United States Government Accountability Office

Report to Congressional Requesters

October 2020

CRUDE OIL MARKETS

Effects of the Repeal of the Crude Oil Export Ban

Accessible Version

GAO-21-118

GAO Highlights

Highlights of GAO-21-118, a report to congressional requesters

Why GAO Did This Study

Between 1975 and the end of 2015, the Energy Policy and Conservation Act directed a ban on nearly all exports of U.S. crude oil. This ban was not considered a significant policy issue when U.S. oil production was declining and import volumes were increasing. However, U.S. crude oil production roughly doubled from 2009 to 2015, due in part to a boom in shale oil production made possible by advancements in drilling technologies. In December 2015, Congress effectively repealed the ban, allowing the free export of U.S. crude oil worldwide.

GAO was asked to provide information on the effects of repealing the crude oil export ban. This report describes the effects of the repeal of the crude oil export ban on the domestic crude oil production, petroleum refining, and related sectors of the U.S. shipping industry.

GAO analyzed data from EIA and other federal databases to determine the effects of repealing the export ban. GAO also interviewed a nongeneralizeable sample of economists, market analysts, and stakeholders from the oil and gas, refining, and shipping industries. GAO's analysis focused on the repeal of the crude oil export ban and any effects of the repeal on U.S. crude oil and related industries through March 2020.

View GAO-21-118. For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov.

October 2020

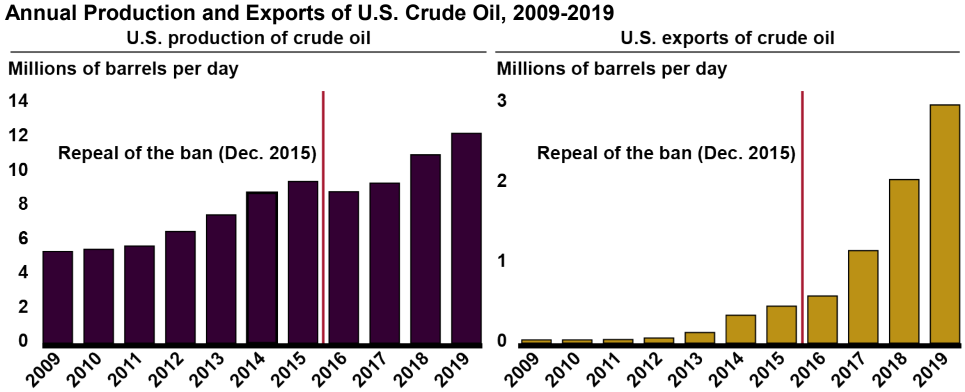
CRUDE OIL MARKETS

Effects of the Repeal of the Crude Oil Export Ban

What GAO Found

GAO's analysis of U.S. Energy Information Administration (EIA) data and interviews with industry stakeholders shows that the repeal of the U.S. crude oil export ban is associated with increased crude oil exports—from less than half a million barrels per day in 2015 to almost 3 million barrels per day in 2019. The repeal of the ban expanded the market for U.S. crude oil to overseas buyers and, along with other market factors, allowed U.S. crude oil producers to charge higher prices relative to comparable foreign crude oil. Higher prices and an expanded market for U.S. crude oil further incentivized domestic crude oil production, which had been growing since the shale oil boom began around 2009 (see figure). During the period after the repeal, total U.S. imports of crude oil remained largely unchanged.

Annual Production and Exports of U.S. Crude Oil, 2009-2019



Source: GAO analysis of Energy Information Administration data. | GAO-21-118

GAO's analysis found limited effects associated with the repeal of the ban on the production, export, and import of domestic refined petroleum products, such as gasoline. However, profit margins—which are determined in part by the costs a refiner pays for the crude oil and the earnings a refiner receives from the sale of refined products—likely decreased as the prices refiners paid for domestic crude oil increased relative to international prices. Because gasoline prices are largely determined on the global market, U.S. refiners could not pass on to consumers the additional costs associated with the increase in crude oil prices, resulting in decreased profit margins for U.S. refiners.

Finally, after the repeal of the crude oil export ban, the U.S. shipping industry experienced a decline as demand fell for U.S. tankers—known as Jones Act tankers—used to move domestic crude oil between U.S. ports. The increase in the relative price of domestic crude oils associated with the repeal of the export ban may have resulted in some U.S. refineries deciding to use more foreign crude oil. Foreign crude oil is typically transported by foreign tankers, reducing the demand for Jones Act tankers compared to what it would have been if the export ban had remained in place, according to six of the seven shipping industry stakeholders GAO interviewed.

Contents

Abbreviations

COVID-19	Coronavirus Disease 2019
EIA	Energy Information Administration
PADD	Petroleum Administration for Defense District
SIS	Step-Indicator Saturation
WTI	West Texas Intermediate

U.S. GOVERNMENT ACCOUNTABILITY OFFICE

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October 21, 2020

The Honorable Tom Carper
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Edward J. Markey
United States Senate

In 1975, after the 1973 global oil embargo and resulting economic recession, Congress passed the Energy Policy and Conservation Act, which directed a ban on the export of most domestically produced crude oil.[1] From 1975 to 2009, U.S. domestic crude oil production generally declined, and with the exception of the years 1979 to 1985, U.S. imports of crude oil generally increased. However, starting about 2009, advancements in horizontal drilling techniques and hydraulic fracturing technologies increased the extraction of shale oil and changed U.S. crude oil markets.[2] This shale oil boom almost doubled U.S. crude oil production, from 5.4 million barrels per day in 2009 to 9.4 million barrels per day in 2015, and industry analysts projected the growth in crude oil production would continue. Increasing domestic production resulted in a surplus of U.S. crude oil that generally could not be exported and sold outside the United States. In turn, this surplus contributed to domestic oil prices that were significantly lower than international prices. At one point, in 2011, U.S. crude oil prices, as measured by the North American benchmark West Texas Intermediate (WTI), were about $31 less per

[1]The oil embargo took place from October 1973 through March 1974, when Arab members of the Organization of the Petroleum Exporting Countries imposed an embargo against the United States in retaliation for U.S. actions in the 1973 Arab-Israeli War. The Energy Policy and Conservation Act, Pub. L. No. 94-163 § 103, 89 Stat. 871, 877 (codified at 42 U.S.C. § 6212), passed in 1975, effectively banned the export of most domestic crude oil. The act led the Department of Commerce's Bureau of Export Administration (the predecessor to the Bureau of Industry and Security) to promulgate regulations that required crude oil exporters to obtain a license for export in limited circumstances on a case-by-case basis.

[2]Hydraulic fracturing, commonly known as fracking, is an oil and gas production process that involves injecting a combination of water, sand, and chemical additives under high pressure to create and maintain fractures in underground rock formations that allow crude oil and natural gas to flow.

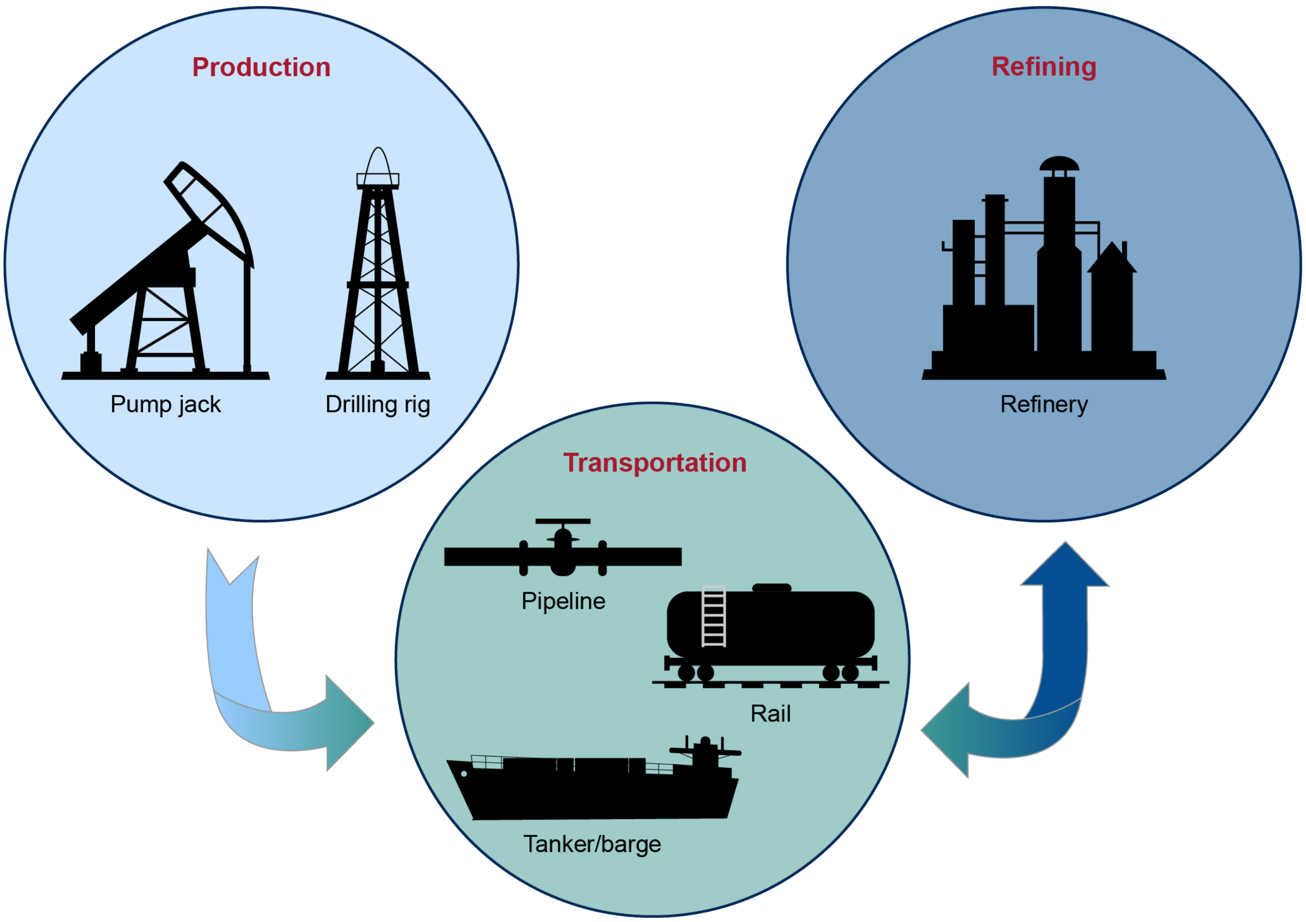
barrel (2019 dollars) than international crude oil prices.[3] On December 18, 2015, Congress passed the Consolidated Appropriations Act, 2016, which effectively repealed the crude oil export ban and allowed U.S. crude oil to be freely marketed and sold on the global market.

Domestic crude oil supply, demand, and prices affect three main activities and their related industries: (1) exploration for and production of crude oil; (2) refining of crude oil into refined petroleum products, such as gasoline; and (3) the transportation of crude oil and refined products by ships and other modes of transportation.[4] (See fig. 1.)

[3]WTI crude oil is produced in Texas and southern Oklahoma and is widely used as a domestic benchmark. WTI serves as a reference for pricing light, sweet crude oil in North and South America.

[4]The U.S. Energy Information Administration (EIA) notes that refined petroleum products include but are not limited to gasoline, kerosene, distillates (including No. 2 fuel oil), liquefied petroleum gas, asphalt, lubricating oils, diesel fuels, and residual fuels. For the purpose of this report, we refer to refined petroleum products as refined products.

Figure 1: Segments of the Crude Oil Production and Refining Process



Source: GAO. | GAO-21-118

Note: For the purpose of this figure, we did not represent movement of crude oil and refined products by truck in the transportation circle because such movement tends to be for shorter distances or for transporting refined petroleum products from wholesale terminals or refineries to retail fuel stations.

You asked us to provide information on the effects of repealing the crude oil export ban. This report describes how repealing the export ban affected U.S. crude oil production, refining, and related sectors of the domestic shipping industry.

To describe how repealing the ban affected U.S. crude oil production, refining, and related shipping industries, we reviewed literature and interviewed knowledgeable stakeholders, such as economists, market analysts, and representatives from the oil, shipping, and refining industries. For background purposes and to help identify relevant stakeholders to interview, we conducted a literature search of studies and articles that analyzed and summarized the economic effects of the crude oil export ban and the effects of its repeal on domestic crude oil production, refining, and shipping (including its effects on exports, imports, and prices).[5] Based on the literature we reviewed, our prior reports, and recommendations from other interviewees, we identified 66 stakeholders with relevant knowledge, including economists, market analysts, and stakeholders in the oil and gas, refining, and shipping industries. We contacted all 66 stakeholders, of whom 25 agreed to be interviewed. In 21 interviews, we captured the opinions of nine economists and market analysts, five refining industry stakeholders, and seven shipping industry stakeholders.[6] We generally asked the same questions of each stakeholder relative to their area of expertise or the industry they represented, but we also discussed individual stakeholders' perspectives, as appropriate. When possible, we summarized their views, noting areas of consensus or disagreement. The views of the stakeholders we selected are not generalizable to all potential stakeholders, but they provide a range of perspectives from individuals familiar with the effects of the repeal of the ban. In addition, we interviewed agency officials at the Departments of Energy, Labor, Transportation, Defense, and Commerce to discuss our objective and the data described below.

We analyzed relevant data to understand the effects of the repeal of the export ban on U.S. crude oil production. Specifically, we analyzed data from the U.S. Energy Information Administration (EIA) on the production, import, and export of crude oil from 2009 through 2019.[7] To determine how repealing the ban affected U.S. crude oil prices relative to international crude oil prices, we analyzed EIA monthly data on the first purchase prices of crude oil in different states and compared these to the

[5]We identified and reviewed existing literature from 2009 (widely considered the beginning of the shale oil boom in the United States) through December 2019 by conducting searches of various databases, such as Scopus and EconLit.

[6]The number of stakeholders we interviewed is greater than the number of interviews we conducted, because in a few cases multiple stakeholders participated in the same interview. In addition, three of the seven shipping industry stakeholders we interviewed represent U.S. shipping-related trade associations.

[7]EIA is a statistical agency within the U.S. Department of Energy that collects, analyzes, and disseminates independent information on energy issues.

international Brent benchmark price.[8] We examined the difference between these prices from January 2009 through March 2020. We also analyzed quarterly EIA data on the growth in the capacity of crude oil pipelines between PADDs from the first quarter of 2010 to the first quarter of 2020.

To determine how repealing the ban affected the refining industry, we analyzed EIA data on the production of refined products and the import and export of refined products from 2009 through 2019. To determine how repealing the ban may have affected profitability in the refining sector, we examined the difference between gasoline prices and the price of crude oil, also known as the crack spread. Specifically, we analyzed monthly data from EIA on the price of gasoline at the New York Harbor spot market and the first purchase price of crude oil in selected high-producing crude oil states.[9] To determine how repealing the ban affected refineries in different regions of the United States, we analyzed the differences in the acquisition cost of crude oil by region. We examined the difference in prices between these indicators from January 2009 through March 2020.

To describe how repealing the ban affected the domestic shipping industry as it relates to the movement of crude oil and refined products,[10] we analyzed how crude oil moves from production sites to refineries within the United States. Specifically, we examined data collected by EIA from January 2009 through March 2020 on the amount of crude oil transported to refineries by major modes of transportation, such as

[8]The first purchase price of crude oil is the price at which the crude oil is first purchased from the producer. The data for first purchase price are collected at the state level and are an indicator of local U.S. crude oil market conditions, whereas the Brent price reflects global market conditions. Brent is a benchmark crude oil from the North Sea, located between the United Kingdom and Norway. Brent is typically used as the global benchmark for light, sweet crude oil. Brent is of a similar quality to WTI crude oil and, therefore, the two are often compared, so we used it for our analysis.

[9]A spot market is a market in which a commodity, such as gasoline, is bought and sold for immediate or very near-term delivery and does not imply a continuing arrangement between the buyer and the seller. A spot market is more likely to develop at a location with numerous transportation options, such as New York Harbor, thus allowing for a large number of buyers and sellers.

[10]For the purpose of this report, we use the term U.S. shipping industry when we are referring to all sectors of the industry, such as shipbuilding, mariners, etc., that specifically pertain to the shipping of crude oil and refined products.

pipelines, tankers, and barges. To adjust our data for inflation, we used the consumer price index from the Bureau of Labor Statistics.[11]

To assess the reliability of the data we used, we reviewed relevant documentation and interviewed EIA and other officials familiar with the data. We determined these data to be sufficiently reliable for the purposes of this report. Appendix I provides additional information on how we conducted our data analysis. Our analysis focused on the repeal of the crude oil export ban in December 2015 and any effects of the repeal on U.S. crude oil and related industries through March 2020. Therefore, we did not examine the effect of subsequent events, such as the Coronavirus Disease 2019 (COVID-19) pandemic and its associated economic dislocations.

We conducted this performance audit from December 2018 to October 2020, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The production, refining, and shipping of crude oil and refined products exists within the broader context of U.S. and global energy markets. Conditions in U.S. and global energy markets—including commodity prices, the availability of resources, demand for those resources, and the ability to transport resources from a production site to interested buyers—can change rapidly. A change in any market condition can affect other market conditions, including production levels and prices in the United States and abroad.[12] For example, COVID-19 and the resulting stay at home orders and travel restrictions led to a collapse in global demand for

[11]EIA uses the consumer price index in its Short-Term Energy Outlooks to calculate real current dollar values.

[12]For more information on the increased globalization of energy markets and its effect on the U.S. energy supply and prices, see GAO, *Energy Markets: Increasing Globalization of Petroleum Products Markets, Tightening Refining Demand and Supply Balance, and Other Trends Have Implications for U.S. Energy Supply, Prices, and Price Volatility*, GAO-08-14 (Washington, D.C.: Dec. 20, 2007).

transportation fuels as well as the crude oil used to produce them. According to EIA, in April 2020, total U.S demand for petroleum products, such as transportation fuels, was about a third lower, or 31 percent, than the average in the months preceding the travel restrictions. At the same time, domestic crude oil supplies continued to increase because refiners responded faster to declining demand than crude oil producers.[13] Combined with insufficient storage capacity to accommodate the oversupply of crude oil, these factors led to a significant decrease in the price of U.S. crude oil in the spring of 2020, according to EIA.[14]

Crude Oil Export Restrictions

The Energy Policy and Conservation Act of 1975 effectively prohibited the export of domestically produced crude oil and led the Department of Commerce's Bureau of Export Administration to promulgate regulations requiring a license for the export of crude oil. The Bureau, consistent with decisions by the President, established a limited license exception that authorized certain exports of crude oil, including

- exports from Alaska's Cook Inlet;
- exports to Canada for consumption or use therein;
- exports of certain California crude oil up to 25,000 barrels per day; and
- exports made by the President under certain statutes.

In addition to these exceptions, the Bureau considered export license applications on a case-by-case basis. Because of these exceptions, prior to the repeal of the ban in 2015, the United States exported approximately 500,000 barrels per day (or 5 percent) of the crude oil produced in the United States, nearly all of which went to Canada.

On December 18, 2015, Congress passed the Consolidated Appropriations Act, 2016, which included a provision that effectively

[13]Crude oil producers may not respond as quickly to market conditions because there is a lag between when the initial investment in crude oil exploration and production is made and when actual production occurs, and the majority of the costs associated with crude oil production are incurred early in the process.

[14]As noted previously, we did not assess the effects of COVID-19 on U.S. crude oil and related industries in this report.

repealed the export ban and allowed U.S. crude oil to once again be marketed and sold to more countries on the global market.

Features of U.S. Crude Oil Production, Petroleum Refining, and Relevant Transportation Infrastructure

As previously noted, the supply, demand, and price of domestic crude oil directly affects the production, refining, and transport of crude oil and refined products.

Production

After a decades-long decline, U.S. crude oil production began to increase in 2009. The successful application and expansion of horizontal drilling and hydraulic fracturing led to a boom in the extraction of crude oil from shale formations.[15] Most of the crude oil produced in the United States since the shale oil boom has been light, sweet crude oil, which has characteristics that differ from heavy crude oil, which comprises most historic domestic production.[16]

According to EIA, as of August 2020, the top oil producing formations in the United States were the Permian Basin in Texas and New Mexico; the Bakken Shale play in Montana and North Dakota; and the Eagle Ford Shale play in Texas.[17] EIA reports data on crude oil and refined products regionally by Petroleum Administration for Defense Districts (PADDs), which are geographic aggregations of the 50 states and District of

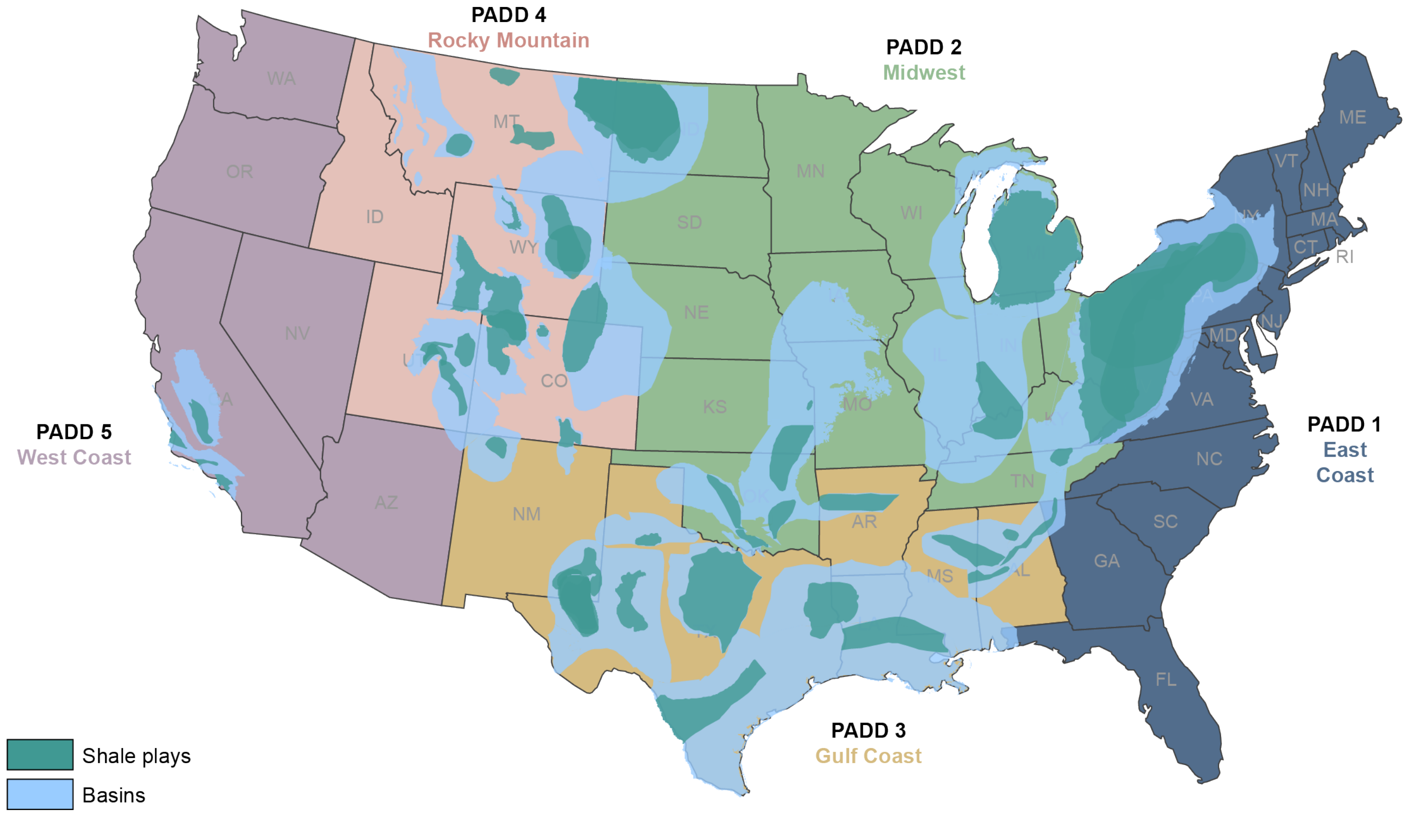
[15]For the purpose of this report, shale oil formations refer to both shale plays and shale basins. Shale plays are located within basins, which are large-scale geological depressions, often hundreds of miles across, that may also contain other oil and gas resources.

[16]Crude oil production is generally measured in barrels per day, with the oil characterized according to its density and sulfur content. Less dense crude oils are known as light, while denser crude oils are known as heavy. Crude oils with relatively low sulfur content are known as sweet, while crude oils with higher sulfur content are known as sour. For example, less dense crude oil with a low sulfur content is referred to as light and sweet, while denser crude oil with a higher sulfur content is referred to as heavy and sour.

[17]Development and production of crude oil in the Permian Basin increased significantly in the years after the repeal of the ban.

Columbia.[18] Figure 2 shows where the major shale formations are located in regards to the five PADD regions.

Figure 2: Petroleum Administration for Defense Districts (PADD) and Major Shale Formations, as of January 2018 for the Basins and October 2019 for the Plays



Source: Energy Information Administration (shale location data). | GAO-21-118

Refining

Petroleum refineries use crude oil to make refined petroleum products, such as gasoline, diesel, and aviation fuel. U.S. refineries purchase and process a combination of U.S. and foreign crude oils, as well as a combination of light and heavy crude oils. Refineries vary by size, capacity, and configuration, which generally determines the amount and

[18]For the purpose of this report, we refer to the PADDs by their regional names rather than their numbers.

mix of crude oil used and the types of refined products produced. Many U.S. refineries tend to be complex because they were designed to process historically cheaper heavier crude oils, which require additional distillation.[19] The light, sweet crude oil increasingly produced in the United States differs from the crude oil that many U.S. refineries were optimally designed to process. Because of this mismatch, prior to the repeal of the ban, many domestic refineries had reached or were close to reaching a point where they would need to invest in significant and costly modifications to process the additional supplies of light, sweet crude oil, according to our past work.[20]

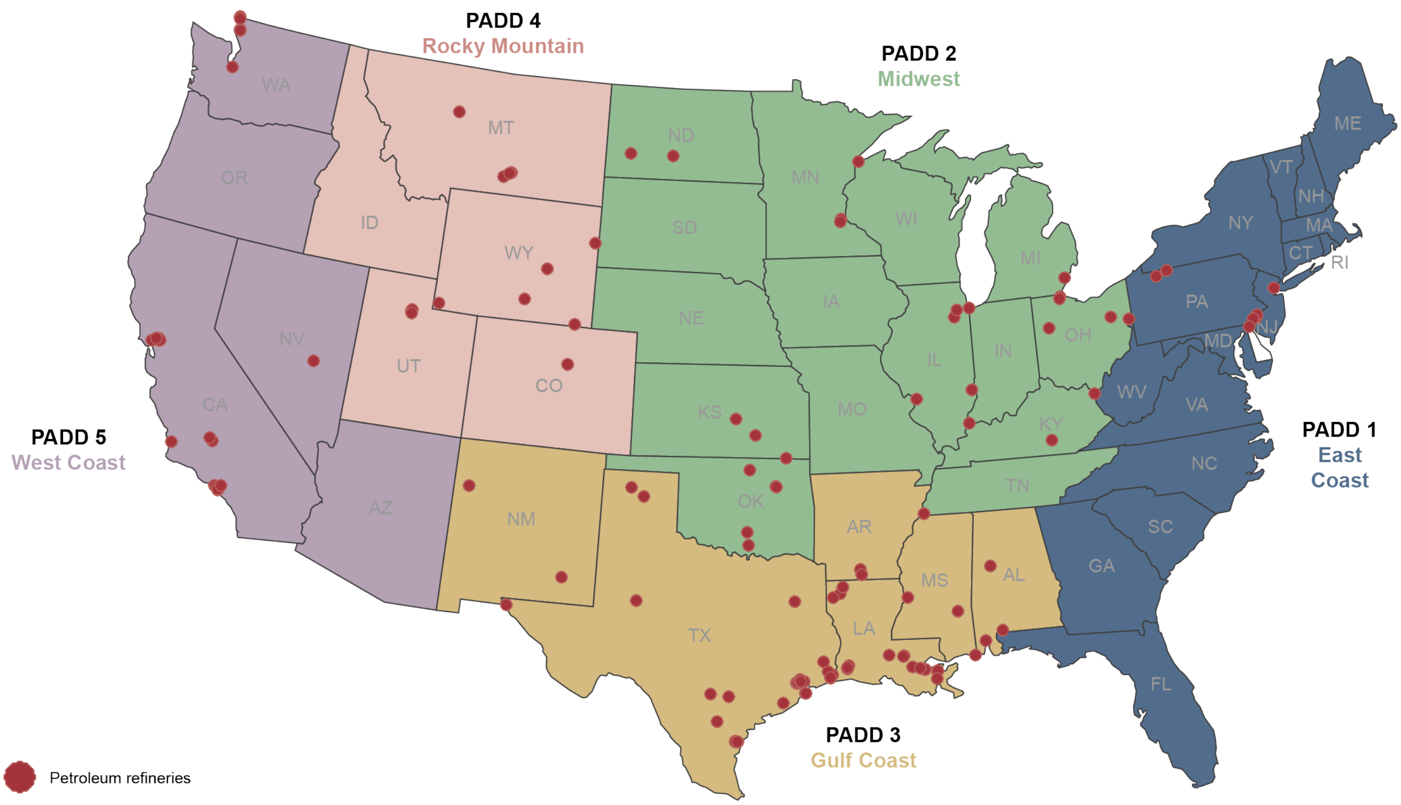
According to EIA data, as of January 2020, there were 135 petroleum refineries in the United States with the capacity to process a total of 19 million barrels of crude oil per day.[21] While refineries are located around the country, as of January 2020, more than half of U.S. refining capacity (around 53 percent) was located in the Gulf Coast region, where the refineries receive crude oil by land or sea (see fig. 3). Additionally, Gulf Coast refineries typically have upgraded equipment to refine historically cheaper heavy crude oils into refined products, according to EIA.

[19]Through the addition of specialized equipment, refineries can be optimized or upgraded to process different types of crude oil than they were originally constructed to process. However, adding capacity to or significantly changing a refinery configuration requires significant capital investment.

[20]GAO, *Changing Crude Oil Markets: Allowing Exports Could Reduce Consumer Fuel Prices, and the Size of the Strategic Reserves Should Be Reexamined*, GAO-14-807 (Washington, D.C.: Sept. 30, 2014).

[21]A refinery's capacity refers to the maximum amount of crude oil that it can process. EIA collects information from refineries located in the 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, Guam, and other U.S. possessions, and publishes the information in an annual Refinery Capacity Report.

Figure 3: Petroleum Refineries in the United States, as of October 2019



Source: Energy Information Administration. | GAO-21-118

Transportation

In the United States, crude oil and refined products are transported through an extensive infrastructure of pipelines, tankers, barges, rail, and trucks. In general, pipelines are the least costly way to transport crude oil and refined products. We previously reported that the growth in domestic crude oil production that resulted from the shale oil boom occurred in areas with insufficient infrastructure to transport crude oil to refineries.[22] For example, some areas on the East and West Coasts do not have pipelines; as a result, domestic refineries in those regions relied more on other modes, such as rail and trucks, to receive domestic crude oil. Over time, additional pipeline capacity was added, and most domestic crude oil

[22] GAO-14-807.

is now moved by pipeline from production sites in the Midwest and the Rocky Mountain regions to domestic refineries or to ports for transport on the Gulf Coast.[23]

In addition, waterborne tankers or barges can transport crude oil and refined products. The Jones Act requires that all waterborne transportation between points in the United States, such as from the Gulf of Mexico to the Northeast, use vessels that are U.S.-built, U.S.-owned, U.S.-crewed, and U.S.-flagged.[24] As a result of these requirements, shipping or operating costs typically are greater for Jones Act vessels than for vessels that are foreign built, crewed, and flagged, according to our prior work.[25] Before the repeal of the export ban, investors began to build more tankers and barges to move domestic crude oil to areas not serviced by pipelines, such as from ports in the Gulf Coast to refineries on the East Coast.[26]

Figure 4 shows the infrastructure related to transporting crude oil and refined products by pipeline; figure 5 shows the infrastructure for

[23]Constructing new pipelines or expanding or reversing the direction of flow of existing pipelines may lag behind increases in crude oil production such as those experienced in the Permian and Bakken shale formations.

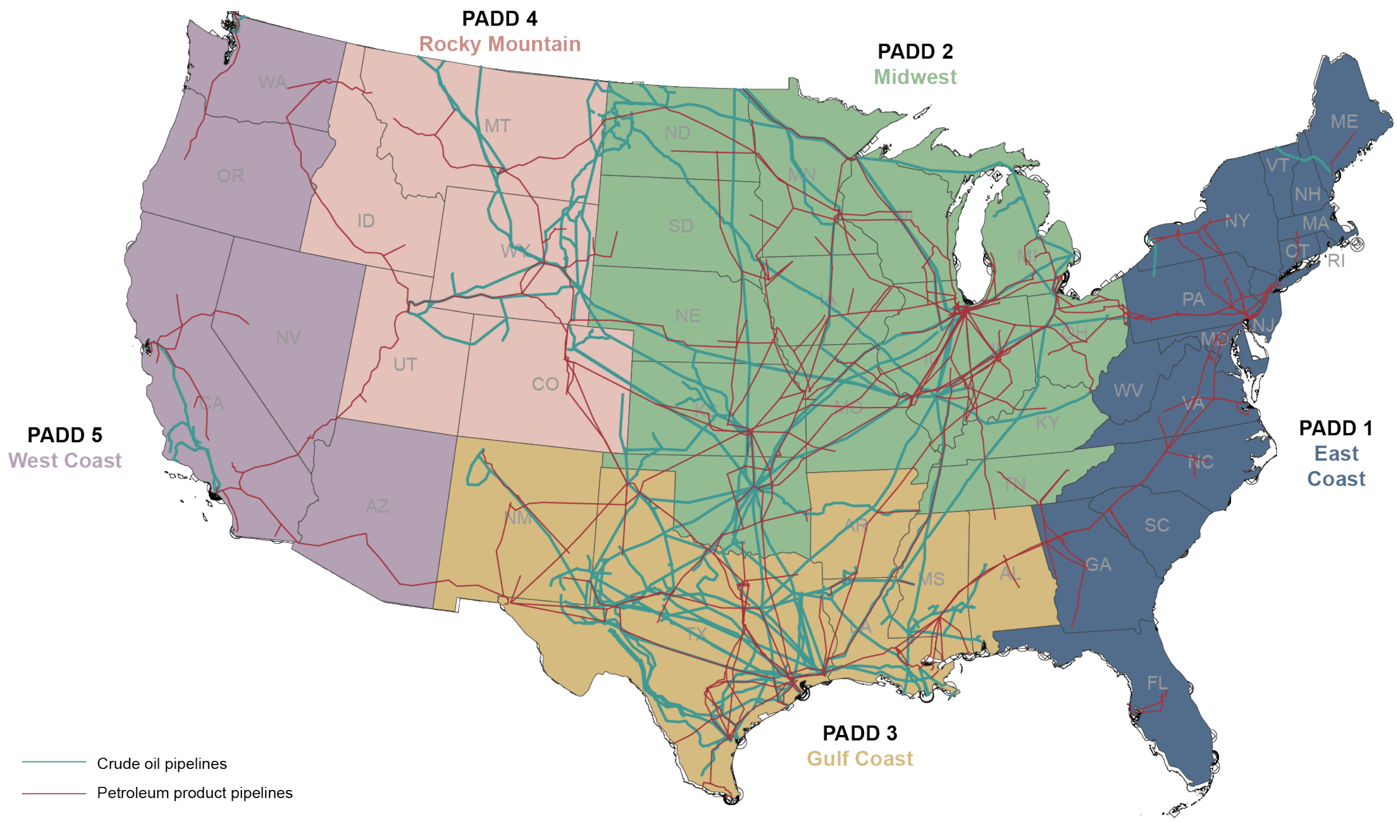
[24]The Jones Act historically refers to section 27 of the Merchant Marine Act of June 5, 1920, Ch. 250, 41 Stat. 988, 999. With the codification of title 46 of the *United States Code* in 2006, the requirements of the Jones Act have been restated and codified at 46 U.S.C. § 55102.

[25]According to a 2011 study by the U.S. Department of Transportation Maritime Administration, U.S.-flag vessels, such as a Jones Act tanker, can cost almost three times as much to build, around five times as much to operate (primarily related to the cost of employing U.S. crews), and almost two times as much for overhead costs, such as to charter or rent the vessel, as an equivalent foreign-flagged vessel. As a result, international trade, such as of foreign crude oil, is typically transported by foreign-flag vessels. For more information, see GAO, *Maritime Security: DOT Needs to Expeditiously Finalize the Required National Maritime Strategy for Sustaining U.S.-Flag Fleet,* GAO-18-478 (Washington, D.C.: Aug. 8, 2018) and GAO, *Puerto Rico: Characteristics of the Island's Maritime Trade and Potential Effects of Modifying the Jones Act*, GAO-13-260 (Washington, D.C.: Mar. 14, 2013).

[26]Although most gasoline is moved by pipeline, some states that are not serviced by pipelines, such as Florida, receive the majority of their refined products, such as gasoline, by rail, tanker, or barge.

transportation by rail; and figure 6 shows the infrastructure for transportation by tankers or barge within the United States.[27]

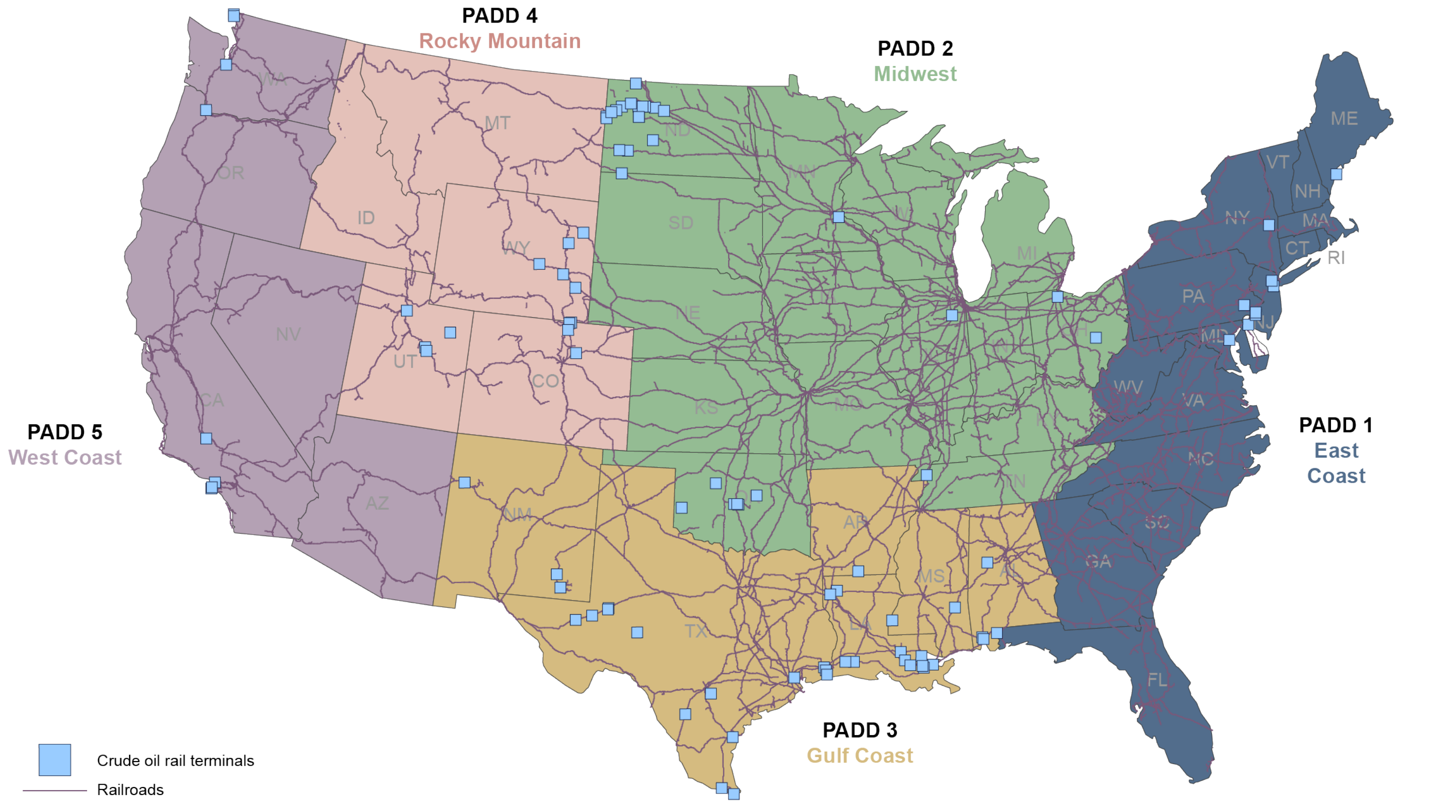
Figure 4: Map of Pipeline Infrastructure for Crude Oil and Refined Petroleum Product Transport in the United States, as of April 2020



Source: Energy Information Administration. | GAO-21-118

[27]We did not represent the transport of crude oil and refined products by truck in the figures, since such movement would have required the mapping of all major roads and highways.

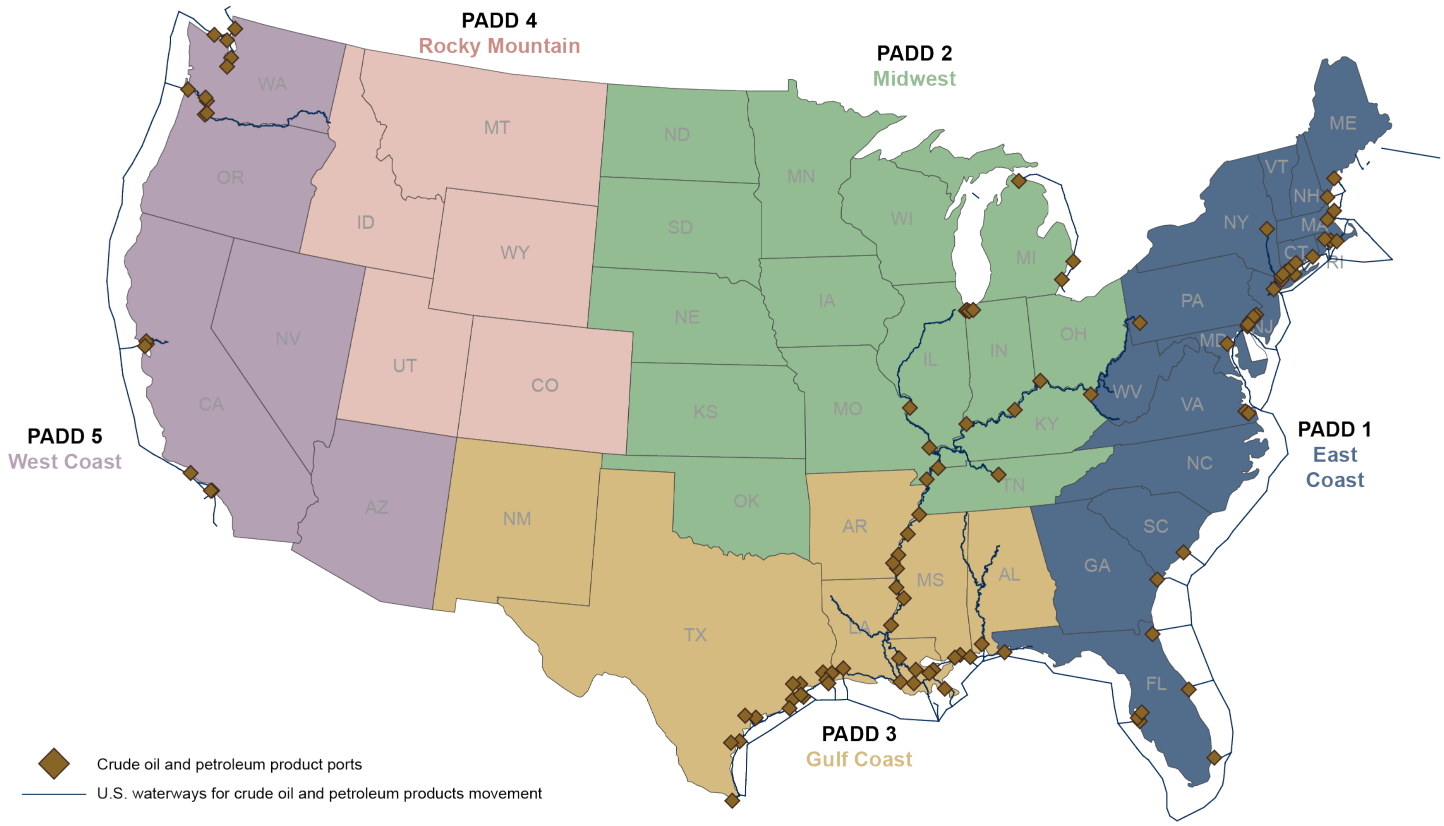
Figure 5: Map of Rail Infrastructure for Crude Oil and Refined Petroleum Product Transport in the United States, as of January 2019



Source: Energy Information Administration. | GAO-21-118

Note: For the purpose of this figure, the railroads represented on our map are Class 1 railroads, which are used for transport by large freight railroad companies. The rail terminals are for crude oil and not petroleum products because, according to EIA officials, petroleum products can move by single tank cars, which would expand the number of terminals and complicate tracking.

Figure 6: Map of Waterborne Infrastructure for Crude Oil and Refined Petroleum Product Transport in the United States, as of October 2019



Source: Energy Information Administration. | GAO-21-118

Note: For this figure, the waterways connect principal ports in the United States, including inland and coastal ports such as deepwater ports.

Interrelated Factors that Affect Energy Markets

Conditions that affect energy markets, including oil production, refining, and transportation, are interrelated; a change in one factor can affect others and, in turn, affect markets as a whole. This can be observed in the period after the shale oil boom and before the repeal of the export ban. During this time, there was an oversupply of stranded light, sweet oil in the United States and U.S. crude oil prices were lower than international prices.[28] According to our past work and other sources, several factors caused this, including:

- The crude oil export ban limited the market for domestic crude oil producers. Consequently, with few exceptions, domestic refineries were the only buyers of U.S. crude oil.[29]
- Due to an expansion in horizontal drilling and hydraulic fracturing, U.S. crude oil production in the Bakken, Eagle Ford and, later, Permian Basin shale formations rapidly increased. Light, sweet crude oil made up the majority of the increased production, which was not well suited for many domestic refineries that were configured to process heavier crude oils.
- Transportation limitations, such as insufficient pipeline capacity, stranded U.S. crude oil near production sites or required the use of more expensive transportation options.[30] The rapid increase in the production of U.S. crude oil outpaced the construction of pipelines in some regions, specifically in the Midwest and Rocky Mountain regions, and pipelines are the least costly option for transporting oil to domestic refineries. In order to be competitive with other crude oils, prices for transportation-constrained oil would generally have to be lower to make up for its higher transportation costs.

Effects of the Repeal of the Crude Oil Export Ban on U.S. Crude Oil and Related Industries

According to our analysis and interviews with economists, market analysts, and industry stakeholders, the repeal of the crude oil export ban is associated with increased U.S. crude oil exports, prices, and production, which generally benefitted domestic crude oil producers. There were limited effects on the production, export, and import of refined petroleum products after the repeal of the ban. However, profit margins for many domestic refiners likely decreased as the prices refiners paid for

[28]We refer to the abundance of domestic crude oil in the United States that could not be sold on the global market prior to the repeal of the ban as stranded oil.

[29]Refineries are the principal buyers of crude oil, and even with the export ban in place, domestic refineries imported crude oil from multiple sources.

[30]As a result of these transportation costs, the price of U.S. crude oil was depressed to be made competitive with other crude oils that refiners could import from other countries.

domestic crude oil increased.[31] Additionally, related sectors of the domestic shipping industry experienced a decline as demand for U.S. crude oil tankers fell after the repeal of the ban.

The Repeal of the Ban Is Associated With Increased U.S. Crude Oil Exports, Prices, and Production that Generally Benefitted Domestic Crude Oil Producers

The repeal of the export ban generally benefited the domestic crude oil production industry because it allowed producers to sell on the global market, leading to increased crude oil exports, increased domestic crude oil prices relative to international prices, and continued growth in domestic shale oil development and crude oil production. After the repeal of the ban, the market for U.S. producers expanded, allowing for an increase in exports from 465,000 barrels per day to 10 countries in 2015 to almost 3 million barrels per day to 43 countries in 2019, according to our analysis. In addition, U.S. imports of crude oil remained largely unchanged for several years after the repeal of the ban.[32] One market analyst we interviewed noted that after the repeal of the ban, the U.S. crude oil market became a free market in which prices are based on the availability and cost of transportation.

The repeal of the ban expanded the market for U.S. crude oil, allowing domestic producers to obtain higher prices relative to comparable foreign crude oil, according to our analysis and interviews with stakeholders. More specifically, the first purchase price of crude oil—the price that crude oil producers receive for their product—in four of the five largest crude oil-producing states rose by between 4 percent and 9 percent relative to international prices in the months after the repeal of the ban,

[31]Profit margins for refiners (also known simply as refining margins) are determined in part by how much refiners pay for the crude oil used in their refining processes—which constitutes their largest cost component—and the price they receive for their refined products, such as gasoline.

[32]Prior to the repeal of the export ban, U.S. imports of crude oil were trending down, from about 9.2 million barrels per day in 2010 to about 7.4 million barrels per day in 2015. After the repeal of the ban, U.S. imports of crude oil increased for 2 years—from about 7.4 million barrels per day in 2015 to about 8 million barrels per day in 2017—before decreasing again in 2018 and 2019.

according to our analysis.[33] After the ban, domestic producers no longer had to sell their crude oil at depressed prices to incentivize domestic refineries and other buyers since the growing supply of domestic crude oil could be sold on the larger global market, according to eight of the nine economists and market analysts we interviewed.

More than half (12 of 21) of the stakeholders we interviewed said that crude oil pricing, production, and transportation are a few of the interrelated factors that affect energy markets. From 2010 through 2016, pipeline capacity in some regions rose faster than crude oil production, according to our analysis. This was accompanied by an increase in domestic crude oil prices (for the first purchase price in those regions) relative to international crude oil prices. However, when crude oil production increased faster than pipeline capacity—partly due, in this case, to the substantial increase in U.S. production driven by output from the Permian Basin—transportation costs tended to increase, which lowered the price domestic crude oil producers could charge relative to international crude oil prices. For example, after 2016, pipeline capacity and production grew at similar rates in the Gulf Coast region, but pipeline capacity did not keep up with production increases in the Midwest and Rocky Mountain regions, according to our analysis. This likely put downward pressure on the price of U.S crude oil from these two regions relative to foreign crude oil; this tended to reduce the gains in domestic crude oil prices seen immediately after the repeal of the ban.[34]

The expanded market and higher prices for U.S. crude oil after the repeal of the ban provided stronger incentives for greater investment in domestic crude oil production,[35] according to eight of the nine economists and market analysts we interviewed. These incentives eventually caused production to increase compared to what it would have been had the

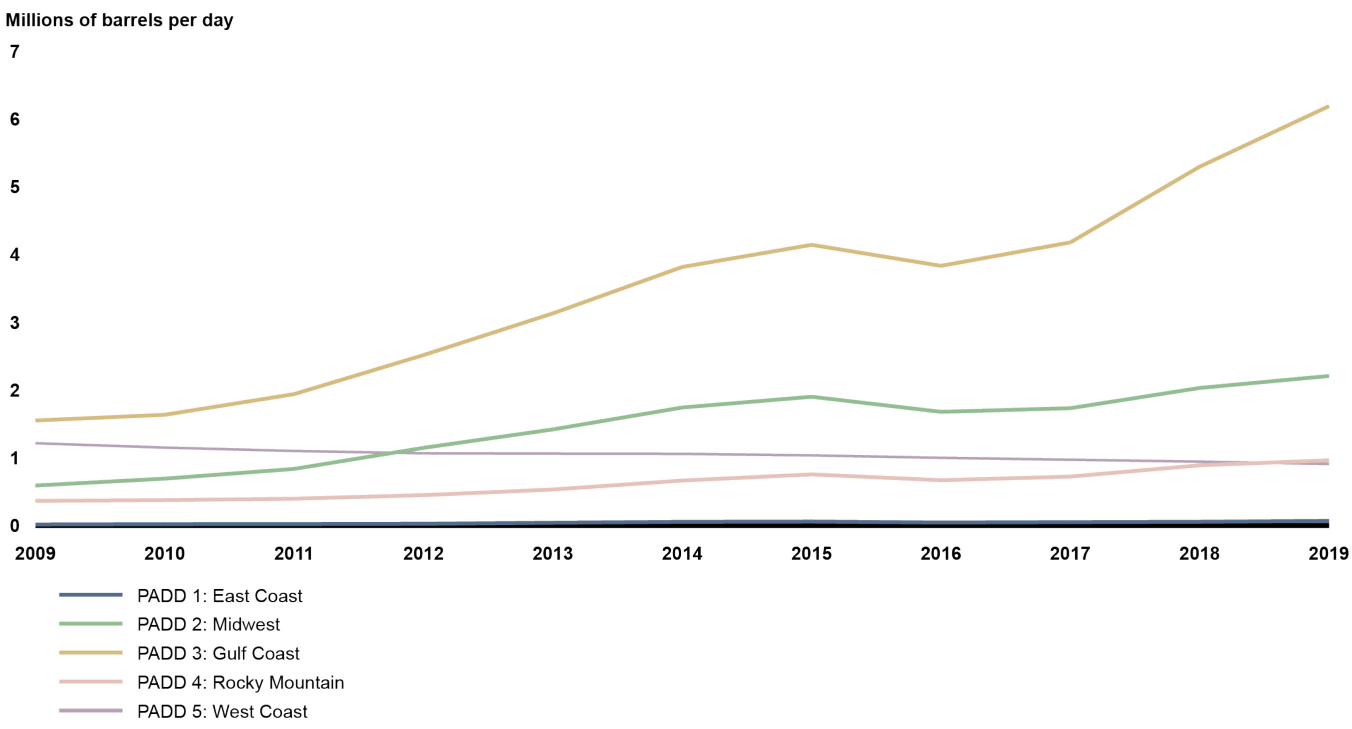
[33]As of December 2019, according to EIA, the largest crude oil-producing states (in descending order) are Texas, North Dakota, New Mexico, Oklahoma, and Colorado. The refiners' acquisition cost of crude is likely a more accurate variable to use in a margin calculation, but those data are only available at the PADD (regional) level, while first purchase prices are available at the state level. We discuss this in Appendix I.

[34]There was no pipeline capacity increase on the West Coast during this period, and a single pipeline was completed on the East Coast in 2012.

[35]As we previously reported, observable effects on production due to higher prices do not occur immediately. There is a lag between the time producers begin to receive higher prices for domestic oil and the time it takes for additional development activities to produce more oil. See GAO, *Alaskan North Slope Oil: Limited Effects of Lifting Export Ban on Oil and Shipping Industries and Consumers*, GAO/RCED-99-191 (Washington, D.C.: July 1, 1999).

export ban remained in place. According to EIA data, total production of U.S. crude oil rose by roughly one-third, from approximately 9.3 million barrels per day just before the repeal of the ban in December 2015 to about 12.8 million barrels per day in December 2019. Since the shale oil boom began, domestic production has been concentrated in the Permian shale formation in Texas and New Mexico, the Bakken shale formation in the Midwest, and the Eagle Ford shale formation in the Gulf Coast, and production has continued to increase in those regions. Production in the Gulf Coast region—specifically, the Permian Basin—more than doubled, increasing from about 2 million barrels per day in December 2015 to almost 5 million barrels per day in December 2019, according to EIA data (see fig. 7). After an initial reduction in 2016, crude oil production also increased in the Rocky Mountain region after the repeal of the export ban.

Figure 7: U.S. Crude Oil Production by Region, Annually from 2009 through 2019



Source: GAO analysis of Energy Information Administration data. | GAO-21-118

Note: The figure shows onshore U.S. crude oil production by region as defined by the Energy Information Administration Petroleum Administration for Defense Districts; it does not include offshore crude oil production. In addition, the production of U.S. crude oil experienced a temporary decrease during 2016 before increasing again. This decrease corresponded with a decrease in the WTI and Brent crude oil benchmark prices from 2014 to 2015, which may have made the production of crude oil less attractive.

The Repeal of the Ban Had Limited Effects on U.S. Refined Products, but Domestic Refiners' Profit Margins Generally Decreased

The repeal of the ban had limited effects on the production, export, and import of domestic refined products, in part because refined product markets remained global and unfettered throughout the crude oil export ban. However, according to our analysis, the increase in U.S. crude oil prices after the repeal likely resulted in a decrease in domestic refiners' profit margins relative to what they would have been with the ban in place. Furthermore, the extent to which profit margins differed varied by region. The production of refined products by domestic refiners varied from 2010 through 2019 but generally remained stable at around 12 million barrels per day.[36] According to the refining industry stakeholders we interviewed, the repeal had no effect on the type or quantity of products they produced. In addition, there were no significant regional changes after the repeal—the Gulf Coast region continued to produce the majority (about 56 percent) of refined products in the United States, while the Rocky Mountain region produced the least (about 4 percent) of these products.

Similarly, there was little effect on the export and import of refined products associated with the repeal of the ban, according to the stakeholders we interviewed. For example, exports of refined products had been increasing before the repeal and continued to increase at approximately the same rate after the repeal, according to EIA data. Exports increased by a rate of between 9 percent and 12 percent during the 2 years before and the 2 years after the repeal of the ban—specifically, 2014 through 2017.[37] In addition, imports of refined products increased by 10 percent from 2015 to 2019, according to our analysis, and were not substantively affected by the repeal of the ban, according to four of the economists and market analysts we interviewed.[38]

[36]According to EIA data, there was a reduction in refinery production in 2016, immediately after the ban was repealed. However, in 2017 and 2018, production recovered and then in 2019 dropped, although not to 2016 levels.

[37]Exports of refined products increased from 3.5 million barrels per day in 2013 to 4.3 million barrels per day in 2015, and then to 5.2 million barrels per day in 2017.

[38]Not all of the nine economists and market analysts we interviewed provided input on this topic.

However, profit margins for domestic refiners likely fell after the repeal because the price of U.S. crude oil rose relative to international prices, according to our analysis of EIA data. As a result, refiners had to pay more for the domestically produced crude oil they used in their refining processes after the repeal of the ban, or import more foreign crude oil as a substitute. Specifically, our analysis shows that the difference between a benchmark price of gasoline in New York[39] (an indicator of refinery revenue) and the first purchase price of crude oil in four of the five largest crude oil producing states[40] (an indicator of refinery costs) fell by between 9 percent and 17 percent in 2016, after the repeal of the ban.[41] This drop indicates an increase in the price of crude oil produced in these states relative to the price of gasoline.[42] However, because gasoline prices are largely determined on the global market, U.S. refiners could not pass on to consumers the additional costs associated with the increase in crude oil prices, resulting in a decrease in their profit margins.

Lastly, the effects associated with the repeal of the ban varied by region, according to our analysis, as the cost for refiners to acquire domestic crude oil increased by between 2 percent and 9 percent in all other regions relative to the Gulf Coast region.[43] This can be explained in part by several advantages of Gulf Coast refineries, such as proximity to booming areas of production including the Permian Basin and access to an extensive network of pipelines for cheaper transport.

[39]The New York Harbor spot price of gasoline is a one-time open market purchase at a specific location. New York Harbor is a benchmark price for the global gasoline market.

[40]As mentioned earlier, the first purchase price of crude oil is the price at which the crude oil is first purchased by the producer at the site of production. In 2016, the difference between the spot price for gasoline at New York Harbor and the first purchase price for crude oil fell for Texas, North Dakota, Oklahoma, and Colorado, but not New Mexico.

[41]For more information on the spread between the price of gasoline and the first purchase price of crude oil, see the technical explanation in Appendix I.

[42]For the purpose of this report, we use the difference in the price of gasoline and the price of crude oil—also known in the industry as the crack spread—as a proxy for refinery profitability because EIA no longer publishes information on refining margins or profit margins for refiners.

[43]For more information on refiners' costs to acquire domestic crude oil see the technical explanation in Appendix I.

Sectors of the U.S. Shipping Industry Experienced a Decline Associated with the Repeal of the Export Ban

The repeal of the ban is associated with a decline in sectors of the U.S. shipping industry related to the transport of crude oil, as demand for Jones Act tankers and barges to transport crude oil fell.[44] As previously noted, some domestic refineries—especially those on the East Coast without access to cheaper transportation options, such as pipelines—paid more to receive U.S. crude oil via Jones Act tankers and barges before the repeal of the ban, when U.S. crude oil was sold at a depressed price relative to foreign crude oil. However, after the repeal of the ban, the price of U.S. crude oil increased relative to the price of foreign crude oil, which decreased the demand for Jones Act tankers and barges compared to what it would have been had the export ban remained in place, according to six of the seven shipping industry stakeholders we interviewed. Specifically, exports of U.S. crude oil from the Gulf Coast rose by more than 200 percent from 2016 to 2017, and were likely shipped on foreign vessels for which operating costs are generally cheaper than Jones Act tankers and barges. Relatedly, shipments of U.S. crude oil by Jones Act tankers and barges from the Gulf Coast to the East Coast fell by 57 percent in 2016, according to EIA data.[45] At the same time, imports of foreign crude oil to the East Coast rose by 35 percent in 2016, likely to replace the decline in shipments of domestic crude oil from the Gulf Coast. Taken together, these two factors led to a decline in the demand for Jones Act tankers to transport U.S. crude oil from points within the United States in the years after the repeal of the ban.

Four of the seven shipping industry stakeholders we interviewed said that the decline in demand for the use of Jones Act tankers and barges to transport crude oil has primarily affected the shipbuilding sector. For example, after the repeal of the ban, one of the two remaining U.S.

[44]While the U.S. shipping industry is larger than just the transport of crude oil and refined products, for the purpose of this report, we use the term U.S. shipping industry when we are referring to sectors of the industry that specifically pertain to the shipping of these products.

[45]Crude oil transport from the Midwest to the East Coast also decreased after the crude oil export ban was repealed, as movement of crude oil by pipeline from the Midwest to Gulf Coast ports for export also increased. The EIA data we used for this analysis measures shipments by barrels of crude oil transported. In addition, the data do not specify whether these tankers and barges are Jones Act vessels but, as previously noted, the law requires that movement of products by ships between points in the United States must be on Jones Act vessels.

shipyards with the capability to build Jones Act tankers for crude oil transport experienced a 90 percent decrease in employment from its peak employment, according to one shipping industry representative we interviewed. In addition, the boom in the construction of tankers to transport stranded domestic crude oil prior to the repeal of the export ban left shipping companies with excess shipping capacity, which has since been used to transport other products (such as refined products), salvaged for parts, or idled, according to all seven shipping industry representatives we interviewed. One industry representative we interviewed explained that approximately 80 percent of the Jones Act fleet was built between 2007 and 2016, and since such vessels have a lifespan of approximately 30 years, it is unlikely that there will be a need to build new tankers in this decade given the decrease in demand. In addition, shipping companies that continue to operate Jones Act tankers to transport crude oil have been forced to significantly cut their shipping rates, according to five of the seven shipping industry stakeholders we interviewed. Finally, the decline in the number of vessels in operation also led to a decline in the number of mariners employed by shipping companies that operate Jones Act crude oil tankers and barges, according to six of the seven shipping industry stakeholders we interviewed.

In contrast, none of the shipping industry stakeholders we interviewed said that the repeal of the ban directly affected movement of refined petroleum products by Jones Act tankers and barges because, as previously noted, the repeal had limited effects on the production, export, and import of domestic refined petroleum products. Refined products are still shipped by Jones Act tankers and barges between some points in the United States, such as refineries in Texas and Louisiana to consumers in Florida, due to a lack of pipelines connecting these states.

Agency Comments

We provided a draft of this report to the Departments of Commerce, Defense, Energy, Labor, and Transportation for their review and comment. We received one technical comment from the Department of Commerce, which we incorporated.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretary of Commerce, Secretary of

Defense, Secretary of Energy, Secretary of Labor, Secretary of Transportation, and other interested parties. In addition, the report is available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.

Frank Rusco

Frank Rusco
Director, Natural Resources and Environment

Appendix I: Technical Explanation of Crude Oil and Refined Product Prices and Cost Spreads

Methodology

To determine whether, after the repeal of the oil export ban in December 2015, there were significant effects on producers of crude oil and refiners of petroleum products, we used monthly data from the U.S. Energy Information Administration (EIA) for January 2009 through March 2020 to analyze key product and crude cost and price differences, or spreads, in the five largest crude oil-producing states.[1]

Difference between First Purchase Price and Brent Crude Oil Price

To determine the effects on U.S. crude oil producers—in particular, whether U.S. producers received a significantly different price for their product relative to Brent crude, a global benchmark crude oil price—after the repeal of the oil export ban, we analyzed the (log) difference between the crude oil first purchase price and the Brent crude oil price:

$$s_{rt} = \ln(P_{rt}) - \ln(P_{bt}),$$

[1]As of December 2019, according to EIA, the largest crude oil-producing states (in descending order) are Texas, North Dakota, New Mexico, Oklahoma, and Colorado. These states produce over 80 percent of total U.S. crude oil.

where P_{rt} is the first purchase price at time t for the ith state and P_{bt} is our benchmark price, Brent.[2] In order to analyze these spreads, we used Step-Indicator Saturation (SIS), a methodology developed and described by Castle et al. (2015),[3] to find changes in previous unconditional means of data, known in the literature as “location shifts.” In particular, we were interested in whether there was a location shift in these spread variables after the lifting of the crude oil export ban at the end of 2015.[4]

Our SIS specification was:

$$s_{rt} = \mu_r + \sum_{j=1}^{T-1} \delta_j \, 1_{\{t \leq j\}} + \varepsilon_t, t = 1, \dots, T; r = 1, \dots, R.$$

In this model, $\delta_j 1_{\{t \leq \tau_j\}}$ are all the possible location shift terms with the $1_{\{t \leq \tau_j\}}$ function taking a value of 1 from $t = 1$ to $t = j$; μ is the mean under the null hypothesis of no location shifts; and $\varepsilon_t \sim IN(0, \sigma_\varepsilon^2)$ is an independently distributed normal disturbance term. This model is not feasible to estimate due to the number of parameters (T). The SIS estimation will select m <

[2]According to EIA, the first purchase price is the price from an equity (not custody) transaction of an arms-length transfer of ownership of crude oil associated with the physical removal of the crude oil from a property (lease) for the first time. A first purchase normally occurs at the time and place of ownership transfer where the crude oil volume sold is measured and recorded on a run ticket or other similar physical evidence of purchase. The reported cost is the actual amount paid by the purchaser, allowing for any adjustments (deductions or premiums) passed on to the producer or royalty owner. Using the log difference allows a convenient interpretation of the variable; namely, it is the proportional difference between the two variables.

[3]Castle, Jennifer L., Jurgen A. Doornik, David F. Hendry; and Felix Pretis. “Detecting Location Shifts during Model Selection by Step-Indicator Saturation.” *Econometrics*, vol. 3 (2015): pp. 240–264.

[4]Prior to our SIS estimation, we performed a standard set of tests for stationarity on the levels of each of the spreads, all of which rejected the null hypothesis of a unit root at the 5 percent level or better; that is, we found these variables to be stationary in their levels. In heuristic terms, a stationary variable is a variable whose mean and variance are constant over time. We used Adjusted Dickey-Fuller tests, for which the lag length was set using the Akaike criterion. Castle et al. derive their results assuming the variable of interest is stationary. We used the same stationarity tests for the spread variables that we analyzed, all of which rejected the null hypothesis of stationarity at the 5 percent level except for PADD 2 versus PADD 3 total acquisition costs in table 3 below, where the p-value was 6.4 percent.

(T-1) parameters, $\phi_{i,\alpha}$ for $i = 1$ to m for a given significance level α, thus our estimated model is

$$s_{rt} = \mu_r + \sum_{i=1}^{m} \phi_{i,\alpha}\, 1_{\{t \le T_i\}} + \nu_t, t = 1, \dots, T; i = 1, \dots, R,$$

where μ and $\phi_{i,\alpha}$ are the model's parameters and $\upsilon_t \sim IN(0, \sigma_\upsilon^2)$ is an independent identically distributed normal disturbance term. The SIS method selects m location (intercept) shifts and estimates each "Step", $\phi_{i,\alpha}$ at time τ_j. We used an α value of 1 percent to determine the location shifts.[5]

Crack Spread for First Purchase Price versus Spot Gasoline Price

To determine the effect of the repeal of the oil export ban on U.S. refiners of crude oil—in particular, whether their profitability was affected—we analyzed the (log) difference between the crude oil first purchase price and the New York Harbor Conventional Gasoline Spot price reported by EIA as our gasoline benchmark price. This difference is also known as the "crack spread," which we used as a proxy for profitability.[6] Again, we used SIS to establish whether there was a location shift in the crack spread after the crude oil export ban was lifted at the end of 2015. Our crack spread variable of interest was

$$c_{it} = \ln(G_{bt}) - \ln(P_{it}),$$

[5]According to Castle et al. (2015), "In this selection context, the null retention frequency of indicators is called the gauge by [16], [Castle et al. (2011)] akin to the size of a test denoting its (false) null rejection frequency but taking into account that indicators that are insignificant on a pre-assigned criterion may nevertheless be retained to offset what would otherwise be a significant misspecification test. Johansen and Nielsen [4] establish that using small nominal significance levels α, (e.g. $\alpha \le 0.01$) for selection in IIS [Impulse Indicator Saturation], despite testing T indicators, on average, αT are retained, so the gauge is approximately α …".

[6]The acquisition cost of crude oil measures the cost of crude paid by the refiner and so is likely a better variable to use in the crack spread. However, acquisition cost data are available only at the PADD (regional) level, as we discuss in the section on the limitations of our work in this appendix.

where G_{bt} is our gasoline benchmark price, the New York Harbor Spot price, and P_{it} is the first purchase price at time t for the ith location.

Crude Acquisition Costs for Refiners and Variation Across PADDs

To assess whether there was geographic variation in refiners' cost of acquiring U.S. crude oil, we analyzed the (log) difference between the domestic acquisition cost of crude in the Petroleum Administration for Defense District (PADD) regions relative to the main refining and production region, namely PADD 3 in the Gulf Coast Region.[7] We chose PADD 3 (Gulf Coast) as our base case since it contains over half the refining capacity in the United States. We used SIS to establish whether there was a location shift in the difference between a PADD's domestic acquisition cost of crude relative to PADD 3, after the crude oil export ban was lifted at the end of 2015. Our variable of interest was

$$r_{ijt} = \ln(d_{it}) - \ln(d_{3t}).$$

In this specification, r_{ijt} represents the log difference between d_{it} and d_{3t}, which represent domestic acquisition costs for PADDs i (i is either 1, 2, 4, or 5) and 3, respectively, at time t.

Results

Results for the Difference between Crude Oil First Purchase Price and the Brent Crude Oil Price

Our results for the top five oil-producing states are shown in table 1 and in figure 8, with the actual series values versus the fitted values of the spreads. In all these states except New Mexico, after the repeal of the crude oil export ban (vertical line), there was a significant jump in the spread value, indicating an increase in value of crude oil produced in these states relative to the Brent crude price. This step-up persists for some length of time beyond the time the crude oil export ban was lifted, and its duration varied depending on the location of the oil-producing state. In some locations, the increase effect lasted just over a year, and in

[7]In the body of the report, we refer to the PADDs by their regional name rather than their number. Here, we refer to them by their number: PADD 1 (East Coast); PADD 2 (Midwest); PADD 3 (Gulf Coast); PADD 4 (Rocky Mountain); and PADD 5 (West Coast), or use Figure 2 as a reference.

others between 2 and 3 years until the next significant drop in the domestic first purchase price relative to international price for (Brent) crude.

The results showing the presence of a location shift following the repeal of the oil export ban are presented in table 1. According to our analysis, the first purchase of crude, namely, the price that crude oil producers receive, shifted significantly by between about 4 percent and 8 percent, relative to the price of Brent crude in four of the five largest oil-producing states (Texas, North Dakota, Oklahoma, and Colorado). There was no statistically significant effect for New Mexico. In Colorado and North Dakota, after the lifting of the ban in December 2015, there was an initial downward location shift in the difference, but this was followed by a larger location shift increase in the difference in May and March 2016, respectively.

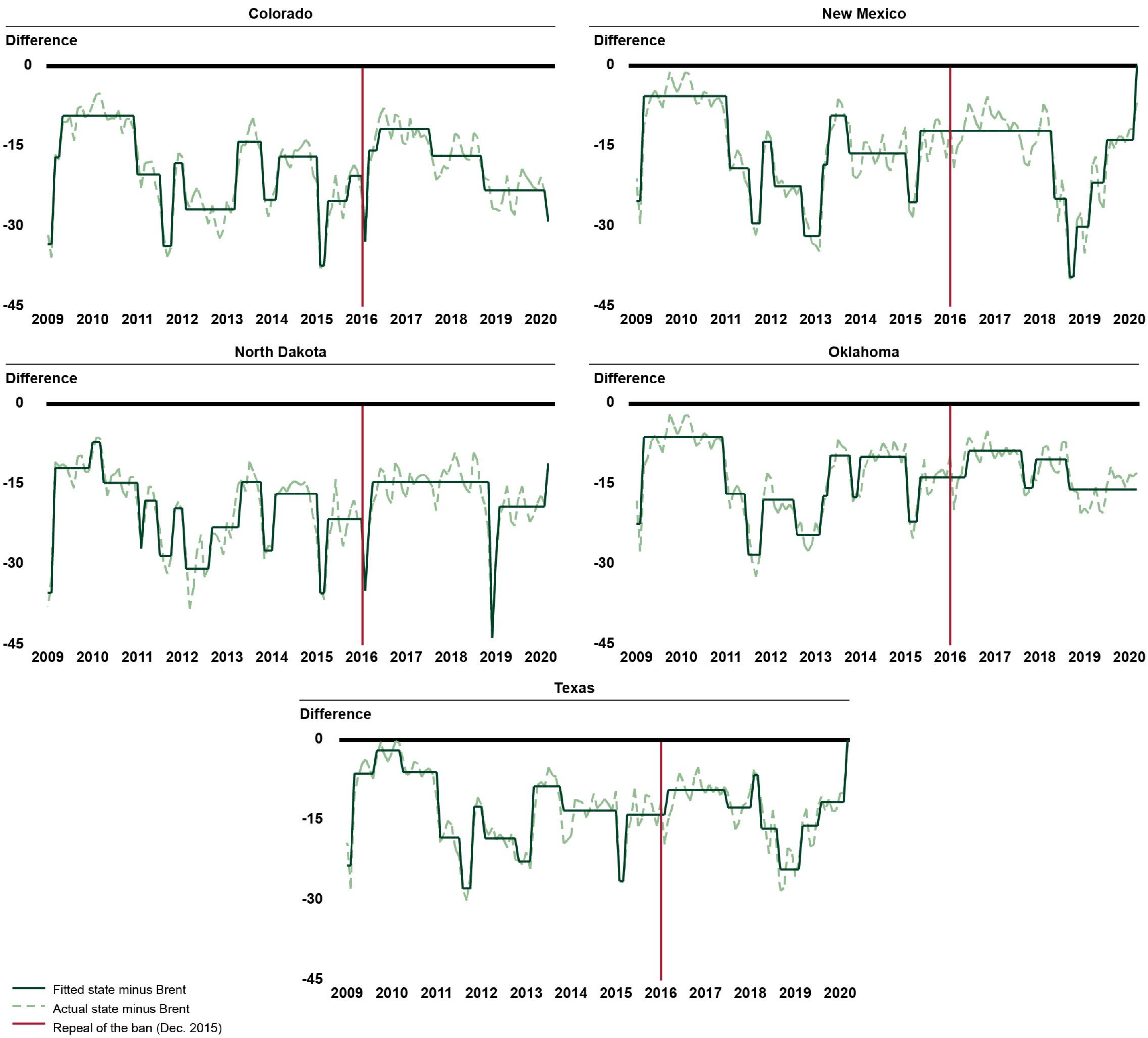
Table 1: Summary of Results for Spread between the States' First Purchase Price of Crude Oil and Brent Crude Oil Price Using Step-Indicator Saturation, January 2009 through March 2020

State	Month of shift	Shift (%)	Next downward shift
Colorado	May 2016	4.1	July 2017
New Mexico	No significant effect	-	-
North Dakota	March 2016	8.4	November 2018
Oklahoma	May 2016	4.9	August 2017
Texas	February 2016	4.6	June 2017

Source: GAO analysis of Energy Information Administration data. I GAO-21-118

Notes: The p-value or α used for the SIS estimation is 1 percent. The spread is the log difference between the two variables. The states in the table are the top five oil-producing states.

Figure 8: Percentage Log-Difference between First Purchase Price and Brent Crude Oil Price, by State, for Top Five Crude Oil-Producing States



Source: GAO analysis of Energy Information Administration data. | GAO-21-118

Results for the Crack Spread for Crude Oil First Purchase Price versus Spot Gasoline Price

In all five states, after the repeal of the crude oil export ban, there was a significant drop, or downward location shift, in the crack spread, indicating an increase in the value of crude oil produced in these locations relative to the price of gasoline on world markets. The results are presented in table 2 and in figure 9. Specifically, we found that in all five top oil-producing states, there was a significant drop of between about 9 percent and 17 percent in the difference between the price of gasoline and crude oil.[8]

Table 2: Summary of Results for Spread between the States' First Purchase Price of Crude Oil and New York Harbor Conventional Gasoline Price Using Step-Indicator Saturation, January 2009 through March 2020

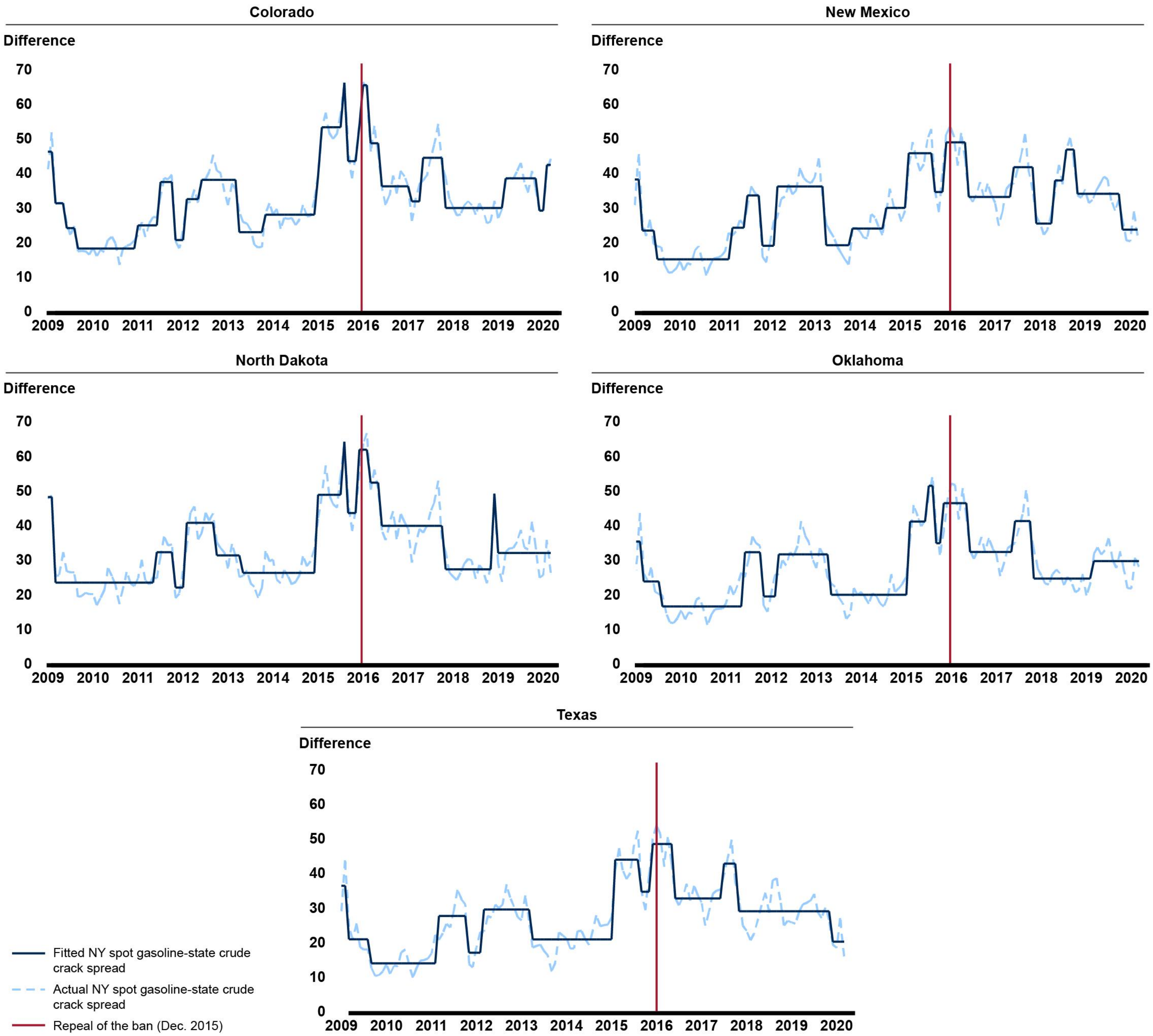
State	Month of shift	Shift (%)	Next upward shift
Colorado	February 2016	-16.8	April 2017
New Mexico	May 2016	-15.8	May 2017
North Dakota	February 2016	-9.5	November 2018
Oklahoma	May 2016	-14.1	May 2017
Texas	May 2016	-15.8	June 2017

Source: GAO analysis of Energy Information Administration data. I GAO-21-118

Notes: the p-value or α used for the SIS estimation is 1 percent. The spread is the log difference between the two variables. The states in the table are the top five oil-producing states.

[8]We also estimated this model at the PADD level replacing the first purchase price of crude with refiners' acquisition costs of crude. Our results were similar in terms of the direction and significance of the location shifts after the repeal of the crude oil export ban.

Figure 9: Percentage Log-Difference between New York Harbor Spot Gasoline Price and First Purchase Price, by State, for Top Five Crude Oil-Producing States



Source: GAO analysis of Energy Information Administration data. | GAO-21-118

Results for the Crude Oil Acquisition Costs for Refiners and the Likely Effect on Refining Margins – Variation across PADDs

The results from our SIS estimations, presented in table 3 and figure 10, showed a significant increase in PADD 1, 2, 4 and 5 domestic acquisition costs relative to PADD 3 after the repeal of the oil export ban. Domestic crude acquisition costs rose by between 2 percent and 9 percent, depending on the PADD, relative to PADD 3. In particular, in PADDs 1 and 4, they rose by 5.9 percent and 8.8 percent, respectively, relative to PADD 3.

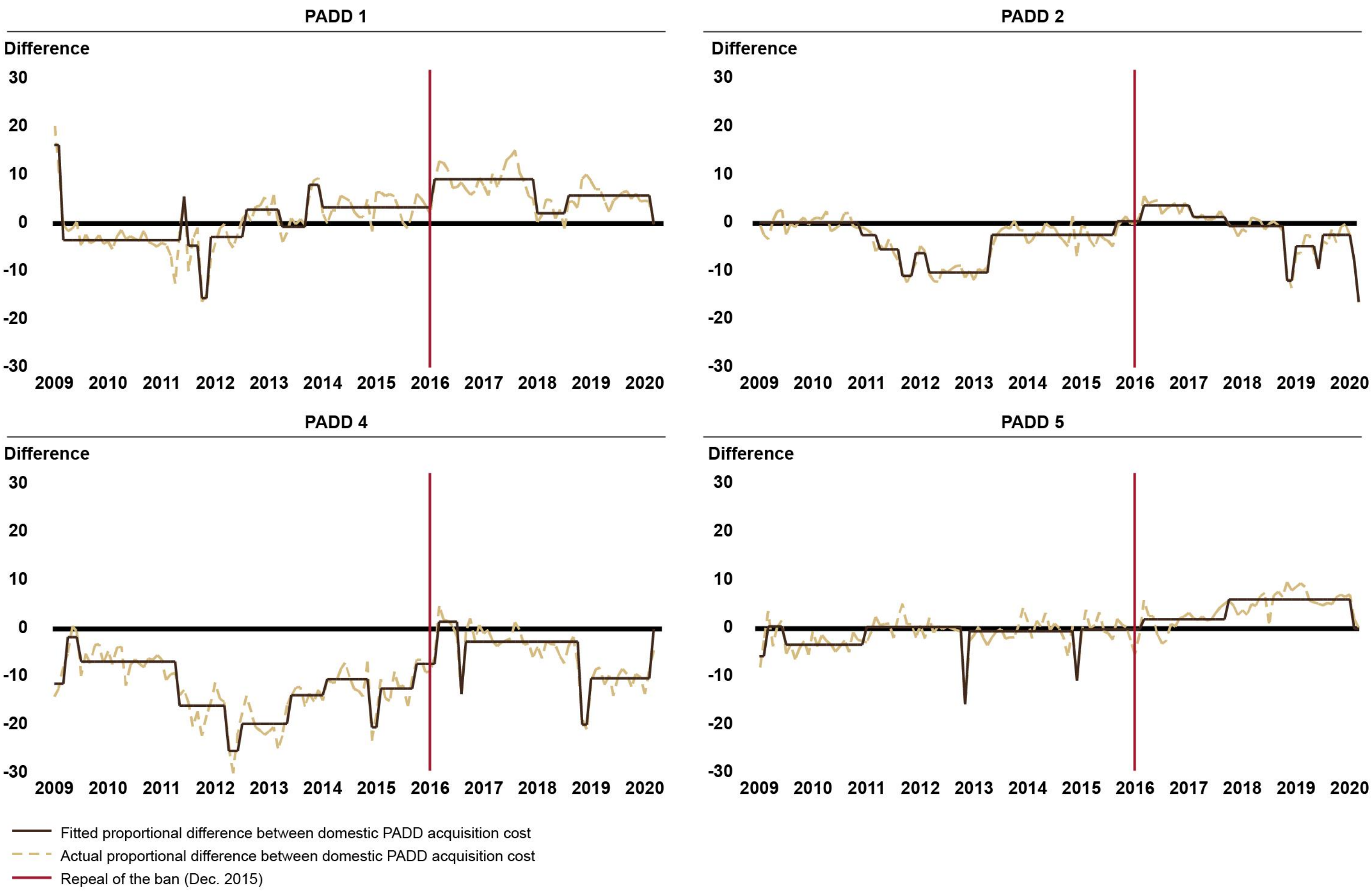
Table 3: Summary of Results for Spread between PADDs' Domestic Acquisition Costs relative to PADD 3 Using Step-Indicator Saturation, January 2009 through March 2020

PADD's	Month of shift	Shift (%)	Next downward shift
PADD 1 v PADD 3	January 2016	5.9	May 2017
PADD 2 v PADD 3	February 2016	3.3	January 2017
PADD 4 v PADD 3	February 2016	8.8	July 2016
PADD 5 v PADD 3	February 2016	2.1	September 2017

Source: GAO analysis of Energy Information Administration data. I GAO-21-118

Notes: The p-value or α used for the SIS estimation is 1 percent. The spread is the log difference between the two variables. The states in the table are the top five oil-producing states.

Figure 10: Percentage Log-Difference in Domestic Acquisition Costs for PADDs 1, 2, 4, and 5 relative to PADD 3



Source: GAO analysis of Energy Information Administration data. | GAO-21-118

Limitations

The SIS analysis contains no explanatory variables other than the location shift variables. Thus, the results can only be seen as generating a statistical association between the timing of the lifting of the crude oil export ban and change in spread values.

There are many factors that may influence price spreads, such as the difference between first purchase prices and the Brent crude oil price. These factors include transportation costs, new product pipelines, changes in government policies, technological changes, and other changes in economic circumstances. Our analysis does not control for these factors, and we acknowledge the possibility of location shifts near the start of 2016 as being coincidental with these other factors. In addition, there may be lags of the effects of key economic events such as the lifting of the crude oil ban on the prices and production of petroleum products.

The data for first purchase price are aggregated at the state level. In states such as Texas, there may be significant intra-state price variation, which the data do not capture. This variation is especially an issue for the acquisition cost data, which are only available at the PADD (regional) level.

We used the first purchase price in the crack-spread formula. Ideally, the acquisition cost of crude should be used because that measures the amount refiners pay for crude as compared with the first purchase price, which measures what crude oil producers receive for crude. However, the acquisition cost data are only available at the PADD (regional) level. Given our concerns about aggregating across large areas, we used state-level purchase price data even though it is a less accurate measure of refiners' cost of crude.

Appendix II: Accessible Data

Data Tables

Data table for Highlights Page Annual Production and Exports of U.S. Crude Oil, 2009-2019

Year	US Crude Oil Exports	US Crude Oil Production
2009	0.043667	5.356
2010	0.04175	5.484833
2011	0.046833	5.66475
2012	0.067333	6.517417
2013	0.134333	7.491167
2014	0.350833	8.783333
2015	0.464583	9.4395
2016	0.59075	8.839417
2017	1.158333	9.350833
2018	2.046583	10.98667
2019	2.97825	12.24508

Data Table for Figure 7: U.S. Crude Oil Production by Region, Annually from 2009 through 2019

Year	PADD 1 Crude Oil Production	PADD 2 Crude Oil Production	PADD 3 Crude Oil Production	PADD 4 Crude Oil Production	PADD 5 Crude Oil Production
2009	0.015083	0.590167	1.550583	0.36375	1.214917
2010	0.019917	0.692167	1.63475	0.375	1.15025
2011	0.021833	0.8355	1.939833	0.395667	1.1005
2012	0.025667	1.146833	2.516417	0.448417	1.065917
2013	0.041167	1.418667	3.132417	0.531417	1.061167
2014	0.054083	1.742167	3.817333	0.663833	1.058167
2015	0.057917	1.900917	4.144167	0.755	1.035333
2016	0.044	1.67825	3.833917	0.668583	0.99925
2017	0.04975	1.732083	4.179667	0.7225	0.971
2018	0.055167	2.030917	5.298	0.888667	0.94325
2019	0.069417	2.225667	6.169583	0.962833	0.908917

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Frank Rusco, (202) 512-3841 or ruscof@gao.gov

Staff Acknowledgments

In addition to the contact named above, Christine Kehr (Assistant Director), Michael Kendix (Assistant Director), Amy Ward-Meier (Analyst in Charge), Kevin Bray, Colleen Candrl, Ming Chen, Gita Devaney, Marissa Dondoe, John Delicath, Quindi Franco, Cindy Gilbert, Greg Marchand, John Mingus, Sheryl Stein, and Sara Sullivan made key contributions to this report.

Congressional Relations

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