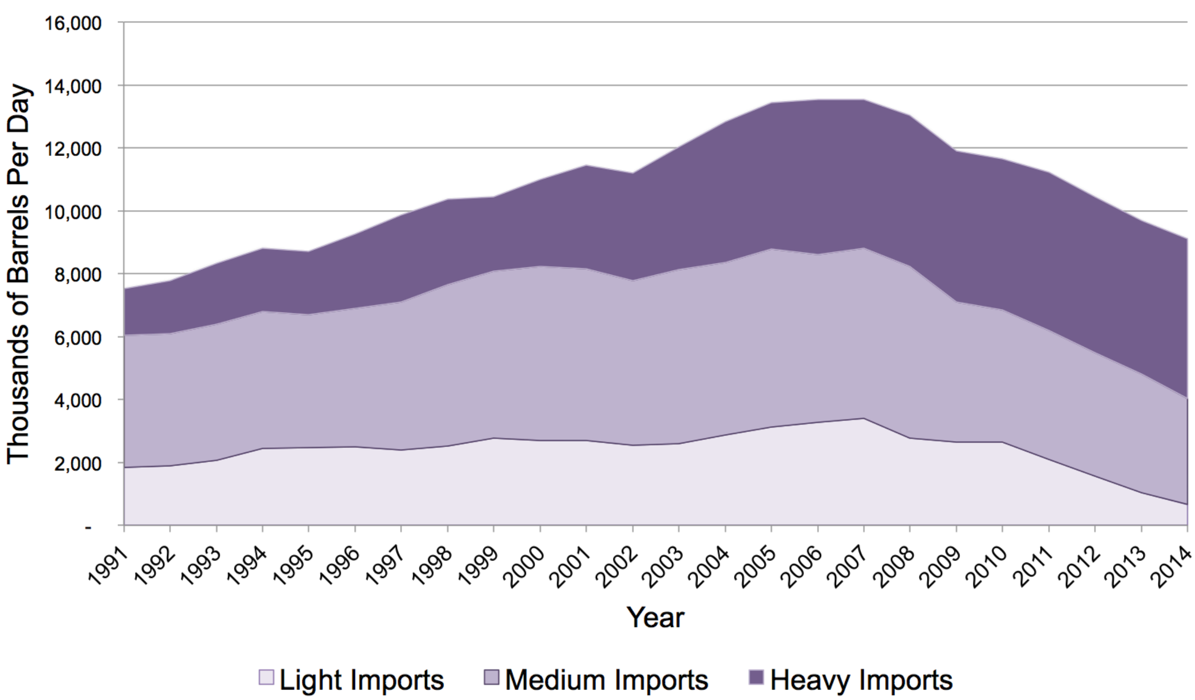


Figure 2.10: U.S. Imports by API Gravity
Source: Energy Information Administration, U.S. Department of Energy and Author's Calculations.
Note: Light, medium, and heavy crudes defined as more than 35 API, Between 25 and 35 API, and less than 25 API, respectively.

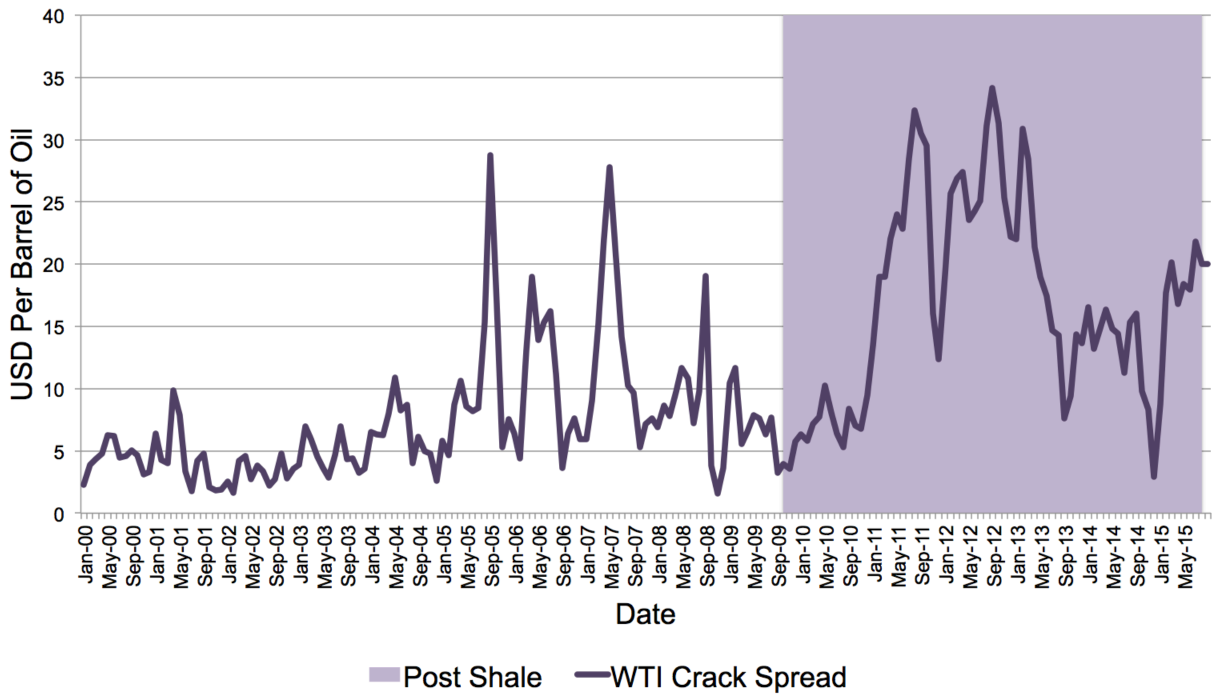


Figure 2.11: Crack Spread

Source: Energy Information Administration, U.S. Department of Energy.

3 The Louisiana Economy

Before discussing the specific implications of lifting the export ban on Louisiana's economy, I first discuss overall Louisiana labor market trends and how the oil and gas sectors have impacted earnings and employment growth.

Figure 3.1 shows the growth of both employment and earnings in Louisiana since 1995. Both wages and employment have grown over the past two decades in Louisiana. Earnings experienced significant growth in the 1990s and then experienced significant volatility throughout the 2000s. Since the recession ending in 2009, real earnings have grown by less than 1 percent per year, which is below the average growth of 1.8 percent per year since 1995. About 1.2 percent of the average annual increases have been associated with the increase in average earnings while the residual is associated with employment growth. Unlike earnings, which have been relatively volatile through the business cycles, employment growth has been relatively steady, growing at about ½ percent per year on average.

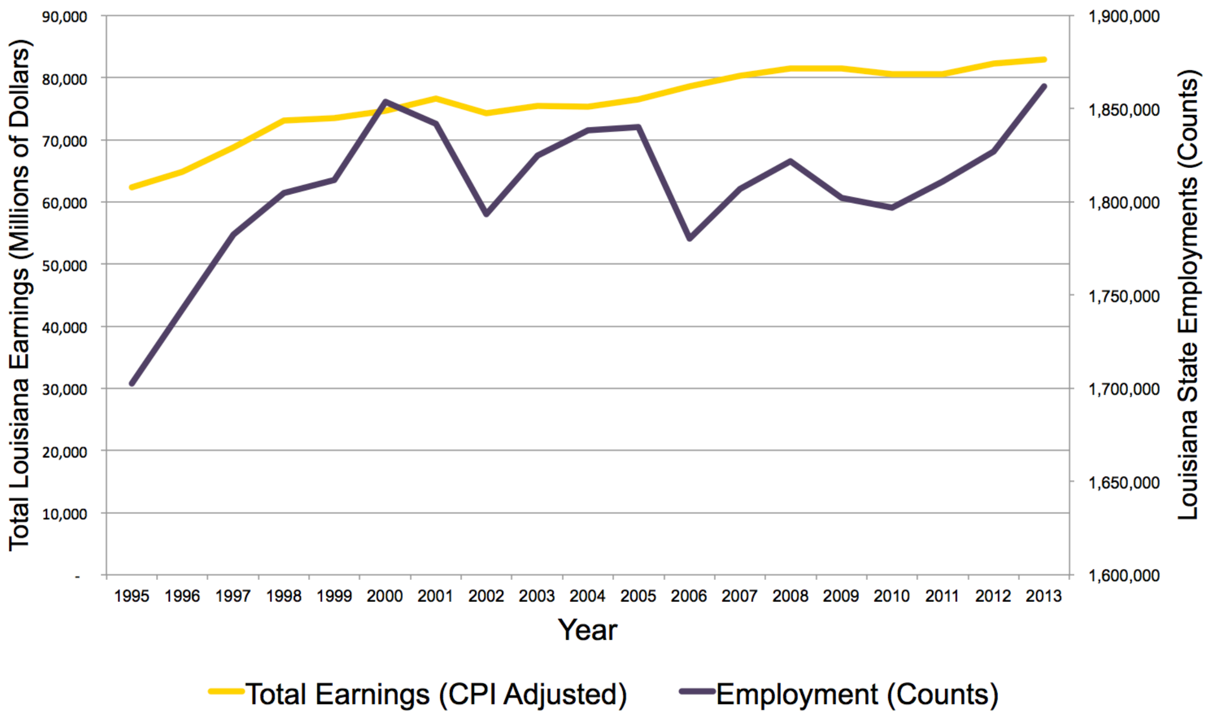


Figure 3.1: Louisiana Total Earnings and Employment
Source: U.S. Census Bureau Quarterly Workforce Indicators and Author's Calculations

3.1 Upstream Oil and Gas

The upstream oil and gas industry has been an important component of Louisiana's economy throughout Louisiana's history. Figures 3.3 and 3.4 show labor market trends in the Louisiana upstream oil and gas sector. First and foremost, this industry has consistently accounted for between 4 and about 5.5 percent of Louisiana's total earnings in recent decades. Second, wages in the upstream oil and gas industries have grown faster on average in real dollars than the state as a whole with an average growth rate of 4 percent in real dollars. About 2.3 percent of this average annual increase is associated with increases in average wages, while the residual is associated with growth in employment.

While the upstream oil and gas industry has experienced on average a higher growth in earnings than the state as a whole, the volatility of these earnings on a yearly basis is much higher than the state on aggregate. In a given year, earnings have oscillated an average of 8.5 percent increase in "boom" years and an average of 9.5

percent decrease in “bust” years. This is much more volatile than state earnings overall, which have oscillated on average from about a 2.4 percent increase to a 1.9 percent decrease in a given year. Not only are earnings volatile, so too is employment. Changes in employment in the upstream oil and gas industry have been on average 7.1 percent in years with earnings increases and an average of 5.8 percent in years with decreases. So, while the upstream oil and gas industry is an important component of Louisiana’s economy that has grown both in absolute terms and relative to Louisiana’s growth over the last two decades, the volatility of this industry has also exacerbated the ups and downs. Thus the data supports the conventional wisdom that this is indeed a “boom and bust” industry.

3.2 Refining and Petrochemical Sectors

The refining and petrochemical sectors have also been an important part of Louisiana’s economy. Louisiana is home to 19 refineries and 66 petrochemical plants—the lion’s share of which are located in southern Louisiana. The refining and petrochemical industries have a symbiotic relationship in that outputs from refineries are feedstocks to petrochemical plants. Figure 3.2 shows the 13 refineries in southern Louisiana and the petrochemical plants that are primarily clustered around these refineries. Figures 3.5 and 3.6 show labor market trends in the Louisiana refining and petrochemical industries.

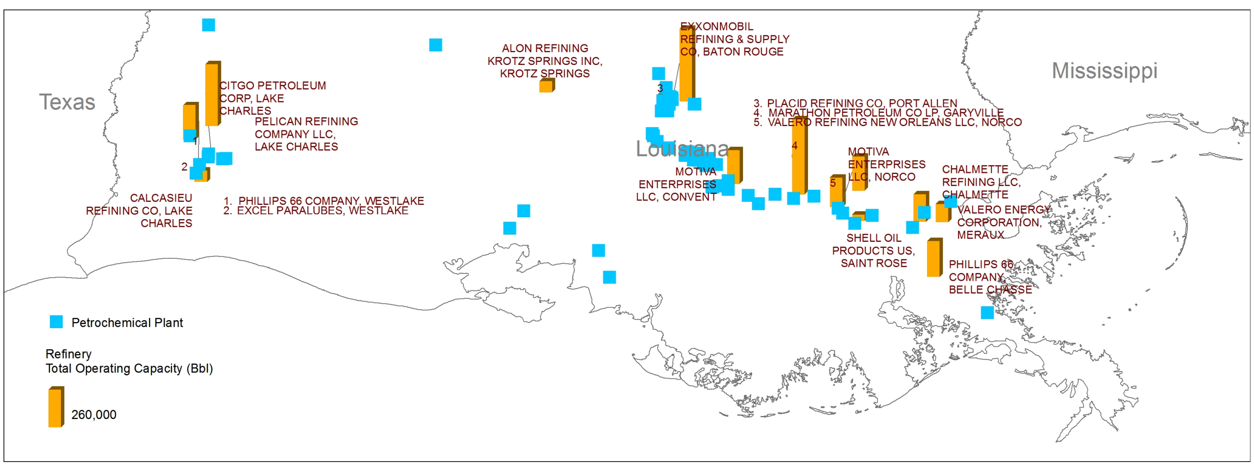


Figure 3.2: Map of Southern Louisiana Refineries and Petrochemical Plants
Source: Author’s Compiled Research

While aggregate earnings (in real dollars) and employment in these industries have been flat since the 1990s, the average earnings have grown by about 1 percent per year on average. Today, these industries make up more than 4 percent of total state-wide earnings and about 2 percent of state-wide employment. Due to the large capital expenditures needed to invest in new refineries and petrochemical plants, it is unsurprising that employment and total earnings have been relatively flat over this time period.

But unlike the upstream oil and gas industry that has been relatively volatile over time, the refining and petrochemical industry has been much more stable with total earnings oscillating on average between 3.4 percent increases and 3.9 percent decreases. Employment has similarly been relatively stable. While any one industry is likely more volatile than the state as a whole, compared to the upstream oil and gas industry that has large ups and downs that are mainly a function of the oil price, the refining and petrochemical industries have provided consistent and high paying jobs for decades.

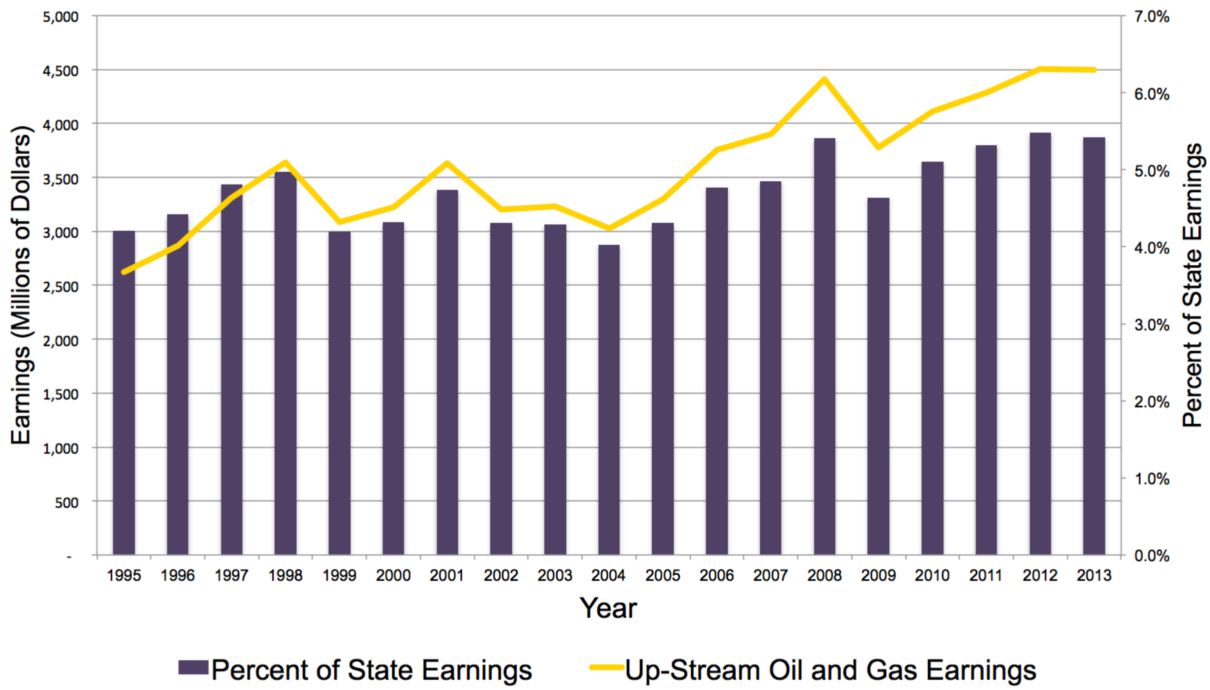


Figure 3.3: Louisiana Upstream Oil and Gas Earnings

Source: U.S. Census Bureau Quarterly Workforce Indicators and Author's Calculations

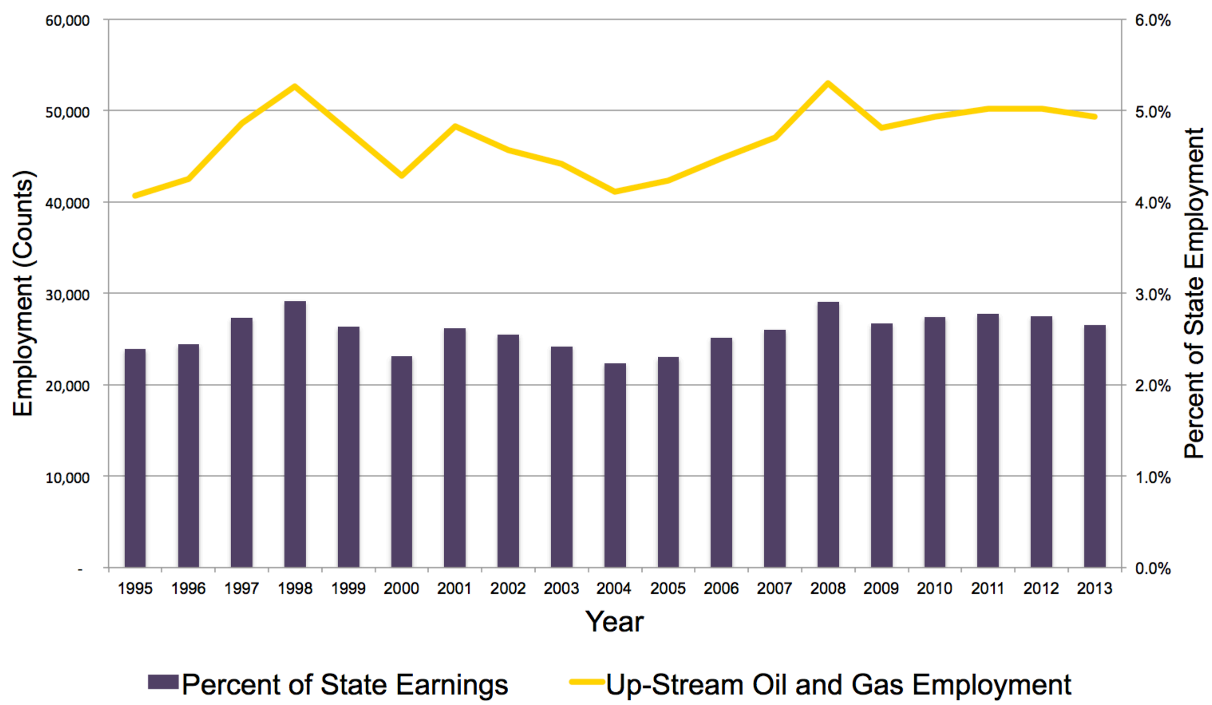


Figure 3.4: Louisiana Upstream Oil and Gas Employment

Source: U.S. Census Bureau Quarterly Workforce Indicators and Author's Calculations

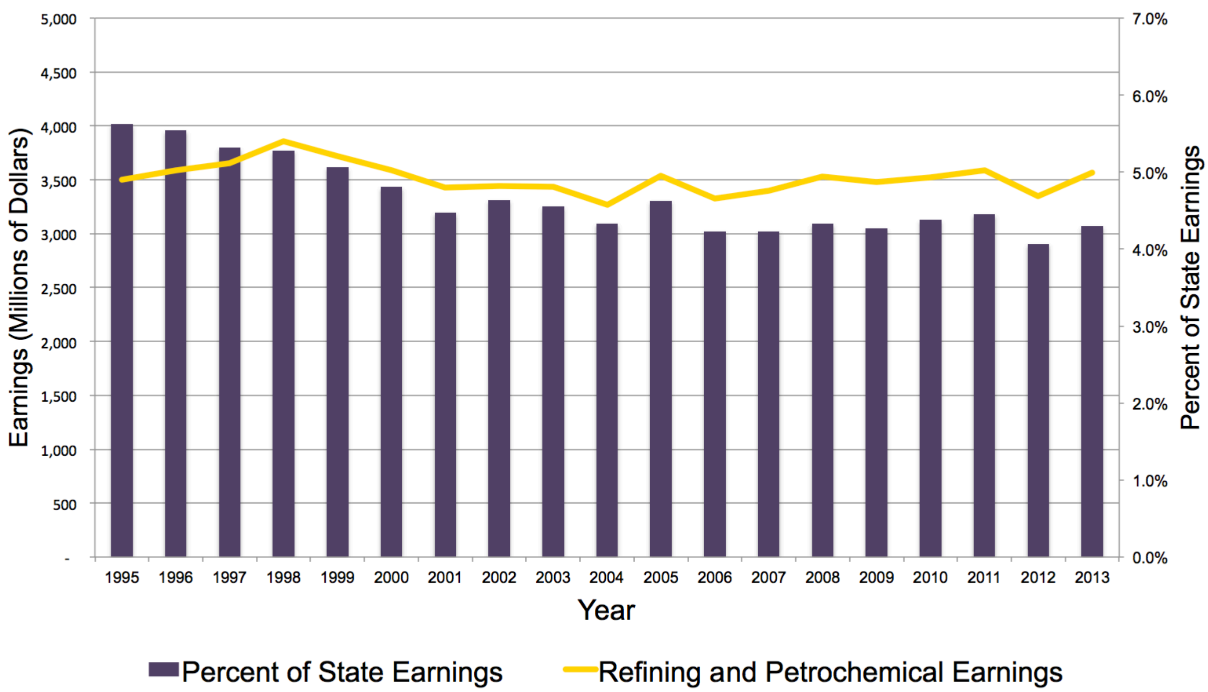


Figure 3.5: Louisiana Refining and Petrochemical Earnings
Source: U.S. Census Bureau Quarterly Workforce Indicators and Author's Calculations

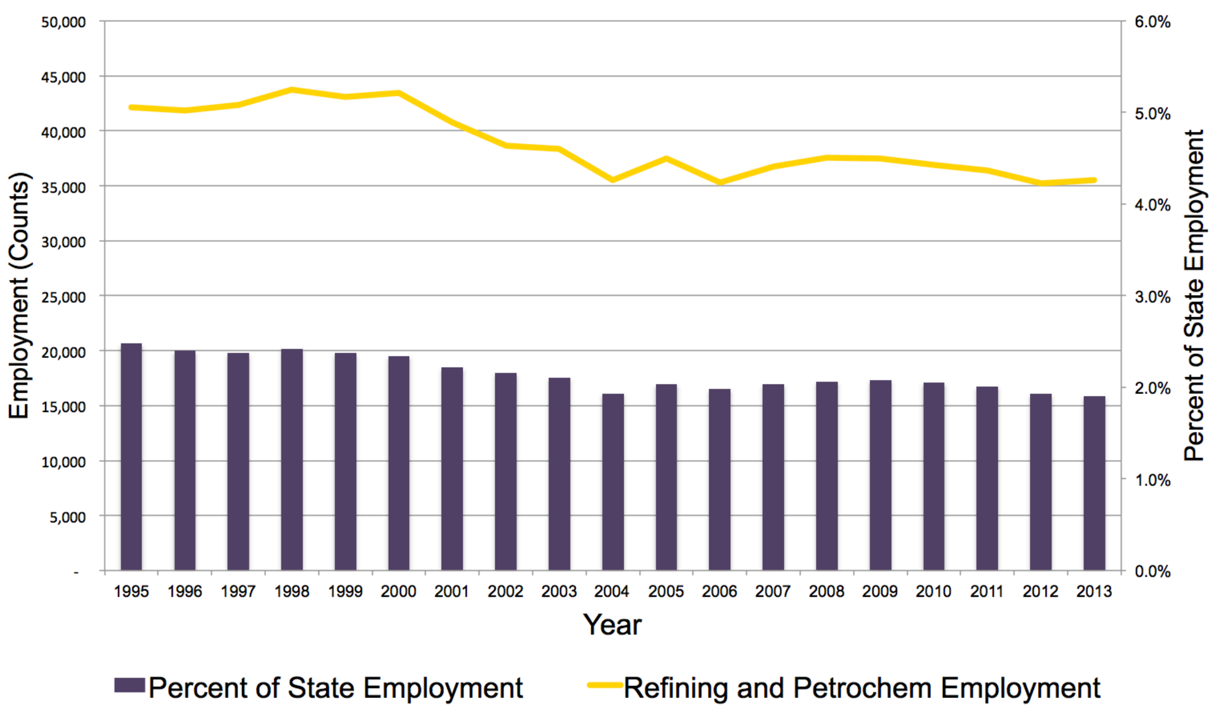


Figure 3.6: Louisiana Refining and Petrochemical Employment
Source: U.S. Census Bureau Quarterly Workforce Indicators and Author's Calculations

4 A World without Export Restrictions

In light of these historical trends alongside the theoretical model, this next section discusses the likely implications that the export ban has had on oil producers, refineries, consumers, and new investment opportunities. Discussion will start with the baseline model, but in addition likely limitations of the model assumptions are also considered as well as likely implications if these assumptions are removed. This will provide a foundation for what a world would likely look like without an export restriction—and who would be the likely winners and losers.

4.1 Oil Producers

The model suggests that domestic producers are unlikely to be impacted in the long run by export restrictions. While it is understandable that domestic producers will advocate for the removal of export restrictions given the recent shale boom, the model predicts that prices will converge once again, thus the export restriction is unlikely to have a meaningful impact on the long-term strategies of these companies. The usefulness of such a conclusion in setting policy can be debated, though; as John Maynard Keynes famously argued, “in the long run we are all dead.” While a structural change in the price differential did indeed occur after the shale boom, this price differential has collapsed, and continues to collapse, consistent with the predictions of the model. Upstream producers might (implicitly) point to the Keynes’ adage and thus might not be soothed by such a conclusion especially after a historic shock.

While the model presented assumes that there are no transportation costs and constraints, Borenstein and Kellogg (2014) and Kaminski (2014) suggest that part of this price differential between Brent and WTI observed has been due to pipeline capacity constraints between the Midwest and the Gulf Coast. Thus, potentially, none of the remaining price differential between Brent and WTI is due to the export ban, but instead due to actual transportation constraints within the U.S. If this is the case, then the lifting of the export ban today might have *no impact* on the price differential going forward.

Yergin et al. (2014) argues that if the ban is not lifted, domestic crude production will be lower by 1.2 million B/D because “domestic oil will sell at an increasing discount.” If the ban is lifted, Yergin estimates that production will increase leading to $750 billion of investment and nearly one million additional annual jobs at the export restriction removal boom’s peak. Such a result is contingent upon a sustained price differential of $15-25 in 2016 and 2017 more than $8 per barrel on average from 2016 to 2030. However, such a result is not supported by either this model or by the most recent data that shows that the price differential has collapsed. Ebinger and Greenely (2014) and Vidas et al. (2014) similarly attribute economic benefits to the removal of the export ban, and these benefits too are contingent upon a sustained price differential if the ban is not lifted. Simply put, the economic benefits found in both of these studies are contingent upon the assumption that the removal of the export ban will increase the domestic price of crude leading to increases in production.

If the theories by Yergin et al. (2014), Ebinger and Greenly (2014) and Vidas et al. (2014) are correct, then any remaining price differential between foreign and domestic production will be removed if the export ban is lifted. In other words, this would mean that none of the price differential between Brent and WTI that is left is due to the transportation constraints highlighted by Kellogg (2014) and Kaminski (2014). To assess the validity of this theory, Figure 4.1 considers the price differential between West Texas Intermediate (WTI) Spot Price and Louisiana Light Sweet (LLS) wellhead price. If the relationship between LLS and WTI price have not systematically changed since the advent of shale, then this will infer that the price differential between Brent and WTI is indeed due an export restriction, not some shipping constraint within the United States. On the other hand, if LLS price increases relative to WTI after the shale boom, this will indicate that the difference in prices are likely due to transportation constraints between the mid-continent crudes and Gulf Coast crudes, not due to export restrictions.

As seen in Figure 4.2, before the shale boom, LLS and WTI tracked each other closely as theory would predict. Around 2006 though, at the very beginning of shale production, a price differential began to emerge with LLS trading at a premium of a few dollars per barrel. In 2009, when shale oil began to hit the market in a big way, this price differential soared. At its peak, LLS sold for more than $25 dollars per barrel higher than the WTI trading price. Could the export ban be the culprit for the price differential between these mid-continent and Gulf Coast crudes? Unlikely.

As a corollary, Figure 4.3 and Figure 4.4 show the prices of Brent and LLS. Similarly, Brent and LLS track each other closely before the shale boom. Interestingly, though, while the shale boom does induce a devaluation of LLS relative to Brent, the magnitude of this devaluation is not nearly as dramatic compared to WTI. While the volatility of the price differential has certainly increased, at the time of this writing, the LLS wellhead price is currently about $2 less than the Brent spot price—certainly not a large enough price differential to create an arbitrage opportunity for Louisiana oil producers to sell their crude overseas in the absence of the export ban, as the transportation costs would certainly be larger than this price differential.[13]

So what would a world likely look like without an export ban? Given the recent shale boom, with or without an export ban, this game changing technology would have likely created transitory shocks to domestic oil prices, and also to price differentials between domestic and foreign crudes. Plausibly, the export ban created additional frictions that likely exacerbated these price differentials. But today, the market has had time to adjust, to at least some degree, and this can be seen in that the WTI spot price has already rebounded considerably relative to Brent and LLS wellhead prices. The sustained price differential has induced investment in pipelines, and it is likely that these adjustments are still being made. But lifting the export ban today is unlikely to have a significant impact on domestic oil producers. This can be seen in that Louisiana producers are currently receiving wellhead prices that are about $2 less than the Brent trading price. There is no evidence to suggest that the export ban is the culprit for this price differential.

This analysis suggests that the export ban in aggregate has very little impact on producers today. Although this is not to downplay two important concerns that upstream

[13] EIA (2015b) assumes that a $6-to-$8/barrel price differential is needed to create an arbitrage opportunity for domestic producers to ship crude overseas. While Gulf Coast crudes might be on the lower end of this due to their close proximity to the Gulf of Mexico, this price differential of about $2 is still not large enough to create an arbitrage opportunity.

producers are likely facing. First, simply because the export ban is likely not having a large impact on the upstream oil and gas industry on aggregate, does not mean that individual producers do not (or during the shale boom did not) have opportunities to produce in specific areas and/or sell their production for a better price to a foreign buyer. The model and analysis presented here focuses on aggregate impacts on the industry as a whole. This should not be interpreted to downplay specific frictions that specific producers are facing that could plausibly be relieved by lifting the ban.

Second, while this analysis suggests that lifting the ban today will not have a large impact on price differentials going forward, the share of the price differential induced by the export ban compared to actual constraints from transportation and shipping can certainly be debated. A look at the data suggests that much of the price differential observed between Brent and mid-continent crudes can be explained by frictions between the mid-continent and Gulf Coast, as LLS wellhead prices did not experience nearly the price differential from Brent over this time period. But, this is not to say that no share of the price differential can be attributed to the export ban. Simply put, while the data does suggest that the prior studies' estimates of the impact of the export ban are overstated, economic theory does predict that the upstream producers will be on the losing end of the transitory price shock.

Results of this research suggest that Louisiana producers in particular did not experience a significant decrease in production due to the ban during the shale boom. Simply put, the price differential between Brent and LLS stayed consistently below $5 per barrel (with the exception of one month where a short-live price differential of about $10 was observed). It is simply implausible that this price differential created a significant arbitrage opportunity for Louisiana producers. EIA (2015b) discusses the potential arbitrage opportunities for domestic producers, and assumes that a $6 to $8 per barrel price differential is needed for this to occur. While LLS crude that is already close to the Gulf Coast might be on the lower end of this range, it is implausible that a significant arbitrage opportunity arose even during this historic shale boom for Louisiana producers. With a glut of mid-continent crudes available during the shale boom, demand stayed strong for LLS crude here domestically.

In fact, during the shale boom, Louisiana producers actually experienced a higher wellhead price than other producers across the country because of the very fact that the production was geographically close to the refining industry on the Gulf Coast. Even today when producers are facing a low price environment, Louisiana crude still has the comparative advantage as it is selling for a few dollars per barrel higher than its mid-continent counterparts.

It is hard to argue that the export restriction had a significant negative impact on Louisiana upstream producers during the historic shale boom, and it is even more difficult to argue that the lifting of the export ban today would create benefits for these producers moving forward.

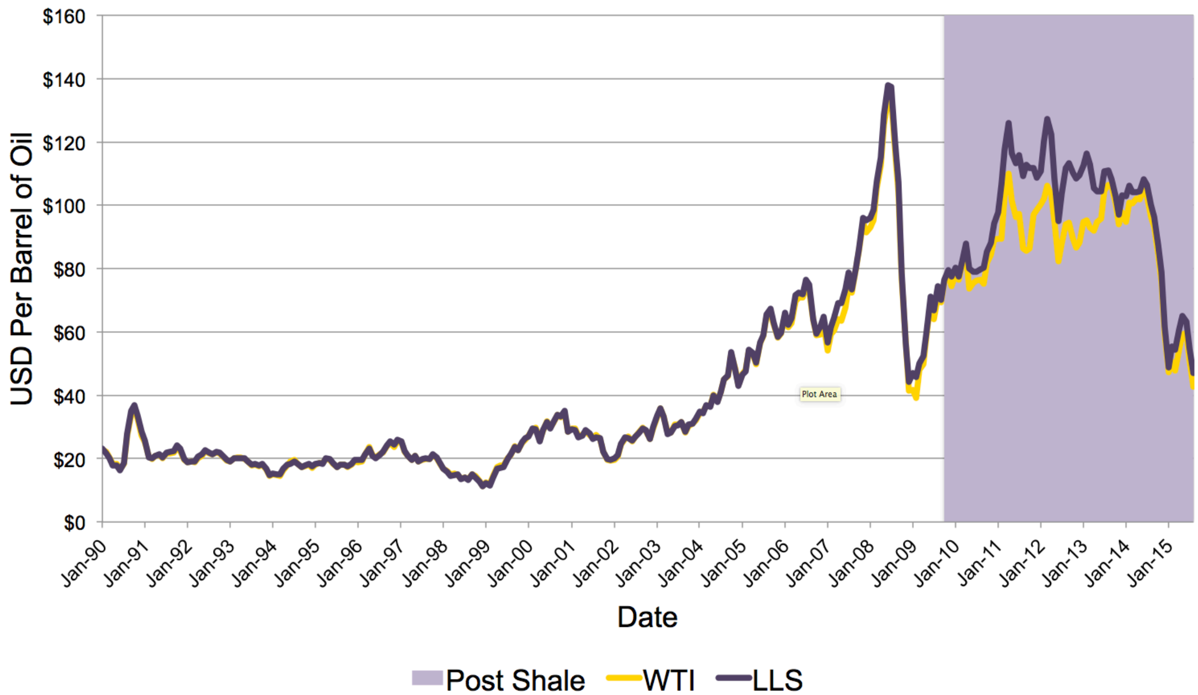


Figure 4.1: Comparison of WTI and LLS Spot Prices
Source: Bloomberg

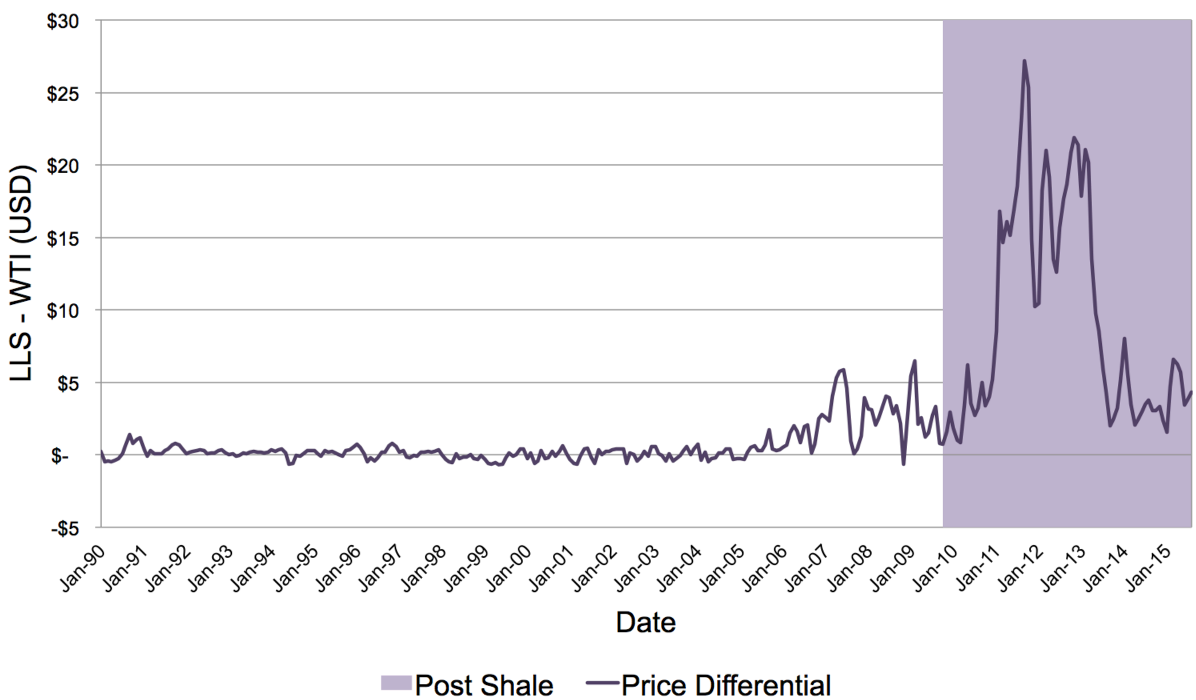


Figure 4.2: Price Differential between LLS and WTI
Source: Bloomberg and Author's Calculations

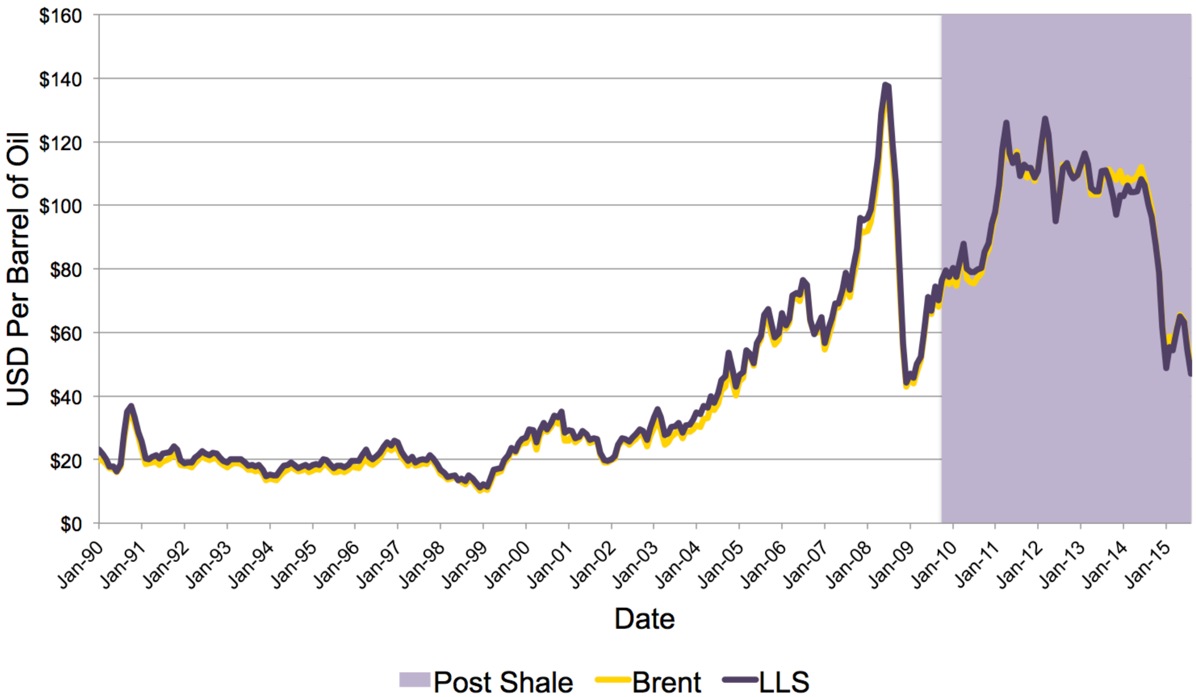


Figure 4.3: Comparison of Brent and LLS Spot Prices
Source: Bloomberg

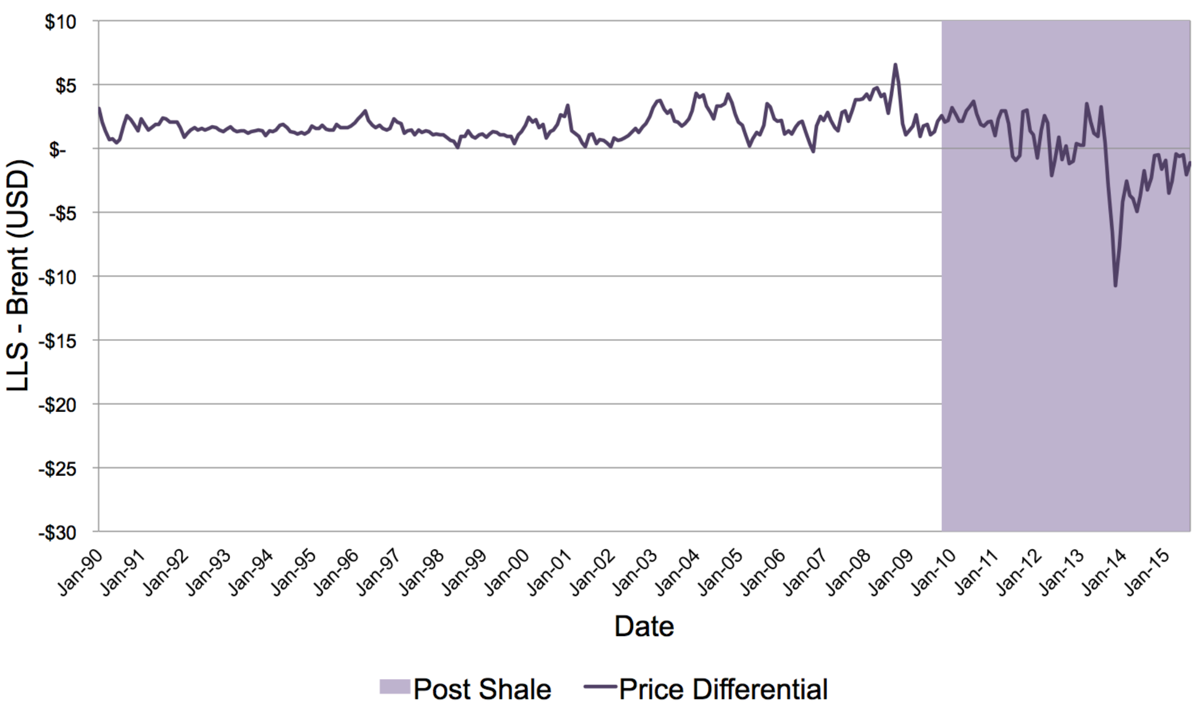


Figure 4.4: Price Differential between Brent and LLS
Source: Bloomberg and Author's Calculations

4.2 *Refineries*

The prior discussion of the impact of the export ban on the upstream oil and gas industry provides insight needed for assessing the plausible impact on the refining sector. As shown in the economic model presented, the refining sector is the beneficiary of transitory shocks when an export ban is in place and there are zero transportation constraints and/or costs. This is due to the fact that the crude oil producers do not have the option of selling to a foreign buyer, and therefore domestic refineries are able to purchase the crude at a discounted price even if there is a foreign buyer willing to pay more.

Thus, theoretically, it is unambiguous that refineries are the beneficiaries of the export ban at the expense of the upstream producers. But in practice, the impact of the ban on refining is more ambiguous. To see this, consider the discussion of the price differentials between WTI, Brent and LLS in the prior section. While the theoretical model implies that a price differential will ensue due to the export ban after a domestic supply shock, in practice the price differential observed can be dissected into (at least) two components. Some share of the price differential can be associated with the export ban, the other with transportation constraints.

In the event that there is a large domestic supply shock, in practice there will be a decrease in the domestic price of crude regardless of whether an export ban is in place. Thus, two other important points should also be considered. First, this price differential must exceed the cost of shipping the crude to a foreign buyer *before* it creates an opportunity for producers to sell to foreign producers. Second, a price differential created due to shipping constraints within the U.S. will not be relieved by the removal of the ban. According to EIA (2015b), a price differential between $6 to $8/barrel between Brent and WTI is needed to make moving crude from Cushing to overseas markets competitive. Indeed, a price differential greater than this did ensue in the peak of the shale boom, but as shown previously, this differential is largely associated with internal constraints within the U.S.

The implication for refiners is that they would have benefited from a reduced-price domestic light sweet crude during the shale boom regardless of whether the export ban was in place. While some share of the increase in crack spread observed might have been associated with the export ban, some share of this crack spread would have also occurred regardless of whether the ban was in place because of the simple fact that transporting crude from Europe is costly and that transportation constraints did occur domestically.

Figure 4.5 illustrates the corollary to Figure 4.3 and Figure 4.4 from the refineries' perspective by showing the crack spread over time for both WTI and LLS. After the shale boom, the crack spread for LLS did indeed increase, but not nearly to the extent as WTI. Just as the price differentials between WTI and LLS peaked during the boom but have since converged once again, so too have the crack spreads for these different crudes.

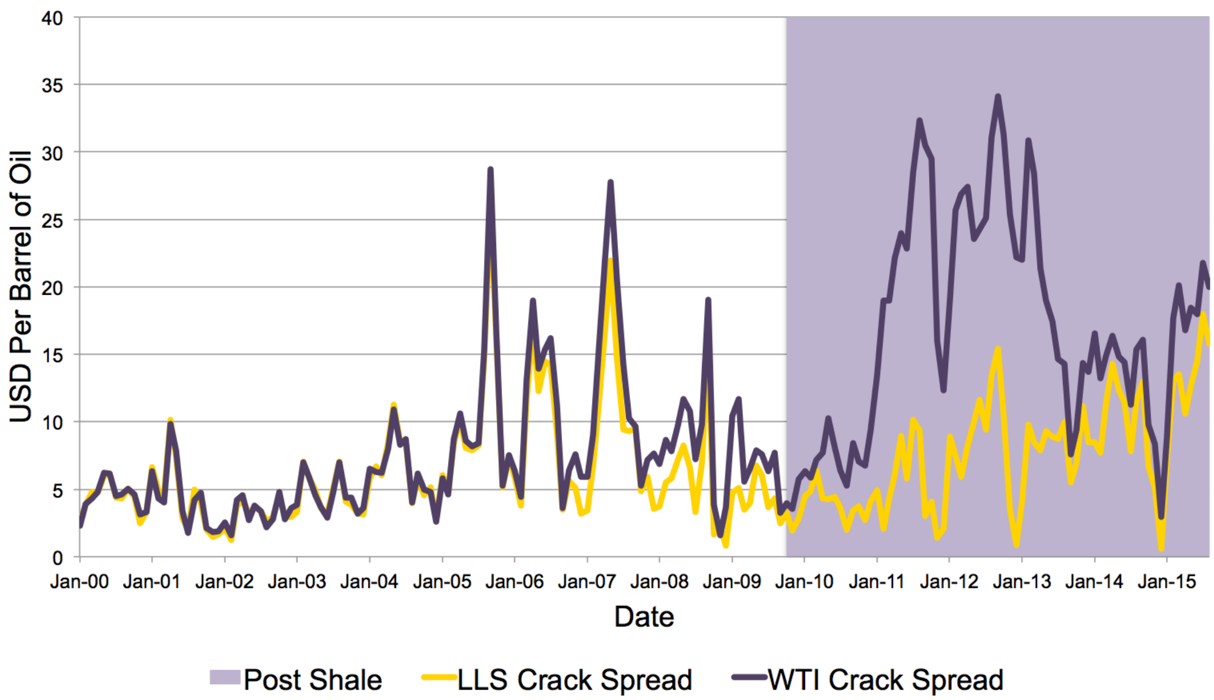


Figure 4.5: Crack Spreads of WTI and LLS
Source: Bloomberg

The implications for Louisiana refineries are twofold. First, refineries benefitted from the shale boom as they were able to purchase discounted domestic crude while continuing to sell products at world prices. Second, refineries are still benefiting from the glut of light sweet crude, but today it is likely due to the decrease in the price of both domestic and foreign crude prices. So what impact will the export ban have on crack spreads going forward? It is hard to identify any significant cost this would create for domestic refineries. WTI is currently trading at a spread to Brent that is less than plausible shipping costs, and some of this price differential is still likely due to shipping constraints. Thus, I see no evidence that the removal of the export ban would have a significant impact on the crack spread for Louisiana refineries.

There are two things, though, that should be noted with respect to the export ban on the refining industry both here in the U.S. and for Louisiana in particular. First, the fact that the export ban exists provides refineries with assurance that they will be able to purchase domestic crude, and therefore mitigates some of the risk associated with making large capital investments to update refineries to handle the glut of domestic crude. Second, if domestic crude production continues to increase beyond the point at which refining capacity exists in the U.S. to handle the production, this would spur investment in domestic refineries that might otherwise go elsewhere, such as Canada, Mexico, or the Caribbean, that also might be in a strategic position geographically to refine North American crude.

But in considering the plausibility of refining moving outside of the Gulf Coast due to the removal of the ban, several comparative advantages of Gulf Coast refineries should be considered. First, Gulf Coast refineries have the comparative advantage for processing Gulf Coast crude for the simple reason that they are in close proximity to where the crude is produced. Second, Gulf Coast refineries are able to use natural gas for process heat in the refining process, while other refineries elsewhere that do not have access to abundant natural gas are forced to use a share of the feedstock (crude) to create the heat needed for processing. Gulf Coast refineries are not only close to the feedstock but are also close to the natural gas that is needed as part of their operations. Third, the Gulf Coast has access to relatively cheap electricity, also primarily due to its abundance of natural gas; refineries are large users of electricity, and therefore this too is a comparative advantage. Finally, Gulf Coast refineries have access to some of the largest ports in the U.S., including the U.S.'s largest port, the Port of South Louisiana, located in on the Mississippi River between Baton Rouge and New Orleans. This is a comparative advantage because these refineries both import a share of their feedstock and also ship refined products around the world.

But Gulf Coast refining might also face challenges if production increases to the point where new refining capacity is needed. In particular, crude production in Louisiana has been declining since the 1980s. While production on the Outer Continental Shelf (OCS) has increased, thus offsetting the large decrease in production on state lands, with the advent of shale it is uncertain if expensive drilling in the deep OCS will continue at the same rate. Thus, while the Gulf Coast has historically been a large producing area, whether this will continue into the future is uncertain. On the other hand, if OCS production does continue to increase, shipping this crude overseas is relatively easy considering the production is already in the Gulf and can easily (and inexpensively) be shipped to Mexico or the Caribbean, for instance. Possibly, the crude would never even need to come onto U.S. soil. This could also create challenges for domestic refineries.

In conclusion, the refining industry in the U.S. and Louisiana has done very well since the shale boom. While some share of this success might have been due to the export ban, an honest look at the data suggests that domestic refineries would have been the benefactors of the shale boom regardless of whether the export ban was in place or not. Looking forward, the price differential between Brent and WTI is likely not large enough to justify moving domestic crude overseas, and thus this analysis suggests that the removal of the ban today is unlikely to have a significant impact on the industry's profitability in the short run, especially if the U.S. continues to experience a glut in light sweet crude.

But, it cannot be denied that the export ban is a long run protectionist policy for the U.S. refining industry. If crude production continues to grow in the U.S., the export ban could lead to increased investment in refining here—and thus increased investment in petrochemical manufacturing—that could go elsewhere in the world if the protectionist export ban is to be removed. While lifting the export ban is unlikely to have a significant impact on the U.S. and Louisiana refining industry in the short run, the policy still does serve as a long run protection for this industry. Thus it is no surprise that the industry has traditionally opposed the lifting of the ban.

4.3 Consumers

Consistent with a number of studies (Medlock, 2015; Yergin et al., 2014; Ebinger and Greenley, 2014; Borenstein and Kellogg, 2014), the basic economic model presented in this research predicts that domestic gasoline prices will not increase if the export ban is lifted. It should be noted that two of these studies actually estimate a *decrease* in gasoline prices due to the lifting of the ban, although these magnitudes are relatively small (7-12 cents/gallon). The results of this research are most consistent with Borenstein and Kellogg (2014) who find that price differentials in crude do not translate into gasoline price differentials for final consumers. Regardless of whether the export restrictions will have *no impact* or a *small negative impact* on gasoline prices, the literature and this paper suggest that increasing gasoline prices should not be a concern for policy makers when considering lifting the ban.

While the consensus among economists is that the export ban has little (if any) impact on domestic gasoline prices, the political realities might continue to make this a concern of policy makers. Currently, the U.S. is experiencing historic lows in gasoline prices. If these prices simply move toward an average historic price over the upcoming years, consumers (and voters) might perceive the lifting of the ban that coincidentally occurred at a time of low gasoline prices to have spurred this increase. This is a political risk that should not be comingled with an actual economic risk.

4.4 New Investment Opportunities

While not specifically included in the economic model, a discussion of the economic implications of the removal of the export ban cannot be complete without a discussion of potential new business opportunities created by lifting the ban. While this decades old discussion rightly focuses on the upstream oil and gas industries compared to the downstream refineries, the recent shale boom has created opportunities for exporting both crude and natural gas to international markets. The Gulf Coast is a unique position to become a world trading hub for crude oil, and hydrocarbons in general.

4.4.1 LOOP Export Terminal

Currently, the Brent spot price is the global standard for the global price of crude. This is because the price of petroleum products globally track Brent. Even gasoline prices here in the U.S. track the Brent spot price—not the WTI spot price. But the removal of the export ban has the potential to change the global dynamic of crude markets, and Louisiana is in a unique position to be at the epicenter of this global market.

The Louisiana Offshore Oil Port (LOOP) began operations in 1981, during a time of declining U.S. oil production. LOOP receives and temporarily stores crude oil from all over the world (LOOP 2015). LOOP serves as a means of efficiently importing crude on large vessels that cannot enter relatively shallow waters to provide the feedstock needed for American refineries. LOOP is the only port in the U.S. capable of offloading crude from “Ultra Large Crude Carriers” (ULCCs) and “Very Large Crude Carriers (VLCCs)” due to its distance offshore and water depth (LOOP 2015). Simply put, LOOP has played an integral role in the petroleum industry in the U.S.

The recent shale boom and glut of light sweet crude has created both a challenge and an opportunity for LOOP. Because crude imports have been declining, this has the potential to impact both LOOP’s utilization and relevance. But the new supply of domestic crude also has the potential to create an opportunity for LOOP to expand its operations to become an export terminal. But of course, the ban on crude exports is a major hindrance to this happening. If the U.S. repeals its ban on crude exports, thus allowing for LOOP to become a two-way import and export terminal, Louisiana will have the potential to become the epicenter for global crude trading.

This could have significant implications for U.S. oil markets and the Gulf Coast economy. An increase in the amount of crude moving through LOOP will likely be accompanied by increases in storage capacity and potentially even pipeline capacity to move the crude along the Gulf Coast, either towards LOOP for export or away from LOOP for import. Recall, that crude is both heterogeneous and substitutable. Thus, creating a dynamic trading platform for crude in the Gulf of Mexico has the potential to give the refining and petrochemical industries the advantage of having access to an almost unlimited mix of crudes on relatively short notice. Potentially, the refining industry could trade its decades old protectionist policies for a chance at truly becoming the world epicenter for hydrocarbon commerce.

4.4.2 LNG Investments

One solution to shipping natural gas in an economical way overseas is to liquefy the natural gas into “Liquefied Natural Gas” (LNG). This process includes cooling the gas to extremely cold temperatures (-260°F) such that the gas becomes a liquid at normal atmospheric pressure. Once the gas is put into a dense liquid form, the gas is loaded onto ships that are constructed specifically to safely store the LNG at these extremely low temperatures. Once the LNG reaches its destination, the LNG is then converted back into gas that is then connected to a natural gas pipeline and sold to consumers.[14] There have been announcements for large projects that will liquefy the natural gas into “Liquefied Natural Gas” (LNG) for export all over the world. These projects are clustered in the Gulf Coast and in the northeast. In particular, the Sabine Pass Liquefaction station near Lake Charles Louisiana is currently under development.

Originally, when EPCA was written, it restricted the export of both crude and natural gas. But due to the political climate of the time and specific national security concerns, the main focus was on crude oil. While natural gas is still listed specifically in EPCA, today natural gas exports are allowed, but there are significant regulatory hurdles that must be crossed to get approval. In particular, there are two permits that an LNG facility will need to obtain. First, the export facility will need to get approval from the Federal Energy Regulation Commission (FERC) for the actual building of the plant. While this process is non-trivial and expensive, in general it is a well-known process with relatively little uncertainty about the final approval. The second approval comes from the U.S. Department of Energy (DOE). DOE is responsible for approval of the export of the commodity itself. This process is different for Free Trade Agreement (FTA) and non-Free Trade Agreement (non-FTA) countries. While LNG export approval to countries for which the U.S. has a free trade agreement is almost a given, approval to

[14] This information is based on specific project proposals by Cheniere, a major player in LNG export who is currently investing in export facilities on the Gulf Coast.

non-FTA countries is not as transparent. This process can be riddled with uncertainty and take years to complete, as approval is based on whether the project is in the "public interest" (Irwin 2013). In practice, the EPCA itself does not impact this regulatory process associated with the export of natural gas. But, the language in the bill does give authority to the president to restrict this export as needed. Discussion of LNG, though, with respect to the export ban does lead to a larger overarching point.

Both natural gas and crude oil are both simply hydrocarbons. In fact, changes in temperature and/or pressure will change whether these hydrocarbons are in the form of a gas or a liquid. Natural gas liquids, which include propane and butane, are largely free from export restrictions because these can be produced as part of the crude oil refining process, while methane (about 95 percent of natural gas) cannot be exported without special approvals from the federal government. On the other side of the coin, crude cannot be exported without being refined, but the natural gas liquids that come out of these same wells can be exported with no restrictions. This has been described as "a very convoluted set of molecule laws" (Irwin 2013) that are confusing and make it difficult to draw lines between natural gas, natural gas liquids, and crude oil. Removal of the export ban can put all of these molecules on an even playing field, and let the market determine their appropriate relative values and highest value end use.

5 Conclusions

This research presents an economic model with two main conclusions. First, it concludes that the export ban creates winners and losers in the short run; namely domestic refineries are able to purchase crude from domestic producers at a discount and sell refined products at the world price. But the long run implications for both domestic refiners and domestic upstream producers are less dramatic. Second, it corroborates past research that has concluded the export ban has little (or no) impact on the domestic price of gasoline for consumers.

While it is important to start with a basic economic model in order to understand the domestic and global markets for crude and how the export ban impacts these markets, there are many other factors that should be considered that go beyond a basic economic model. For instance, the model assumes zero transportation costs and zero capacity constraints. While these are common model assumptions, real world applications must take into account transportation costs not only between trading hubs, but also between where production occurs and where the oil is to be delivered. Results of this research suggest that these transportation constraints are of practical importance, and when these frictions are taken into account, a price differential between Brent and WTI would have still occurred as a result of the shale boom regardless of whether the export ban was in place or not.

Thus, when viewed holistically, basic economic principles alongside the data paint a very humdrum picture for both proponents and opponents of the export ban. Proponents have argued that the removal of the export ban will create large increases in domestic production and hundreds of thousands of domestic jobs (Yergin et al., 2014; Ebinger and Greenley, 2014) while opponents have argued that the repeal of the law will significantly increase oil and gas production thus exacerbating global CO_2 emissions and climate change (Sierra Club, 2015). Results of this research indicate that both these benefits and concerns are likely grossly overstated.

I argue that the debate over the export ban should not be decided based on net economic costs or benefits, nor should it be based on protecting one industry at the expense of another. Nor should it be based on environmentalists' concern that the removal of the ban will increase global CO_2 emissions. All of these supposed costs and benefits are highly speculative and are based on a number of overarching assumptions about the future. When a basic economic model is compared to the data, all of these concerns appear to be over-blown.

Instead, the debate over the export ban should focus on whether the federal government should be in the business of implementing protectionist policies at the expense of creating frictions that are numerous and whose impacts are impossible to fully quantify. The debate should focus on whether or not the export ban has been successful in achieving national security objectives and whether the ban is expected to achieve national security objectives going forward.

For Louisiana, the removal of the export ban will remove a long run federal protectionist policy on an industry that has served as an important component of our economy, but in return will have the opportunity for the state to be at the center of an emerging global trading hub. Certainly, one might find solace in clinging to a decades old policy that was created for national security reasons as justification for protecting a specific Louisiana industry. But having confidence in our state and our nation's energy economy, instead we might decide to move forward and take risks that have the potential to grow Louisiana's economy into a future with a dynamic energy environment.

6 Works Cited

Bausell, C. W., Rusco, F. W., Walls, W. D., 2001. Lifting the Alaskan Oil Export Ban: An Intervention Analysis. *The Energy Journal* 22 (4), 81-94.

Borenstein, S., Kellogg, R., 2014. The Incident of an Oil Glut: Who Benefits from Cheap Crude Oil in the Midwest? *The Energy Journal* 35 (1), 15-33.

Ebinger, C., Greenley, H. L., 2014. Changing Markets. Economic Opportunities from Lifting the U.S. Ban on Crude Oil Exports. Technical Report, Brookings.

EIA, 2014. Total Petroleum and Other Liquids Production. Technical Report, U.S. Energy Information Administration.

EIA, 2015a. Technical Options for Processing Additional Light Tight Oil Volumes wWithin the United States. Technical Report, U.S. Energy Information Administration.

EIA, 2015b. Effects of Removing Restrictions on U.S. Crude Oil Exports. U.S. Energy Information Administration. September 2015.

Hamilton, J.D., 2008. Understanding Crude Oil Prices. NBER Working Paper 14492.

Vidas, H., Tallet, M., O'Connor, T., Freyman, D., Pepper, W., Adams, B., Nguyen, T., Hugman, R., and Bock, A. ICF International and EnSys Energy. The Impact of U.S. Crude Oil Exports on Domestic Crude Production, GDP, Employment, Trade and Consumer Costs. American Petroleum Institute, March 31, 2014.

Irwin, Conway. The U.S.'s Absurd Oil and Gas Export Laws. *Breaking Energy*. November 20, 2013.

Kaiser, M.J. and Y. Yu(a). Louisiana Haynesville shale—1: Characteristics, production potential of Haynesville shale wells described. *Oil & Gas Journal* 109(19):68-79, 109. December, 2011.

Kaiser, M.J. and Y. Yu(b). Louisiana Haynesville shale——2: Economic Operating Envelopes Characterized for Haynesville Shale. *Oil & Gas Journal* 110(1A):70-74, 87. January, 2012.

Kaiser, M.J. and Y. Yu(c). Shale-3 (conclusion): Operating envelope of Haynesville shale wells' profitability described. *Oil & Gas Journal* 110(2):60-67. February 2012.

Kaminski, V., 2014. The Microstructure of the North American Oil Market. *Energy Economics* 46, S1-S10.

Levine, A. H., 2015. Back and Forth Oil Market Confounds Industry Analysts. *The American Oil and Gas Reporter*. May 2015.

LOOP, 2015. The LOOP Story. *https://www.loopllc.com/About-Loop/Story*. Accessed October 2015.

Medlock, K. B., 2015. To Lift or Not to Lift? The U.S. Crude Oil Export Ban: Implications for Price and Energy Security. Technical Report, James A. Baker III Institute for Public Policy Rice University.

Narra, Siddhartha and David E. Dismukes. Estimating Critical Energy Infrastructure Value at Risk from Coastal Erosion. Presentation at 7th National Summit on Coastal and Estuarine Habitat Restoration. November 3-6, 2014. Washington DC. P 19.

Nussbaum, A., Olson, B., March 2014. BP Splitter Refinery Seen Skirting U.S. Oil Export Ban. http://www.bloomberg.com/news/articles/2014-03-06/bp-splitter-refinery-seen-skirting-u-s-oil-export-ban

Theriot, Jason. *American Energy, Imperiled Coast. Oil and Gas Development in Louisiana's Wetlands*. Baton Rouge, La.: LSU Press, 2014

United States Senate, January 2014. Hearing before the Committee on Energy and Natural Resources. United States Senate. One Hundred Thirteenth Congress. Special Session to Explore Opportunities and Challenges Associated with Lifting the Ban on U.S. Crude Oil Exports.

Yergin, D., 1999. The Prize. The Epic Quest for Oil, Money and Power. Free Press.

Yergin, D., Barrow, K., Fallon, J., Bonakdarpur, M., Sayal, S., Smith, C., Webster, J., 2014. US Crude Oil Export Decision. Technical Report, HIS Energy.