Lifting the U.S. Crude Oil Export Ban: Prospects for Increasing Oil Market Efficiency

By Nida Çakır Melek and Elena Ojeda

Over the past decade, U.S. shale oil has substantially changed the nation's energy landscape. The introduction of hydraulic fracturing and horizontal drilling has led to a dramatic increase in shale oil production that has ushered the United States from an era of relative oil scarcity into an era of relative oil abundance. As oil production increased, domestic oil producers began to look for export opportunities. However, until recently, these producers faced export restrictions due to a longstanding federal ban on most crude oil exports. The shale boom put a spotlight on the export ban, as it contributed to an oil glut depressing domestic crude oil prices relative to international prices. Fears of persistent oil price discounts led to calls to lift the oil export ban. In December 2015, the 40-year-old ban was lifted.

In this article, we use aggregated and disaggregated oil market data to explore distortions highlighted by the export ban and potential efficiency gains from the lifting of the ban. We find that together, the shale oil boom and the oil export ban interacted to distort oil trade flows and prices, leading to an inefficient oil market. Although U.S. oil exports were increasing before the ban was lifted, they were flowing mainly to Canada, which was exempt from the ban. As a result, Canada reduced its imports from the rest of the world significantly.

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We also find that repealing the export ban created opportunities for increased trade and efficiency in the oil market. Once the ban was lifted, U.S. oil exports rose despite declining U.S. oil production and small oil price differentials. In addition, U.S. oil exports shifted from Canada to a variety of new destinations, and Canada's oil imports from the rest of the world increased.

Section I describes key features of global oil markets. Section II briefly reviews government restrictions on U.S. oil markets with particular attention to the introduction of the export ban and its exemptions. Section III examines market distortions created by the shale oil boom and the export ban. Section IV investigates efficiency gains resulting from the removal of the ban.

I. Key Features of Oil Markets

Crude oil is not a homogeneous good. It is produced in many different regions domestically and globally, and comes out of the ground with different qualities. One common, simple way to differentiate types of crude oil is by their American Petroleum Institute (API) gravity or density. Oil is typically categorized into three types according to its API gravity: light, medium, and heavy.[1] For simplicity, we consider light and heavy oil in this article. We assume light crude to have an API gravity above or equal to 35° and heavy crude to have an API gravity less than 35°.[2]

Certain crude oils are used as benchmarks for pricing other oils with similar characteristics. For example, prices for West Texas Intermediate (WTI)—a light, sweet crude oil produced in the middle of the United States and priced at the Cushing, OK, trading hub—are used as a benchmark for pricing other types of oil produced in North America (U.S. Energy Information Administration (EIA) 2014c). Louisiana Light Sweet (LLS), an oil produced in the Gulf Coast, is of similar quality to WTI and typically trades at a slight premium to WTI (20 cents per barrel). The most common international benchmark price is North Sea Brent. Brent is a blend of light oils produced in four different areas of the North Sea. WTI and Brent are similar in quality, and Brent typically trades at a slight discount to WTI due to the delivery costs to transport Brent to the U.S. market.

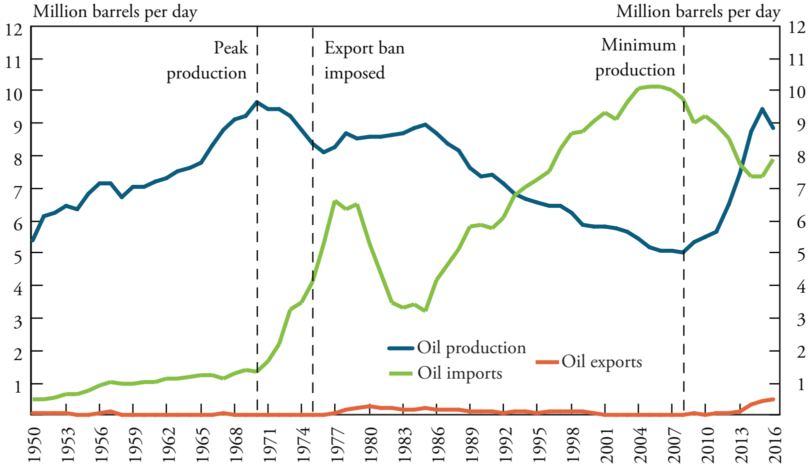
Transportation factors into the cost of crude oil when it is moved to a refinery to be converted into useable petroleum products such as gasoline or diesel fuel. Refineries are costly to build, and they specialize in processing certain kinds of oil.[3] The United States has the world's second-highest refining capacity—20.6 percent of 2014 global refining capacity, according to the *Oil & Gas Journal*—and most domestic refineries are complex, specializing in processing medium to heavy oil. For instance, more than half of the United States' refining capacity is concentrated in the Gulf Coast region, and refiners there are particularly complex, primarily configured to process heavy oil.[4] East Coast refiners, on the other hand, are primarily configured to process light oil. Oil producers thus must transport their oil to its appropriate refinery. Pipelines are the most common and cost-effective mode of transportation, but alternative methods such as rail and truck are also used.

In an efficient oil market, differences in the prices of crude oil would reflect not only quality differences but also transportation costs. The U.S. EIA reports refiner acquisition costs (RAC) as the total cost of crude oil plus transportation and other fees that the refiner pays for domestic and imported crude oil. Historically, the RAC has varied very little between U.S. regions—until the shale oil revolution.

II. Government Restrictions on Oil Including the Export Ban

The export ban was not the first government intervention in the U.S. oil market. Long before the mid-2000s shale boom, several events changed the U.S. oil market and gave rise to government controls on imports, exports, and prices. Chart 1 shows annual movements in U.S. oil production, exports, and imports from 1950 to 2016. From 1950 to 1957, U.S. production of crude oil increased by 33 percent. Meanwhile, U.S. imports more than doubled as new cheap oil from the Middle East reached the market (Bordoff and Houser). Concerned about the nation's growing dependence on imported oil, Congress authorized the Mandatory Oil Import Quota Program in 1959, restricting imports (McNally). From 1959 until 1970, domestic crude oil production increased by 2.58 million barrels per day, and net imports of oil increased by 0.4 million barrels per day. In 1970, annual oil production peaked at 9.6 million barrels per day. The program ended in 1973.

Chart 1
U.S. Oil Production, Oil Exports, and Oil Imports



Note: Minimum production indicates the lowest production level since 1950.
Source: U.S. EIA.

The 1970s were a pivotal decade for the U.S. oil market.[5] Although U.S. consumption was growing, production was beginning to decline. As a result, net oil imports rose significantly in the 1970s after the import quotas were relaxed. In 1973, the Organization of Arab Petroleum Exporting Countries (OAPEC) proclaimed an oil embargo against the United States, leading to dramatic changes in the oil market. The embargo removed 5 million barrels of oil per day from the market, sparking fears about an energy shortage in the United States, as domestic supply was not expected to keep up with demand. In response, Congress passed the Emergency Petroleum Allocation Act (EPAA) of 1973 (Bordoff and Houser). The EPAA restricted exports of oil and refined products by subjecting them to regulation and licensing. It also extended 1971 policies on domestic oil price controls but left imported foreign oil prices unregulated. To further strengthen export restrictions, the Energy Policy and Conservation Act (EPCA) of 1975—commonly known as the crude oil export ban—was signed into law.

The EPCA effectively banned exports of crude oil but gave the president discretion to allow exports that were in the national interest.[6] In fact, several exemptions to the export ban were implemented in the national interest. In 1981, an exemption for refined petroleum products was implemented and licensing requirements were dropped. Oil exports from Alaska's Cook Inlet and North Slope were allowed in 1985 and 1996, respectively. Exports of heavy California crude oil of up to 25,000 barrels per day were allowed in 1992. Oil exports to Canada were partially allowed in 1985 and completely allowed in 1988—though the exemption required exports to be used or consumed within the country. Finally, re-exports of any foreign-produced crude oil were also allowed, provided they were not mixed with U.S.-produced oil.[7]

As a result of both the OAPEC oil embargo and the EPAA's price controls, the price of U.S. crude oil fell below international prices and domestic production slowed. To keep up with demand, crude oil imports doubled from 1973 to 1977. However, demand—and, consequently, imports—fell from 1978 to 1983, when the Iranian revolution led to a loss of production and a subsequent increase in oil prices. In response to the sharp increase in oil prices, President Reagan removed the EPAA's federal price controls in 1981. While removing price controls allowed domestic production to increase slightly, demand continued to fall.[8] By 1983, imports had fallen back near their 1973 level.

III. Market Distortions Created by the Shale Oil Revolution and the Oil Export Ban

From 1975 to 2008, U.S. oil production declined by almost 50 percent and the United States became the world's largest oil-importing country. Specifically, U.S. imports of crude oil increased from 1.3 million barrels per day in 1970 to more than 10 million barrels per day in the late 2000s, exceeding its 1970s peak. Over the same period, U.S. oil exports averaged only 0.1 million barrels per day. Due to falling oil production, the export ban had little discernible effect. In effect, the export ban was a nonbinding restriction on U.S. exports.

However, the shale oil revolution—a product of advances in technology such as horizontal drilling and hydraulic fracturing or "fracking"—dramatically changed U.S. oil market conditions. As these two technologies took hold, U.S. oil production rose back to its 1970s highs. From 2008 to 2015, production increased by 4.4 million barrels per day, and in 2015, annual domestic oil production reached 9.4

million barrels per day, its highest level since 1972. This dramatic increase in production in a short time brought significant challenges, as neither the transportation system nor refineries were prepared for the sudden flood of domestic oil. The ban only aggravated these issues, as producers could not export their abundant oil except to Canada, distorting prices and oil flows.

Price distortions

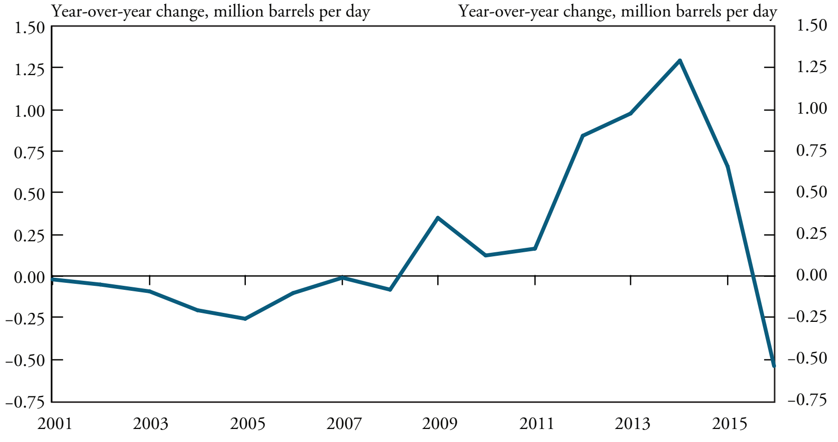
Over the past 10 years, domestic oil production soared without a clear outlet. Chart 2 shows that U.S. crude oil production began increasing in 2008 and accelerated in 2012. From 2011 to 2014, production increased on average by over 0.8 million barrels per day, nearly six times the average year-over-year increase from 2008 to 2011. The accelerated increase over 2011–14 was due in part to high and stable oil prices, which helped boost production from high-cost shale fields (Çakır Melek 2015). Production continued to increase in 2015 but at a slower pace.[9] Notably, almost all of the increase in oil production from 2011 to 2015 was in light grades coming largely from shale oil formations. Production of heavy crude oil was mostly flat throughout this period. As of 2015, light crude oil accounted for about 72 percent of total production.

The rapid increase in shale oil production led to supply bottlenecks, since existing transportation modes were not able to handle the added volume. These bottlenecks in turn depressed U.S. inland oil prices—for instance, insufficient pipeline capacity led to a sharp increase in oil stocks held in Cushing, OK. By 2011, the glut of oil had created a sizable discount in prices for U.S. benchmark WTI relative to coastal crude oil such as LLS, which was not subject to the same transportation constraints. The discount on WTI relative to LLS reached as high as $27 per barrel in 2011, far exceeding the historical discount (Chart 3).

Large price differentials suggest these transportation constraints led to decreased oil market efficiency. As price arbitrage opportunities emerged, inland producers began looking for alternative transportation methods. A higher-than-usual price spread drove some to use more expensive transportation modes such as rail (Çakır Melek and Wilkerson). As new infrastructure—pipelines and storage facilities—were completed, transportation bottlenecks improved and corresponding price gaps

Chart 2

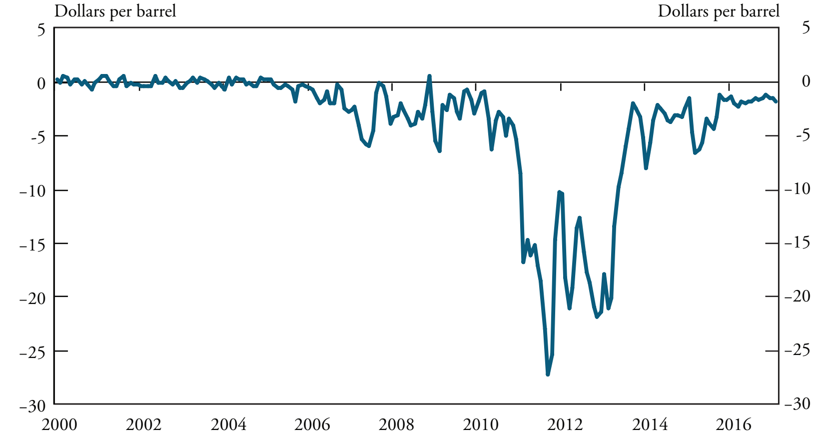
Change in U.S. Oil Production



Source: U.S. EIA.

Chart 3

WTI-LLS spread



Source: Bloomberg.

closed. However, the supply glut has persisted due to sustained growth in production.

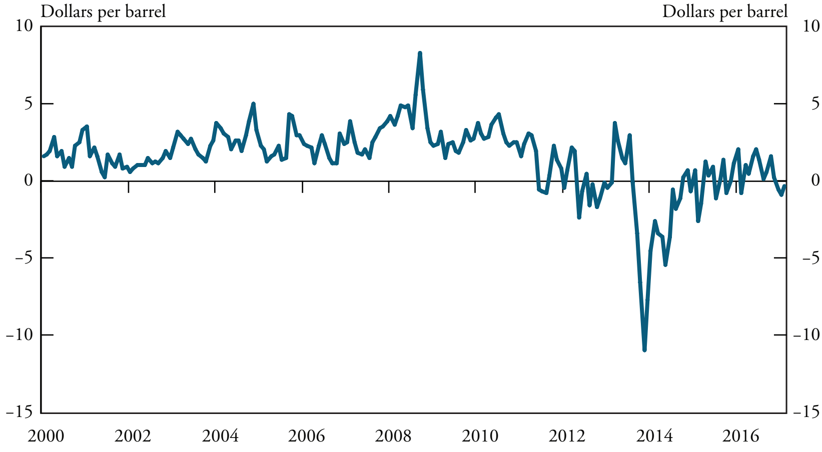
Additionally, the shale boom highlighted a mismatch between refinery configuration and U.S. light oil production. Most domestic refineries specialize in processing medium to heavy oil, and the United States did not substantially increase its capacity to process light oil after the shale boom. Instead, refiners reacted to the supply growth by increasing their utilization rate to above-average levels and by changing the composition of their imports as much as they were able.[10] Therefore, exports of petroleum products soared, as the export ban did not apply to refined petroleum products. In 2011, the United States became a net petroleum products exporter. Consequently, declining net oil imports and increasing net exports of petroleum products contributed to higher energy net exports in real GDP (Hakkio and Nie).[11]

Even after transportation constraints eased, the mismatch between U.S. refinery configuration and domestic crude production, combined with restrictions on oil exports, distorted the market and added to existing inefficiencies. For instance, prior to the light oil boom, LLS, which is similar in quality to Brent, WTI, and Bakken crudes, typically traded at a premium to Brent (Chart 4). However, in late 2013, LLS traded at a discount of almost $11 per barrel driven by both domestic and global factors. The relief of transportation bottlenecks in the middle of the country caused more light oil to flow to the Gulf Coast, which, along with seasonal refinery maintenance, put downward pressure on LLS prices (Border and Houser). Furthermore, a declining supply of light sweet crude from Libya caused Brent prices to rise, resulting in a significant discount for LLS. Because of the export ban, the United States could not export excess light oil to meet foreign demand. Therefore, the U.S. export ban appears to have contributed to price distortions.[12]

Distortions of oil flows

The export ban appears to have distorted oil trade flows as well. Exports to Canada, which were exempt from the crude oil export ban, seemed to provide an outlet for some of the excess supply. From 2008 to 2012, exports of U.S. crude oil increased modestly, averaging around 0.05 million barrels per day over this period. However, as the

Chart 4
LLS-Brent Spread



Source: Bloomberg.

shale boom kicked in, oil exports took off, rising from 0.07 million barrels per day in 2012 to 0.6 million barrels per day by early 2015 (Chart 5). Widening price spreads between international crude oils (such as Brent) and domestic crude oils (such as WTI) further bolstered exports, since U.S. crude was trading at a sizable discount relative to oil produced elsewhere.[13] Although oil prices began to decline in mid-2014, both production and exports continued to increase until April 2015.[14] Production and exports then generally declined until December 2015, when the export ban was lifted.

Chart 5 shows that before the export ban was lifted, almost all U.S. exports went to Canada. In fact, from January 2008 to March 2014, exports to Canada were 99.7 percent of total U.S. oil exports. From April 2014 to December 2015, however, the United States exported modest amounts of crude oil to destinations other than Canada, including re-exported volumes of foreign crude or exports of Alaskan crude. For example, on average, from April to July 2014, 5 percent of exports were Canadian-produced barrels—not mixed with U.S. oil—that moved through the United States before being re-exported to Spain, Singapore, Italy, and Switzerland (U.S. EIA 2014b). Although the United States exported oil to 11 different destinations other than Canada from

Chart 5
U.S. Exports of Crude Oil

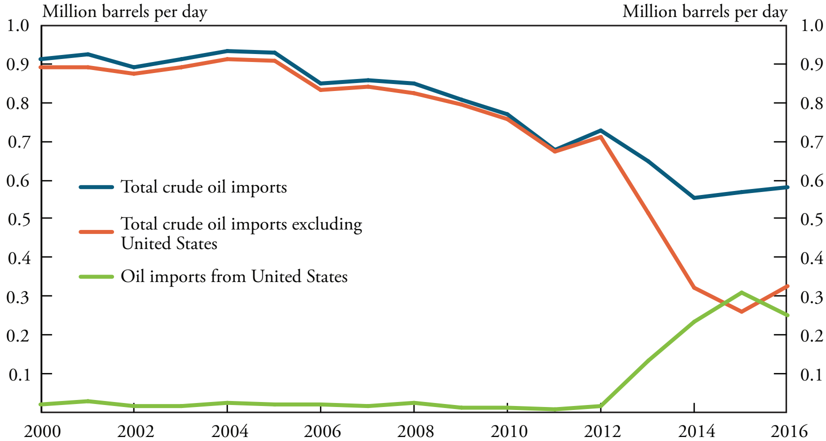
Source: U.S. EIA.

April 2014 to December 2015, Canada still received 92 percent of U.S. exports on average over this period.

The Canadian exemption to the export ban allowed U.S. exports of crude oil to flow to Canada and displace oil exports from other countries, potentially distorting trade flows. Since Canada is a large, geographically close trading partner, it is not surprising that U.S. exports would flow to Canada. Moreover, eastern Canadian refineries are mostly configured to process light oil, so it seems logical for the United States to export to Canada. However, once shale production took off and the export ban became a binding constraint, the United States likely exported to Canada simply because it was the only major country with an exemption from the ban. In this way, the Canadian exception to the U.S. crude oil export ban may have diverted oil exports from other countries to Canada.

Chart 6 shows that Canadian imports from the United States indeed displaced Canadian imports from other countries, providing further evidence of trade distortions. Canada's total oil imports were generally flat in the early 2000s and then declined on average 5 percent per year from 2006 to 2014, due in part to increasing Canadian production. However, Canadian imports from the United States show a sharp break from trend in 2012, a time when U.S. oil production took off. Before 2012, Canadian imports from the United States were flat and essentially zero.

Chart 6
Canadian Oil Imports

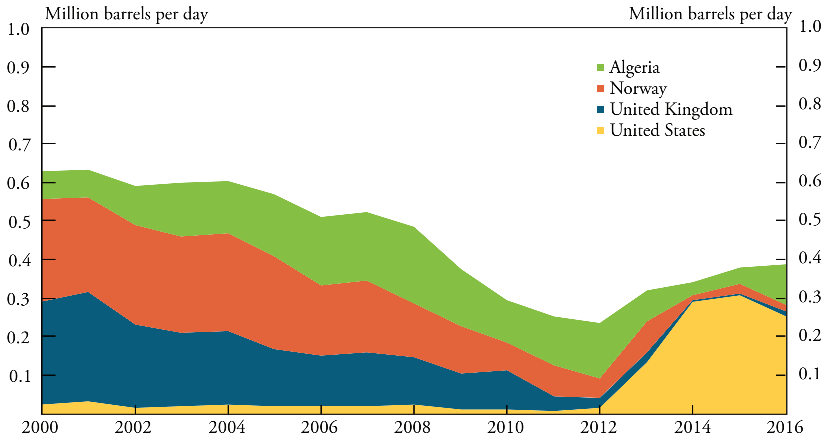


Sources: Statistics Canada and authors' calculations.

After 2012, imports from the United States spiked, even though total Canadian oil imports continued to decline. The share of U.S. imports in total Canadian imports increased from an average of 2 percent over 2000–11 to 42 percent in 2014 and continued to increase in 2015. Imports from other countries declined sharply over the same period.

As an oil exporter producing increasing amounts of crude oil, why would Canada need to import oil from the United States? The answer lies in both the type of crude produced and the locations of production and refineries. First, heavy oil produced in Canada, especially in western Canada, is highly viscous and typically blended with light oil to enable it to flow through pipelines. Thus, as Canada's heavy oil production grew, its demand for light oil may also have grown. Second, refineries in eastern Canada have limited access to western Canadian production or are configured to refine light crude oil (U.S. EIA 2013b). As U.S. production of light oil increased, especially in North Dakota and Texas, refiners in eastern Canada began replacing imports of Atlantic Basin oil with lower-priced U.S. oil, thereby increasing U.S. exports from the Gulf Coast and East Coast.[15] This trade replacement could reflect trade diversion or a shift from higher-priced imports to lower-priced imports from the United States.[16]

Chart 7
Top Origins of Canadian Oil Imports



Note: The top four destinations accounted for 57 percent of total imports on average from 2000 to 2016.
Sources: Statistics Canada and authors' calculations.

Prior to 2013, Canada imported oil primarily from Norway, Algeria, and the United Kingdom. Chart 7 shows that imports from all three countries had been on a declining trend since the early 2000s. However, the rise in U.S. imports accelerated the decline, especially for U.K. imports. Canadian pipeline reversals, as well as opportunities to move oil by rail, enabled Canadian refineries to process more U.S. crude oil and thereby displace other Atlantic Basin crudes.[17]

IV. Oil Market Efficiency Gains after the Removal of the Ban

The export ban appears to have distorted both U.S. and Canadian oil flows and contributed to price distortions by sustaining domestic oversupply. Consequently, U.S. producers pushed for a repeal of the oil export ban, arguing that allowing exports of U.S. oil would help eliminate the domestic price discounts. Increasing U.S. oil production in the 2010s dialed up pressure on lawmakers to remove the ban, but it was a persistent drop in oil prices that triggered its ultimate removal.[18] In December 2015, Congress passed a bill authorizing oil exports as a component of a larger spending and tax measure that included extensions of solar and wind energy tax credits (Harder and Cook).[19] The bill amended the EPCA and effectively repealed the oil export ban. It also included a provision allowing the president to restrict oil exports for up to one year under certain circumstances.[20]

Despite global oversupply and falling U.S. oil production in 2016, U.S. oil exports grew 12 percent more than their 2015 average. Likewise, the number and variety of destinations for exports increased dramatically despite a narrower Brent-WTI price spread. Moreover, the multi-year declining trend in Canadian imports from the rest of the world reversed in 2016, and total imports excluding the United States increased significantly. Together, these developments suggest the oil market became more efficient after the removal of the U.S. export ban.

Efficiency gains from the lifting of the ban: evidence from U.S. and Canadian oil flows

Around the time the export ban was lifted, oil prices were low, and price spreads were narrow. At the same time, U.S. oil production was falling. In 2016, U.S. production posted its first year-over-year decline in eight years (see Chart 2). In light of these events, the removal of the ban might be expected to have a negligible effect on exports.

However, U.S. oil exports have continued to increase since the removal of the ban (see Chart 5). Monthly oil exports increased from 0.39 million barrels per day in December 2015 to 0.44 million barrels per day in December 2016, accounting for 5 percent of December U.S. oil production. Although growth in exports slowed in 2016 relative to 2014 and 2015, the level of exports was still greater than in the previous two years despite a 6 percent year-over-year decline in U.S. oil production. In 2016, U.S. oil exports were 12 percent higher than their 2015 average. Overall, the increase in oil exports after the ban was lifted—during a period of falling U.S. oil production and excess global supply—is evidence that the export ban distorted oil trade flows. Its removal increased efficiency by eliminating these distortions.

Additional evidence for fewer distortions and increased efficiency is that while total U.S. oil exports increased after the ban was lifted, exports to Canada decreased. The blue line in Chart 8 shows that on average, the United States shipped about 61 percent of its oil exports to Canada in 2016, well below its share in 2014 (95 percent) and 2015 (92 percent). In March, May, September, and December 2016, U.S.

crude oil exports to countries other than Canada surpassed exports to Canada. Once the United States could export to countries other than Canada, it did.

The green bars in Chart 8 present the total number of U.S. export destinations. The United States exported oil to 26 countries including Canada in 2016, more than triple the number of destinations in 2014 and almost triple the number of destinations in 2015. Chart 9 shows U.S. oil exports to all (new or existing) trading partners other than Canada for 2015 and 2016. Blue bars indicate 2015 average exports, while green bars indicate 2016 average exports. The blue outlines on some green bars denote countries that imported U.S. oil prior to 2015.[21] Thus, countries with no blue bars or blue outlines received U.S. oil exports for the first time after the export ban was removed. The chart shows that in 2016, 15 out of the United States' 25 trading partners were first-time export destinations.

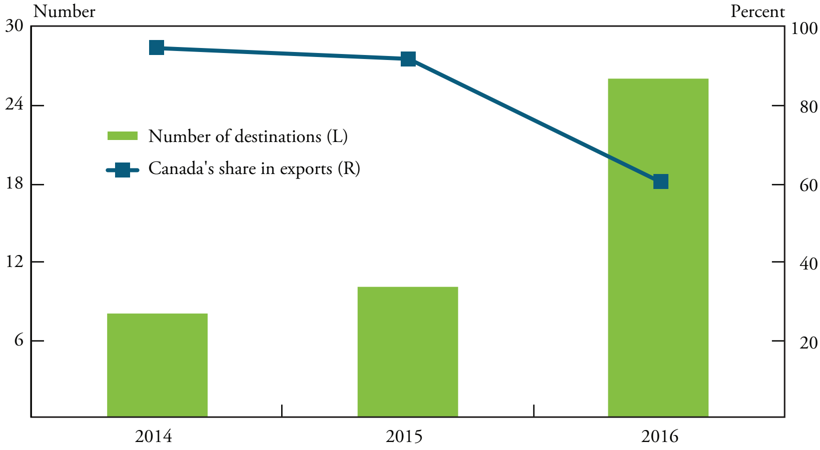
Among the new destinations, Curacao and the Marshall Islands imported the most U.S. oil. Curacao, a Caribbean island and the fourth-largest non-Canadian importer, likely imported U.S. crude to be used as a diluent in a Venezuelan state-owned oil company refinery (U.S. EIA 2016). The Marshall Islands, on the other hand, seem unlikely to be the final destination. According to the EIA, the Marshall Islands may be a location of ship-to-ship transfers for delivery to buyers in Asia. Finally, some new trading partners are taking in comparatively small volumes of U.S. oil. These destinations may have been added due to discounts from U.S. sellers to test the crude's compatibility with foreign refineries in the hope of continued future purchases. Such sporadic purchases could happen despite narrow price spreads.

While the 15 new destinations undoubtedly gave U.S. exports a boost, exports to existing trading partners were also larger in 2016 than in 2015. Exports to previous trading partners, except Brazil, increased dramatically after the ban was removed. For instance, exports to Singapore, the third-largest non-Canadian importer, increased fivefold from 2014 to 2016. Likewise, exports to the Netherlands, the largest importer of U.S. oil excluding Canada, more than doubled from 2015 to 2016 despite a narrowing of the WTI-Brent discount.[22]

Lower transportation costs could be another factor supporting exports. The oil tanker market was sluggish during 2009–13, due in

Chart 8

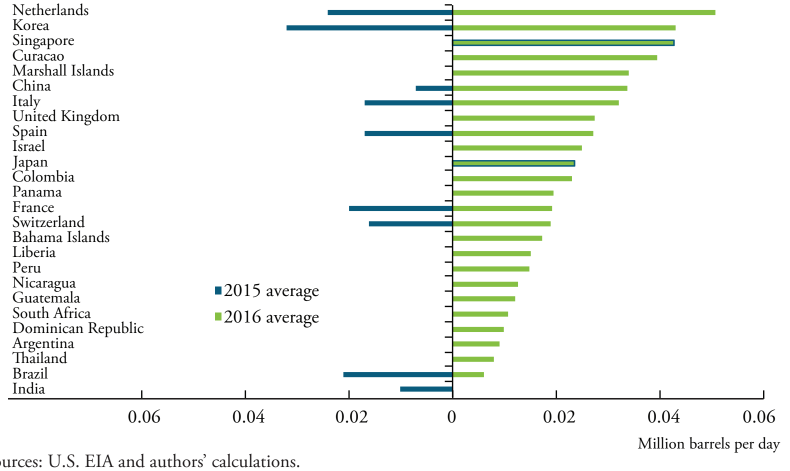
U.S. Export Destinations and Canada's Share in U.S. Exports



Sources: U.S. EIA and authors' calculations.

Chart 9

U.S. Export Destinations Excluding Canada before and after the Lifting of the Ban



Sources: U.S. EIA and authors' calculations.

part to high oil prices dampening trade (Rana). In 2014 and 2015, lower oil prices increased demand for tankers and supported tanker rates. For example, tanker freight rates for a key route from the Arab Gulf to Asia averaged \$6.94 per ton during 2009–13; in 2015, these rates increased to an average of \$10.50 per ton, higher than the long-term average. However, in 2016, tanker rates dropped near 2009 lows and averaged \$7.20 per ton, due in part to tanker oversupply.

Finally, a multiyear declining trend in Canadian oil imports from the rest of the world reversed in 2016, providing further evidence that the export ban distorted trade flows, and that its removal hence increased efficiency (see Chart 6). While imports from the United States declined after the U.S. export ban was lifted, Canadian total oil imports excluding the United States increased significantly, especially from Algeria (see Charts 6 and 7). The increase in Canada's total oil imports suggests greater efficiency in the oil market following the removal of the U.S. export ban. More specifically, it suggests free trade reversed trade diversion.

Efficiency gains from the lifting of the ban: evidence from oil price spreads

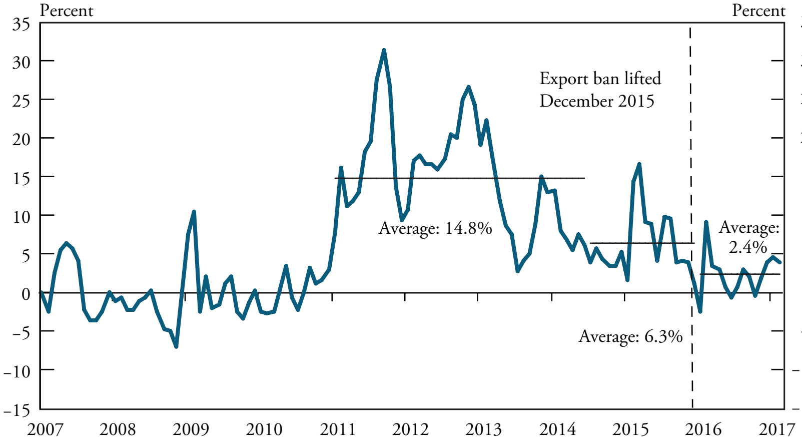
Oil price spreads narrowed further following the removal of the ban, another potential sign of improved oil-market efficiency. Rising inventories both domestically and globally and weak global oil demand had already caused oil prices and spreads to decline for much of 2015. But after the ban was lifted, price spreads declined further. The Brent-WTI price spread as a percent of WTI prices dropped from 1.32 percent in December 2015 to –2.35 percent in January 2016. The spread averaged 2.12 percent over 2016, well below the 2011 to mid-2014 and mid-2014 to December 2015 averages, which might suggest improved efficiency after the removal of the ban (Chart 10). However, price data provides a murkier case for increased efficiency: narrowing spreads might simply be driven by falling oil prices.

IV. Conclusion

Although the U.S. ban on crude oil exports had little discernible effect when it was first introduced, it became a binding constraint after the shale oil boom. The shale boom dramatically increased U.S. oil production, but transportation constraints and refinery mismatch weighed on domestic prices, creating market distortions. Additionally,

Chart 10

Brent-WTI Spread



Sources: Bloomberg and authors' calculations.

the export ban limited exports to destinations other than Canada, distorting oil trade flows. While exports did increase during the boom, they increased only to Canada, displacing Canadian oil imports from other countries. After the export ban was lifted, oil trade patterns changed and contributed to greater efficiency in the oil market. U.S. oil exports increased despite falling production, and U.S. oil exports flowed to a variety of new destinations. Moreover, Canada's multiyear declines in oil imports from countries other than the United States also reversed, while its imports from the United States declined.

Future implications of the removal of the ban will depend on the path of oil prices, domestic oil production and consumption, and technological advances. Recent forecasts suggest oil prices will increase steadily through 2020 but remain below $80 per barrel (U.S. EIA 2017). U.S. oil production is also expected to increase, with growth projected to come almost exclusively from shale oil. As a result, the level of oil exports is likely to continue to rise as it has since the ban's removal, as domestic refineries are likely to have limited demand for light oil. These exports will likely continue to reach countries other than Canada. But for exports to substantially increase, U.S. crude oil would need to trade at a wider discount to oil produced elsewhere—a discount that will only be realized if U.S. production rises significantly.

Endnotes

[1]The U.S. Energy Information Administration categorizes oil by API gravity as follows: heavy oil has an API gravity less than or equal to 27°, medium oil has an API gravity between 27° and 35°, and light oil has an API gravity greater than or equal to 35°. Light crude oil is typically traded at a premium to heavy oil, since it is easier to process and produces higher-quality petroleum products such as gasoline.

[2]Another characteristic of oil is the amount of sulfur it contains. Oil with low sulfur content is categorized as sweet, while oil with high sulfur content is categorized as sour. Crude oil with low sulfur content—sweet crude—is considered to be of higher quality than sour crude.

[3]Most refineries have complex conversion units—that is, coking units plus other secondary conversion units. Coking is a secondary refinery unit operation that can upgrade medium and heavy crude oil into higher-valued products such as gasoline and distillate fuels (U.S. EIA 2013a). As of January 2015, over 70 percent of total U.S. refining capacity was located at refineries with coking units (U.S. EIA 2015). Refinery complexity levels vary depending on the types of processing units they use. The simplest refineries have only a distillation column, while the most complex have additional secondary units that involve chemical processes (U.S. EIA 2012).

[4]The 50 states are commonly aggregated into five distinct regions, known as Petroleum Administration for Defense Districts (PADDs), to track the movement of oil supplies.

[5]Other significant events that shaped the 1970s oil market were the Iranian revolution and the significant increase in the number of oil expropriations across the world (Çakır Melek 2014).

[6]The Bureau of Industry and Security (BIS) was charged with granting licensing for oil exports that fell within the permitted categories. Along with the exempt categories, the BIS reviewed applications on a case-by-case basis and could approve additional exports that were in the national interest. Swaps were the most common type of approved exports after the permitted categories. In 2014, the BIS clarified that oil processed through a distillation tower was not considered crude oil if the API gravity changed materially—thus, this oil could be exported without a license. Afterward, the BIS allowed some light oil exports.

[7]Oil exports to Canada excluded oil transported using the Trans-Alaska Pipeline and oil from the Naval Petroleum Reserve. These restrictions were lifted in 1988. Lastly, re-exports of foreign-produced oil required a license, and certain transactions could be approved under export licensing requirements.

[8]U.S. demand fell in part due to increased fuel efficiency.

[9]Decker, Flaaen, and Tito explore the resilience of U.S. oil production in 2015 despite significant declines in oil prices and rig counts. They argue that large productivity improvements in drilling and steadily falling costs of drilling and production are possible factors.

[10]For example, U.S. refinery utilization rates increased from an annual average of 86.4 percent in 2010 to 91 percent in 2015, as refineries replaced foreign oil with the cheaper, domestically abundant oil as much as they could by reducing (light) oil imports. Still, U.S. refiners process significantly larger quantities of heavy oil.

[11]According to Hakkio and Nie, energy net exports' contribution to annual real GDP growth increased from –0.1 percentage point in 2006 to 0.2 percentage point by the end of 2013.

[12]Agerton and Upton argue that the price spreads were driven mostly by transportation bottlenecks with the export ban having little effect.

[13]For instance, from 2008 to 2010, the WTI-Brent spread averaged 52 cents per barrel. But this premium turned to a significant discount from 2011 to mid-2014 such that the spread averaged –$13.92 per barrel over this period.

[14]Oil prices fell dramatically in 2014, from around $100 per barrel in the first half of the year to around $50 per barrel by the start of 2015. Recent studies of the link between oil and the macroeconomy include Hamilton (2009); Kilian (2009); Balke, Brown, and Yucel; Hamilton (2011); Kilian (2014a); and Kilian and Murphy.

[15]The spread between WTI and Brent was wide from 2011 through most of 2015.

[16]*Trade diversion* and *trade creation* are central concepts in Viner, who introduces the distinction in a study of different arrangements of regional integration. Trade creation occurs when removing a trade barrier allows trade to switch from higher-cost producers to lower-cost producers. Trade diversion, on the other hand, occurs when removing a trade barrier causes trade to be diverted from less-expensive sources to more-expensive sources receiving preferential treatment. These two concepts highlight the source of increased trade due to free trade. See, among others, Clausing, Krueger, and Balassa.

[17]The Line 9 pipeline operated by Enbridge runs east to west from Montreal, Quebec, to Sarnia, Ontario, and has a capacity of approximately 300,000 barrels per day. Enbridge completed the reversal of a section of Line 9 in November 2013. This portion of the pipeline now runs west to east from Sarnia to North Westover Station, Ontario. The reversal of the rest of the pipeline was approved in 2014 and is underway.

[18]Davig and others show that oil price fluctuations from mid-2014 to mid-2015 were primarily driven by shifts in expectations of future demand relative to the availability and stability of future supply. Baumeister and Kilian (2015), on the other hand, suggest conditions in place prior to mid-2014 substantially pulled down prices.

[19]Multiple studies discuss the effects of a free trade policy for U.S. crude oil in 2014 and 2015 (see, among others, Ebinger and Greenley (2014); Brown and others (2014a); Brown and others (2014b); ICF International; IHS (2014); Plante, Bordoff and Houser; IHS (2015); and Medlock). Overall, they argue that the removal of the ban would increase the price of domestic crude oil, thus resulting in higher production and lower gasoline prices, benefiting consumers.

These studies are either qualitative or use simple empirical analyses. Çakır Melek, Plante, and Yucel, on the other hand, examine the effects of a crude-oil export ban in a two-country, open-economy trade model. They find that the distortions introduced by the ban are greatest in the refining sector. Moreover, they find that while light crude oil prices become artificially low in the United States, the effect on fuel prices is negligible.

[20]Oil export restrictions may be imposed if the president declares a national emergency, if restrictions are within the context of sanctions or trade restrictions for national security, or if exports have caused a supply shortage or a significant increase in domestic oil prices relative to global prices. The one-year ban can be extended for additional one-year periods.

[21]Japan and Singapore did not import oil from the United States in 2015, but have done so before. Japan imported oil from the United States (specifically, Alaska) during 1996–2000 following the Alaska North Slope exemption. Singapore imported oil from the United States for the first time in 2014. As a result, they are not considered new export destinations.

[22]Large refining and petroleum trading hubs are located in the Netherlands, in close proximity to the North Sea (U.S. EIA 2016).

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