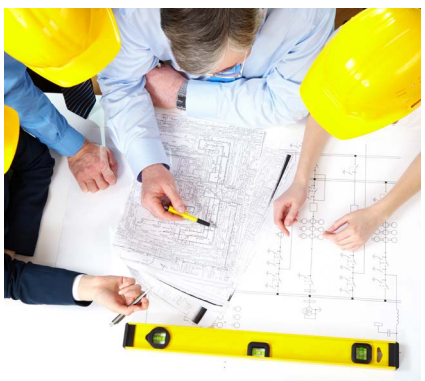
An IHS Energy / IHS Economics report

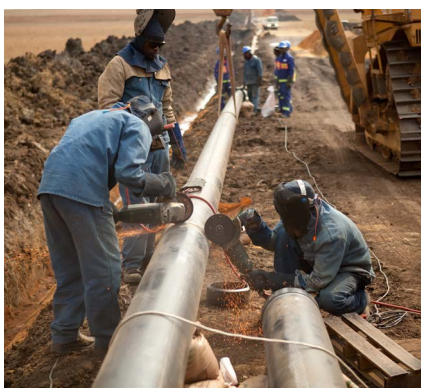
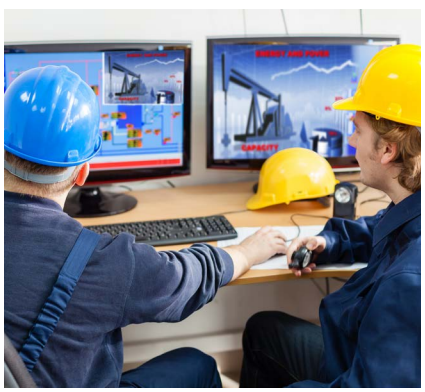
Unleashing the Supply Chain

Assessing the economic impact of a US crude oil free trade policy

March 2015





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Additional resources

Appendices are available at www.ihs.com/crudeoilsupplychain. Additionally, the results included in this study are available on an interactive website that provides access to detailed data for the supply chain and congressional districts which can also be accessed through this website.

Study purpose

Building on prior work assessing the industry and macroeconomic impact of changing US policy to allow exports of US crude oil, this study examines the impact on an intricate and interdependent supply chain that supports the oil industry and has made the scale-up of tight oil production possible. The analysis considers 60 separate supply chain industries and provides granular impact analysis at the congressional district level to fully understand the economic and job growth impact across the nation.

This report draws on the multidisciplinary expertise of IHS, including upstream, downstream and macroeconomic teams across IHS Energy and IHS Economics. The study has been supported by a group of sponsors in numerous industries. The analysis and conclusions contained in this report are entirely those of IHS Inc., which is solely responsible for the contents herein.

Related reports

The "Great Revival" in US natural gas and crude oil production has caused significant market and economic shifts. IHS has provided continuing analysis of these developments, their impact on global oil markets, and their influence on the US economy and US competitiveness. Some of the current studies include:

$30 or $130? Scenarios for the Global Oil Market to 2020

These are momentous times for the oil market. We are in a world without OPEC—at least as we knew it. Companies and investors face a heightened degree of uncertainty about the future of oil supply, price, and demand. IHS addresses the uncertainty through a new study, *$30 or $130? Scenarios for the Global Oil Market to 2020*. IHS Scenarios provide a coherent, dynamic framework to discuss several potential futures for the oil market and to test decisions. Through interactive workshops, study participants participate in the scenario development and helping identify key supply, demand, and geopolitical drivers that will shape the oil market to 2020. Decision making is more robust when analysis takes into account more than one view of the future.

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Oil: The Great Deflation

Through this framework series, IHS is providing insights and decision support to clients as they assess the impact and implications of the low oil price. IHS's unique breadth and depth of expertise spans the energy value chain and into adjacent industries and overall economies providing a fully integrated and objective perspective. The series provide a framework for more detailed discussions and consulting on a wide range of topics including: the tight oil and global production response, capital programs, cost deflation, storage and financial market influences, company strategies, demand response and asset transactions. The series is delivered through IHS Connect and a webinar series.

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America's New Energy Future

America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy is a three-volume series based on IHS analyses of each shale gas and tight oil play. It calculates the investment of capital, labor and other inputs required to produce these hydrocarbons. The economic contributions of these investments are then calculated using the proprietary IHS economic contribution assessment and macroeconomic models to generate the contributions to employment, GDP growth, labor income and tax revenues that will result from the higher level of unconventional oil and natural gas development. Volume 3 in the study includes state-by-state analysis of the economic impacts and projections of additional investment in manufacturing as a result of these supplies.

See more at http://press.ihs.com/press-release/economics/us-unconventional-oil-and-gasrevolution-increase-disposable-income-more-270#.

Unleashing the Supply Chain study sponsors

The following organizations provided support for this study. The analysis and conclusions in this study are those of IHS, and IHS is solely responsible for the report and its content.

Baker Hughes, Chaparral Energy, Chesapeake Energy, Chevron, Concho Resources, ConcocoPhillips, Continental Resources , Devon Energy, Energy Equipment and Infrastructure Alliance, EOG Resources, Exxon Mobil, General Electric, Halliburton, Helmerich & Payne , Hess, Marathon Oil, Newfield Exploration, Oasis Petroleum, Occidental Petroleum, Pioneer Natural Resources, QEP Resources, Rosetta Resources, and WPX Energy

Key findings

- The oil and gas industry depends on a diverse and far-reaching supply chain—a vast and interconnected network of labor, commodities, technologies, and information services across the United States.
- When oil prices are lower, the potential negative impact on jobs and the economy are more—not less—sensitive to further price discounts resulting from an export ban. For example, a $3 per barrel change in a $50 environment can have the same effect as a $10 change in a $100 environment.
- The export ban causes US crude oil prices to be discounted versus international crude oil prices—an effect that *reduces* US oil production, supply chain activity, and job growth, but *raises* US gasoline prices. As of this writing, the spread between the international (Brent) and domestic (WTI) crude prices has widened, ranging from $7 to $12 per barrel.
- The industries that produce, transport and process oil are highly capital-intensive, supporting an extensive and diverse supply chain. Beneficiaries of this investment include domestic companies in equipment and machinery, construction and well services, information technology, materials, and logistics, and in the professional, financial and other services sectors.
- The economic benefits of oil and gas activity throughout this extensive supply chain far exceed benefits to the industry itself. Every new production job creates three jobs in the supply chain and another six jobs in the broader economy. Contributions to Gross Domestic Product (GDP) also multiply: every dollar of GDP created in the oil and gas sector generates two dollars in the supply chain.
- Lifting the ban on crude oil exports increases supply chain jobs and economic activity by stimulating capital investment, increasing crude oil production, and lowering gasoline prices. Based on two levels of crude production analyzed in this report, the positive impact on the crude oil supply chain of lifting the export ban is expected to add $26 billion to $47 billion to GDP and support 124,000 to 240,000 jobs per year on average during the 2016–30 period. The impact from a policy change is greatest in the short term (2016-20).
- The broader US economic impact is $86 billion to $170 billion additional GDP and 394,000 to 859,000 additional jobs.
- The supply chain benefits from lifting the export ban reach into every state and almost every US congressional district, from oil-producing Texas and California to states such as Illinois, Florida and New York, which have diversified manufacturing and services economies. Massachusetts, with its strong information technology and professional and financial services industries, also benefits from free trade. And in Washington State, which has strong information technology and manufacturing sectors, the supply chain contribution is almost half of the total state impact of lifting the crude oil export ban. Additionally, Illinois, ranked only 14th for oil production, accounts for roughly 10% of the overall supply chain impact. Furthermore, 5 of its congressional districts are in the top 20 in terms of value added, accounting for about 5% of that supply chain impact.

Executive summary

A revival in US crude oil production—up 80% since 2008—is expanding economic activity across the nation through an interdependent, technology-driven supply chain. This supply chain encompasses dozens of important and diverse domestic industries well beyond what is commonly thought of as the "oil industry." Consumers are now paying substantially less for gasoline, largely due to the impact on global markets of higher US oil production. But lower oil and gasoline prices are just one benefit. In this report, IHS offers further analysis of the benefits that extend across the nation from free trade of crude oil—benefits that are also placed at risk by an outdated trade policy from an era of oil price controls that were abolished in 1981.

Crude oil production depends on an extensive supply chain—a vast network of interconnected labor, commodities and information that reaches into many communities and industries. For example, the diesel engines driving drilling rigs and hydraulic fracturing equipment are largely manufactured in the industrial heartland of Illinois, Indiana, Wisconsin, and Michigan. Many states — New York, Florida, Illinois, and Massachusetts, for example—with modest or negligible oil production sectors have strong manufacturing or service sectors supplying the oil industry in producing states. As IHS reported in its earlier report, *US Crude Oil Export Decision* (herein referred to as the *Export Decision*), if the trade ban is lifted, the number of US jobs is 394,000 to 859,000 higher each year, on average, under the Base Production and Potential Production cases, respectively, between 2016 and 2030. Supply chains represent a substantial share—about 30%—of the total jobs economy-wide: supply chain jobs under free trade average 124,000 to 240,000 annually in the Base and Potential cases, respectively.

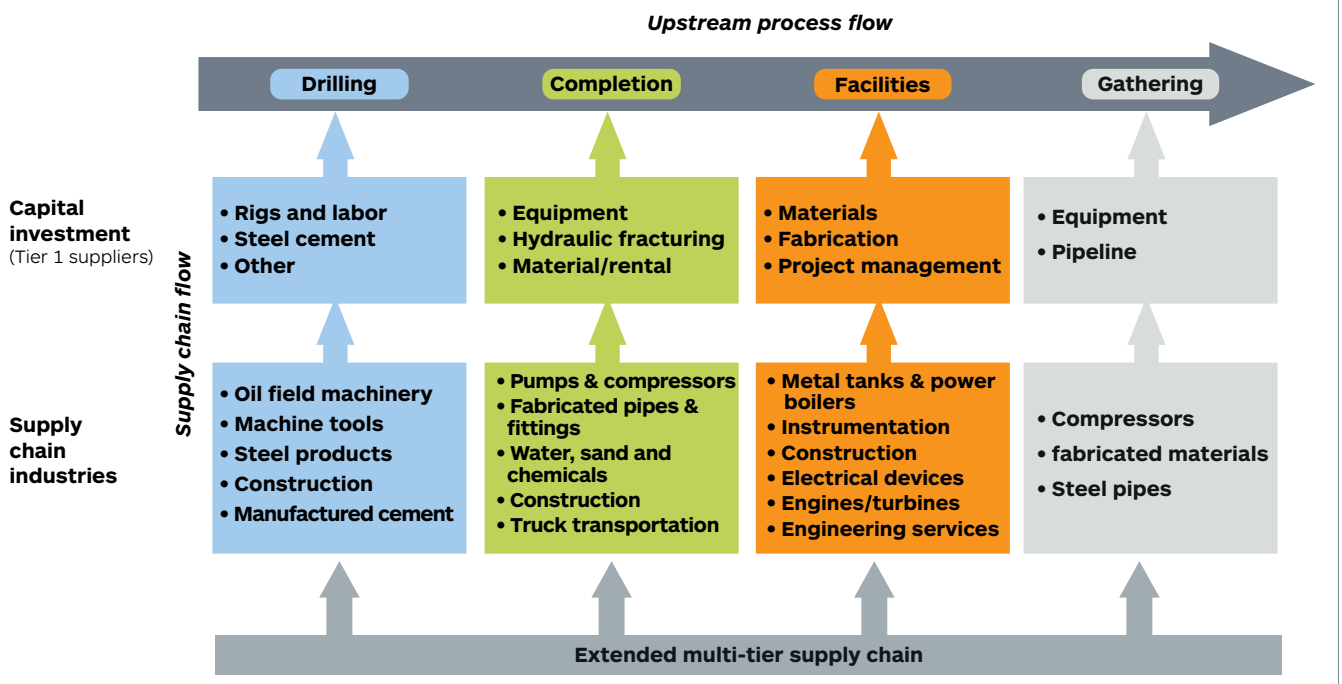
What is the supply chain?

This study, *Unleashing the Supply Chain: Assessing the economic impact of a US crude oil free trade policy*, tracks flows of capital expenditures through 60 industry sectors that comprise a large percentage of the oil industry's upstream supply chain. The supply chain is the extended network of companies providing the labor, commodities, technology, and information required to extract oil and deliver it to the midstream (transportation and logistics) and downstream (processing and marketing) sectors.[1] Capital investment and operating spending in the oil industry, as measured by direct spending within the oil industry's Tier 1 suppliers, trigger multiple streams of additional economic activity throughout an extended, multi-tiered supply chain that has wide geographical impacts at the national, state and local levels. [2]

1 Midstream specifically includes the pipelines, terminals and related logistics infrastructure used to move petroleum and downstream includes refining and product distribution.

2 Tier 1 suppliers are defined as those with whom upstream operators directly spend capital and operating funds.

Upstream supply chain



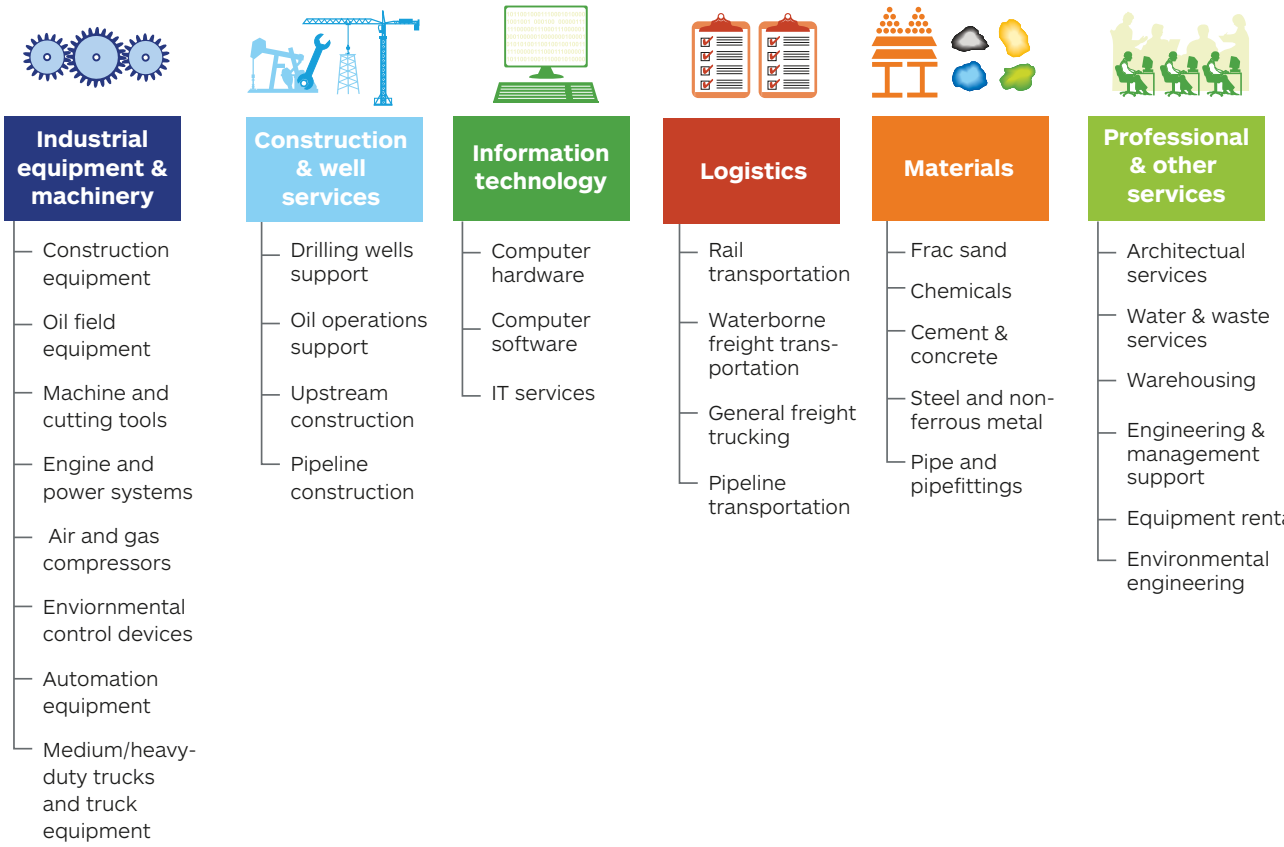
Source: IHS Energy

The key driver of the widespread macroeconomic benefits is investment in the upstream and midstream oil and gas industries. This investment in US energy infrastructure significantly aided the return of US economic growth following the Great Recession. From 2008–13, while US GDP growth averaged 1.2% per year, economic output in the oil and gas industry grew four times faster, at 4.7%. Over the same period, total US employment declined by 0.1%, while oil and gas industry employment grew 4.3% per year. More broadly, the revolution in the production of "unconventional" oil and gas has been one of the major contributors to the US economic recovery; it is estimated by IHS to have added nearly 1% to US GDP annually, on average, over the past six years, explaining nearly 40% of overall GDP growth in that time.

These macroeconomic impacts would be enhanced by lifting the crude export ban as they extend through a diverse network of suppliers. Suppliers benefit from the investment required for the exploration, production, processing, and transport of oil and gas. In turn, suppliers of materials, capital equipment and services enable operators to deploy technology to commercialize their resources. The "multiplier effect" accelerates as Tier 1 suppliers require more production of goods and services and development of efficient technologies within their respective interlinking supply chains. This benefit cascades across the industrial economy and all states.

The diversity of primary sectors that serve the US oil and gas supply chain is depicted in the following graphic.

Primary sectors in the crude oil supply chain



Source: IHS Economics

The companies in this diverse and far-reaching supply chain contribute to employment and to every US state's economy—not just oil-producing states. The US oil revival has increased demand for industrial equipment and machinery, construction and well services, information technology, materials, logistics, and professional, and financial and other services and has spurred research and development investment across numerous industries.

Investment in crude production has a far-reaching impact on jobs, with about 10% of the total employment impact flowing directly to producers and another 30% into the supply chain. The remaining 60% derive from the broader impact of workers' increased income and spending due to higher levels of crude oil activity. In other words, for every job created in the oil and gas extraction sector, three jobs are created in the supply chain and another six jobs in the broader economy. In a similar fashion, contributions to Gross Domestic Product (GDP) also multiply: every dollar of GDP created in the oil and gas sector generates two dollars in the supply chain.[3]

High-quality supply chain jobs also lead to higher wages, reflecting their unique occupations and skill requirements. Supply chain jobs also stand out from other employment opportunities for their technological and innovative nature. The average wage rate in the oil and natural gas extraction and drilling sectors is $51.19 per hour, and the rate for the broader oil and natural gas extraction sector is $35.87 per hour.[4] This compares to an economy-wide average wage rate of $23.96 per hour. The supply

3 Relative to the broader supply chain, the oil and gas sector demonstrates higher productivity (output per worker) and a higher GDP contribution per unit of output. Thus, the oil and gas sector typically accounts for a higher proportion of GDP with fewer employees per unit of output. This explains the differential between the employment and GDP multipliers.

4 Using US Bureau of Labor Statistics (BLS) total annual wage and salary data and number of employees by sector

chain wage of $29.93 per hour is 25% above the national average.[5] Higher wages result in larger multiplier and income effects across the economy as more income is spent on general consumer goods and services by oil and gas and supply chain sector workers.

Great revival in US crude production and uncertain future

The large and rising production of US crude oil has significantly reduced US dependence on imported oil—imports last year accounted for just 27% of US oil demand, down from 60% in 2005. With crude oil production now over 9 million barrels per day, the United States is the world's third-largest crude-oil producer behind Saudi Arabia and Russia. It is the largest producer of oil and natural gas liquids combined.

Continued growth in the oil and gas industry and in the supply chain supporting it could be imperiled by low prices and outdated crude oil export policies that restrain market access and hinder future investment and production. In the early years of the industry's revival, higher oil prices were unusually stable and allowed for the emergence and advancement of a vibrant domestic tight oil industry. Production techniques improved, costs fell, and higher oil output per well was achieved. It is the success and rapid growth of US production that contributed to the global supply surplus that has driven down global oil prices over the past six months. Consumers are already reaping great benefits from this drop in prices.

Production will certainly be affected by low prices, but the pace and degree of the impact remains uncertain. The market price has been roughly halved, and the adjustment process is evolving. Many factors will influence the outcome. Oil markets are prone to cycles, which are often rapid and extreme and reflect the challenge of matching short-term changes in demand with long-term investment requirements. Price changes over the past decade reflect the constant changes occurring in oil market fundamentals, economic conditions and geopolitical events that affect oil prices. The monthly average price of Brent crude oil climbed from $30 per barrel in early 2004 to over $130 per barrel in July 2008 before falling to $40 per barrel in December 2008. Prices then rebounded, exceeding $70 per barrel by August 2009 and remained in the $100 per barrel range from early 2011 through August 2014. As of this writing, the US benchmark price is below $60 per barrel. Crude oil price volatility is expected to continue. While low prices are the primary challenge facing the industry in 2015, the ban on exports of US crude oil production will hinder or even cut short any recovery tomorrow.

The export policy problem

The US oil system is nearing gridlock due to a mismatch between the rapid growth of domestic light tight oil production and the inability of the US refining system to economically process the growing volumes. Seasonal gridlock occurred in the second half of 2013 due to refinery maintenance downtimes. But the rapidly declining crude oil price and the increasing storage of crude oil have so far overshadowed the risk of a more permanent and impending gridlock and reduced the domestic crude price discount to global prices. In fact, gridlock would have a doubly chilling effect on investment and job growth in an environment of lower and volatile global crude prices. The supply chain in every region of the nation has benefitted from investment in US oil production and infrastructure—benefits now put at risk.

The nation is benefiting today from increased employment, lower gasoline prices and an improved trade balance as growing US production puts downward pressure on international oil prices. Lifting the export ban and allowing US crude oil to trade into international markets removes a risk that the full benefits from potential US oil production are not realized. The *Export Decision* report in May 2014 examined the historical context of US export policies; the oil industry's response to a change in policy; and the estimated macroeconomic benefits from free trade accruing to US consumers and the broader US economy. The *Export Decision* analysis projected substantial increases in capital expenditures by upstream operators if the export ban is lifted, granting them access to global markets.

5 Based on a weighted average of the hourly wage rates for each of the supply chain sectors.

Since completion of the previous study, two notable market events have occurred. First, the global crude price has declined sharply, largely due to US production increases and weak demand, and second, the Bureau of Industry and Standards (BIS) has clarified existing rules that allow certain very light crude oil (condensate) to be exported as a "refined product" in defined situations involving sufficient processing.

Oil price decline

The rapid crude oil price decline—by roughly half since mid-2014—is a reminder of the cycles and uncertainty of oil and energy markets caused by the differing time scales of demand and supply adjustments. Producers are responding with reduced budgets, smaller drilling programs and cost cutting. While exploration and development costs are expected to also decline, the industry is expected to produce less crude oil as a result of the price decline, and the impact on employment is magnified throughout the supply chain.

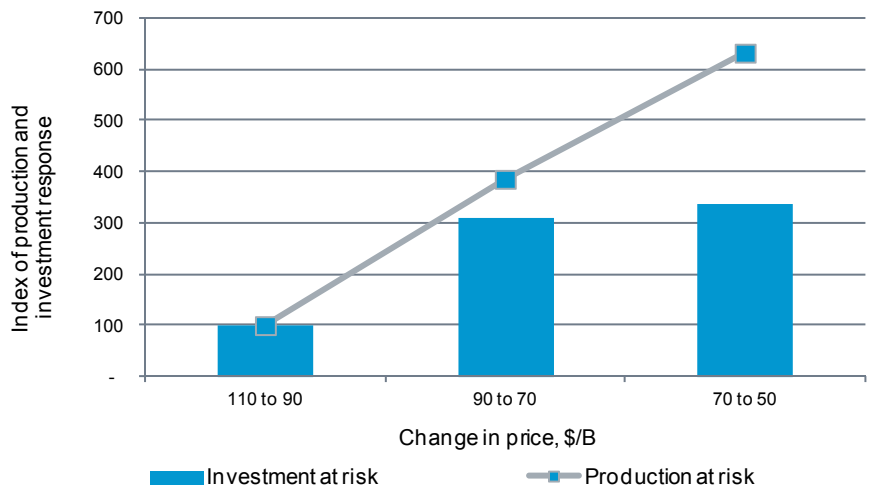
Lower global oil prices have the effect of increasing—rather than decreasing, as some might expect—the impact of the export ban. An export gridlock created by the ban would create a domestic oversupply resulting in US crude oil prices (for example, West Texas Intermediate) becoming disconnected and discounted from international prices, such as Brent crude. The resulting lower wellhead price for US producers dampens upstream investment and reduces economic activity and job creation. The resulting lower wellhead price for US producers dampens upstream investment; reduces economic activity and job creation; and, weakens the competiveness of US companies relative to their international peers.

These employment and economic benefits are increasingly sensitive to declines in crude oil prices. This is because the industry, at lower prices, has a "flatter" supply curve, which means that a small change in price results in a larger supply loss. Therefore, the risk from the export ban is higher in today's low-priced market.

To demonstrate this effect, consider an IHS study of the US onshore oil wells drilled in 2013, excluding Alaska. Each well's break-even price was calculated based on estimated costs and actual production. The total investment and production from this analysis is summarized in the graph using an index for the levels of production and investment put at risk as the price declines in $20 per barrel increments from $110 to $50.

As US prices move lower, the investment and production that becomes uneconomic and "at risk" accelerates. For example, the risk to investments in response to the price declining from $90 to $70 is about three times greater than when the price moves from $110 to $90. The production response is even stronger—about four times—as the price moves from $110 to $90 to $70. Therefore, if the crude export ban were to create a $10 per barrel price discount to global prices in today's already low price environment, it would have a much bigger impact on industry investment and production than it would have had in early 2014 when crude was selling for over $100 per barrel.

Impact of crude oil price reduction



Note: Based on breakeven price analysis of actual onshore oil wells drilled in US Lower-48 in 2013.
Source: IHS

At today's lower global oil price, an export policy-related gridlock would have a doubly chilling effect on investment and job growth.

The industry is dynamic, and efficiencies in production are being realized each year. Still, there is good reason to believe that the shape of the 2013 supply curve is similar today and will remain so for the foreseeable future.

BIS clarification for condensate processing

Some types of very light crude oil (condensate) can be exported after transformation into petroleum products with sufficient processing, as explained by a nuanced clarification of existing regulatory definitions of crude processing.[6] The BIS has provided general guidance and has issued private rulings to a few companies to permit the export of this processed condensate petroleum (condensate product) from individual facilities that were approved based on equipment and processing configuration. Due to minimal processing, the main product has a broad boiling range and is similar to unprocessed condensate. The condensate product is unfinished and not usable as a fuel but only as a feedstock for further refining. More companies will be given permission or will otherwise be able to export this condensate product. These exports will provide some relief to the impending market gridlock. However, the volume of condensate product available for export remains unclear, because new infrastructure must be put into place to segregate this product stream. Condensate production is significant and estimated to be near 800,000 barrels per day (there is no industry standard for the definition of condensate); however, little of this production is coastal, and so, to prevent commingling, additional infrastructure is needed to move the condensate product to export terminals. This new infrastructure must be separate from the three existing infrastructures for crude oil and condensate, for natural gas, and for natural gas liquids (NGL). This segregation creates market and capital inefficiencies. Further, market distortions are likely to arise due to artificial distinctions between similar products (unprocessed condensate and condensate product). This policy-driven investment will likely duplicate more efficient facilities already in place, another example of the economic inefficiencies caused by the outdated crude oil export policy.

Despite a declining global oil price, the clarified classification of processed condensate, and the weaker US production outlook in the near-term, the crude oil export ban is a remnant of a long-past era that could constrain future US production growth and result in higher gasoline prices for US consumers. While the unpredictable events of the past six months may have delayed the most severe gridlock temporarily, these same events also highlight that this gridlock could return sooner than expected as US production growth is supported by greater efficiencies and lower costs. When a recovery occurs, the export ban is expected to retard investment, reduce energy security and self-sufficiency, and ultimately lead to higher gasoline prices and lower job creation.

Free trade impacts on the supply chain

IHS has evaluated a change in crude export policy under each of two scenarios for US crude oil production levels:

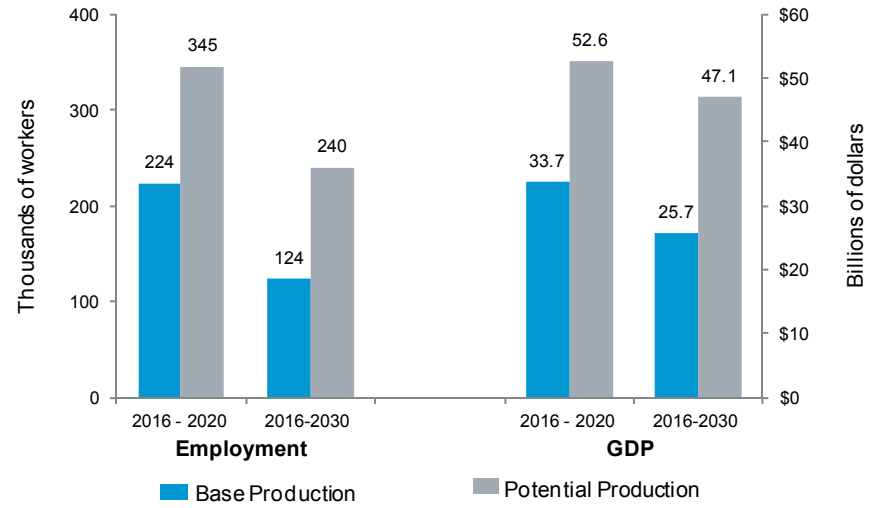
- The Base Production Case provides a conservative view based on known defined oil and gas plays and assumes limited technology improvements over current performance.
- The Potential Production Case includes additional known, but less well defined areas of existing plays and assumes moderate drilling performance and technology improvements in the future.

These scenarios use production outlooks developed in mid-2014 in the *Export Decision* study—before the dramatic fall in oil prices. Since then, actual production and efficiency gains have been higher than forecasted but are now being offset by the expected effects of the price decline. IHS' current production forecast remains within the Base and Potential Production bands found in the prior study. The impact of moving from the current restricted trade policy to free trade is quantified for 60 industries in the petroleum production supply chain under each scenario.

6 Processing at or near wellhead production.

Under each scenario, removing the crude oil export ban will have a dramatic economic impact across all US states in terms of more jobs, higher gross state product (GSP), and increased government revenue. The breadth of these trade impacts reflects the capital intensity of the oil industry and its reliance on inputs from a vast network of domestic goods and services suppliers around the United States. The short-term trade impact (2016–20) reflects a rapid increase in capital spending, while the long-term trade impact (2021–30) moderates as the economy adjusts to changes in the trailing level of investment and moves toward a new equilibrium with lower economic impacts.

Impact of free trade on the supply chain



Note: The supply chain impact represents 28-30% of total free trade impact.
Source: IHS Economics

Measuring the effects of free trade in crude export policy requires a fundamental understanding of the legion of suppliers that often operate out of the spotlight shining on the upstream (production), midstream (transportation and logistics) and downstream (processing and marketing) sectors. Removing the export ban will contribute to enhanced capital investment in this oil value chain, resulting in increased spending throughout the supply chain.

As beneficiaries of energy capital and operating expenditures, supply chain industries play a fundamental role in generating economic benefits nationwide as a result of a change in US crude oil export policy. The supply chain industries represent significant shares of this national impact in both the Base Production/ Potential Production cases, respectively, across all key economic indicators over the 2016–30 period analyzed:

- 31%/28% of the employment impact,
- 30%/28% of the GDP or value added,
- 38%/35% of labor income, and
- 33%/31% of cumulative government revenue.

The Base Production Case under free trade quantifies the value of the alternative path for a US economy benefitting from crude oil exports. In the Potential Production Case, the overall benefits to the supply chain are significantly higher under free trade (even though the percentage of benefits the supply chain is somewhat lower due partly to economies of scale).

Removing the crude export ban creates the following benefits in 2016–30 as higher activity levels work their way through oil industry's supply chain for the Base Production / Potential Production cases, respectively:

- The crude oil supply chain will add $26 billion /$47 billion to GDP per year.
- Supply chain jobs will be 124,000/240,000 higher per year, on average.
- Labor income improves by about $158/$285 per year, on average, for each household.
- Cumulative government revenues from corporate and personal taxes attributed to supply chain industries reach $429 billion/$868 billion.

Broad benefits

The energy value chain encompasses all 50 states, but state sizes and populations vary widely. To evaluate the regional impact on a more equal population footing and to further quantify the breadth of the supply chain, the supply chain impacts were estimated for each US congressional district, as well as each state. The interdependencies throughout the US economy create an array of benefits in the supply chain and local economies. The key state and congressional district-level findings from the analysis include:

- The economic benefits vary considerably across supply chain industries and across the country. In states where the crude oil industry predominates, such as Texas, core supplier industries such as construction and well services are poised to reap the largest economic benefits in terms of jobs and value added, followed by professional services, which play a large role in supporting crude oil activity.
- In states with low crude oil production, such as Florida and New York, the benefits are distributed differently across the supply chain industries. In these states, key supplier industries that incur the largest benefit associated with the adoption of a crude oil free trade policy include the industrial equipment and machinery, professional services, financial services, and information technology sectors.

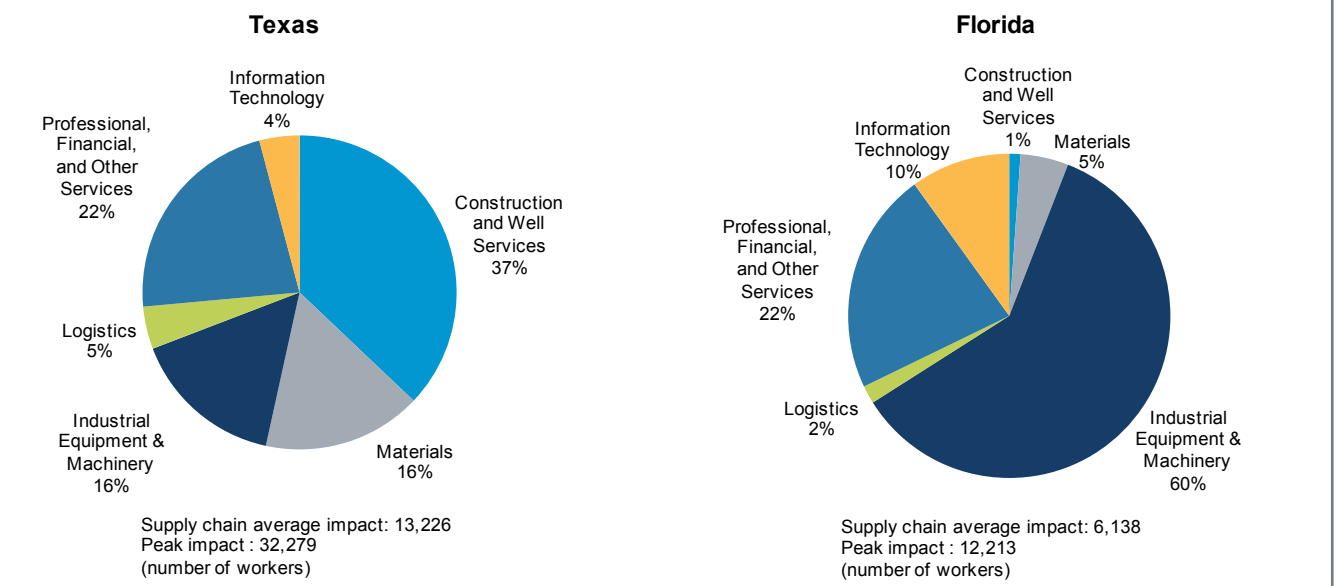
Defining the geographic contribution

The US economy benefits from the great diversity in its states and regions. Each state has unique economic, demographic, and geographic attributes, and they vary widely in size, resource endowment, climate, and population. To evaluate the regional impact on a more equal population footing and to further quantify the breadth of the supply chain, the supply chain impacts of lifting the export ban were estimated for each US congressional district, as well as for each state. The use of congressional districts, which are unique geographic units, allows us to achieve a reasonable equalization of each district's population, based on decennial US Census data.[7] Accordingly, the impact analysis on GDP, employment, labor income, and government revenue by congressional district provides robust metrics to analyze the geographic distribution of the benefits of a change in trade policy change across the supply chain.

7 Based on the 2010 Census estimates, all but 15 of the 435 congressional districts have populations within 10% of the national average.

The following two graphs represent the diversity of the supply chain impact in two states, one with large and one with small oil activity. The construction and well services core group in Texas experiences the largest benefits, while the benefits to Florida are distributed differently across the supply chain industries.

Supply chain employment impact — Base Production
(2016–30 average, difference free trade vs. restricted trade)



Source: IHS

In states with a diverse and mature set of supplier industries, the supply chain can account for half of the value added from lifting the export ban. In Washington, for example, where the information technology (seismic and other software) and manufacturing sectors are expected to quickly expand, the supply chain contribution to GDP comprises 47% of the state's total benefit from higher crude oil exports over 2016–30. Illinois, an oil-producing state with diverse supplier industries, will derive 58% and 54% of the total GDP impacts from its supply chain under the Base and Potential Production cases, respectively.

California and Texas, two of the largest state economies, represent nearly 20% of US economic activity. They are not only large oil producers but also rank in the top five in terms of capital spending by oil producers. California and Texas are also the two largest states for their manufacturing activity and their strong diversified supply chain sectors. As a result, these two states are expected to yield the largest benefits from lifting the crude oil export ban in terms of supply chain jobs, value added, and labor income impacts. Under both production cases, California and Texas together account for about 25% of the total US supply chain jobs and labor income contributions and 20% of the value added contributions in 2016–30.

- Non-oil producing states such as Massachusetts and Maryland will also see strong growth in supply chain-associated government revenues in both production cases. They rank among the top 10 states in terms of the GDP and labor income impacts on their supply chain industries, suggesting strong ties between their supply chain activity and their government revenue from associated taxes.

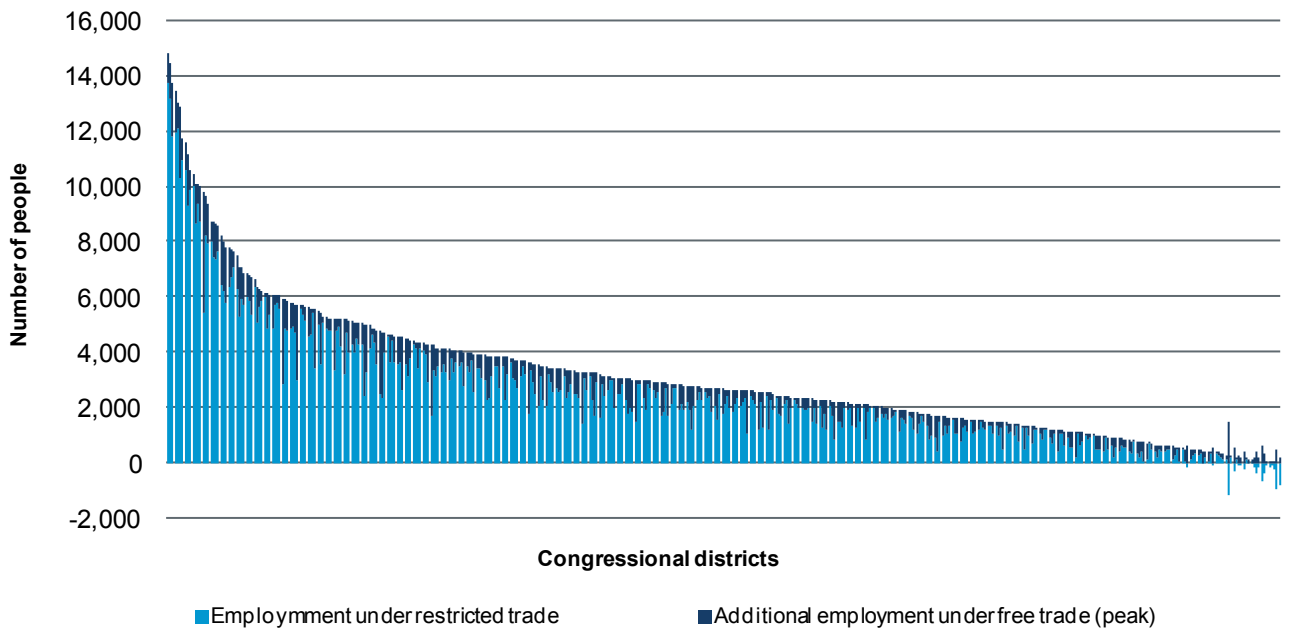
- As observed in the state-by-state analysis, the impact of a change in trade policy will be distributed across suppliers in congressional districts with crude oil activity, as well as in adjacent districts with supporting supply chain sectors. While nearly all congressional districts experience benefits, those districts with crude oil activity and strong supply chains will benefit most.

- Given the breadth of California's and Texas' oil production and the size of their mature supply chain sectors, these major oil-producing states have the largest number of affected congressional districts.

However, impacts will be felt in clusters of congressional districts in other states such as Illinois, Florida, and New York, mainly due to their diversified manufacturing and services sectors, and in Massachusetts due to its information technology and professional and financial services.

- The job impact of removing the export ban is spread across nearly every congressional district. The figure compares the peak annual jobs contribution under the free trade Base Production Case to the average net job gain per year under current policy trade for the time period.

Employment gains by congressional district – Base Production (average, 2016-30)



Source: IHS Economics

Sizing the benefits

The magnitude of the supply chain benefits is significant when compared with the size of entire industries in various states:

- Job impacts in the Base Production Case peak at 293,000 in 2018. That is slightly more than the 285,000 current US workers in the pharmaceutical and medicine manufacturing industry.
- In the Potential Production Case, job impacts peak at more than 439,000—roughly equal to all the non-farm workers in Delaware.
- The value added contribution to GDP from crude oil export supply chain activity reaches a maximum of $40 billion in the Base Production Case, roughly equal to South Dakota's $41 billion Gross State Product in 2014.

Introduction

The renaissance in US crude oil production has reshaped the global petroleum market in less than a decade. The United States is now the world's third-largest crude oil producer behind Russia and Saudi Arabia and is closing in on both. The domestic oil industry's resurgence has driven a post-Great Recession recovery that has also transformed the US economy by reinvigorating our industrial competitiveness. US crude production has counterbalanced losses in other sectors, while greatly reducing global energy prices and economic risks. Even more remarkably, US oil and gas producers have been able to assert a more prominent role in the global crude market even though they lack access to markets outside of North America due to restrictions on crude oil exports under current by US law.

IHS' previous report concluded that continued crude oil export restrictions would depress US crude prices relative to international levels and reduce industry investment and slow the growth in domestic production. The economic benefits of lifting the export ban would accrue to broad swaths of the US economy, including consumers, by encouraging industry investment and limiting the impact of higher production on global crude oil prices.

This study evaluates the economic benefits of additional investment and production in the upstream oil sector should the export ban be lifted. It does so by analyzing how this investment impact flows through 60 industry sectors that are part of the crude oil supply chain.

When the first report was released, in May 2014, global crude prices hovered around $100 per barrel. That first analysis and this one were premised on crude prices maintaining a relatively high price environment through the outlook period. Since that time, several forces have dramatically lowered the near-term crude oil price. As the full impact of the success of crude oil production in this country has been absorbed into the global market, OPEC producers have made a conscious decision to defend their market share and sustain current output levels. These two factors together have driven the price of domestic and global crude down 50% over the past six months. Subsequent analysis by IHS has concluded that in this low price environment and amid OPEC's shifting market strategy, the current ban on US crude oil exports becomes more relevant and carries an even higher potential for economic harm if it is allowed to remain in place.

Companies participating in the supply chain catering to upstream oil and gas producers have benefitted significantly from the growth in hydraulic fracturing and horizontal drilling over the past 10 years. The intensity of labor, machinery and materials use on the well site has been a key demand driver for many of the 60 supply chain sectors, many of which have responded to increased energy production by increasing capacity and employment. While most machinery and materials suppliers still sell to a broad portfolio of customers, sustainable growth in the domestic oil and gas sector is providing business prospects that had been absent during the many years when US crude oil production was in decline. Despite the economic and technological advantages enjoyed by US upstream operators, the industry's growth is now endangered by both a real low crude oil price environment resulting from natural supply-demand forces and also by artificially low crude oil prices, which are a direct result of the export ban. Should export restrictions remain in place when domestic and global prices recover, both US producers and the supply chain on which they depend will be negatively affected. In addition, the geopolitical and consumer benefits of higher US crude production could be at risk.

US Crude Oil Export Decision overview

The 2014 *Export Decision* report examined the historical context, industry response, and potential impacts of a change to US crude oil export policies. The study also provided in-depth analysis of the implications for US and global oil markets should the ban be removed and assessed its national and state-level economic ramifications.

IHS quantified the macroeconomic effects on the United States and on individual state economies by examining industry activity under both a free trade environment and a restricted trade environment for two different crude oil production trajectories: the Base Production Case and the Potential Production Case. The Potential Production Case contains less conservative geologic and technical assumptions, leading to higher levels of future production. Two policy scenarios—Free Trade and Restricted Trade—were applied to the two production cases. The Free Trade scenario assumed that US crude oil could begin trading on the global market, while the Restricted Trade scenario assumed a status quo policy, which currently bans US crude oil exports.

The 2014 report's key findings on the benefits from the free trade of crude oil were as follows:

- **Greater crude oil production and upstream investment.** The differences between the free and restricted trade cases for US crude oil production and investment are quite large, ranging from 1.2 million barrels per day (B/D) and $66 billion in the Base Production Case to 2.3 million B/D and $82 billion in the Potential Production Case. These findings of higher investment and production hold true under a wide range of oil price environments.

- **Higher US economic activity.** The gains to gross domestic product (GDP) from lifting the ban in the Base Production Case with free trade would peak in 2018 at $135 billion—0.7% more than under the current, restricted trade policy. This peak impact is greater in the Potential Production Case, when GDP under free trade would be $221 billion, or 1.2%, higher.

- **More jobs and lower unemployment.** As a result of this higher economic activity, the employment gains due to free trade would be, on average, 394,000 higher in the Base Production Case and 859,000 higher in the Potential Production Case between 2016 and 2030. In the peak year, 2018, the jobs supported would be nearly 1 million in the Base Case and over 1.5 million in the Potential Case. The stronger labor market would increase the average US household's disposable income by $239 and $465 annually in the Base and Potential Production Cases, respectively, in 2016-2030.

- **More government** revenue. Total federal, state and local revenue from corporate, personal and energy-related taxes and royalties due to free trade would be expected to increase by a cumulative $1.3 trillion from 2016 through 2030 in the Base Production Case and by $2.8 trillion in the Potential Production Case.

- **Widespread economic benefits.** The benefits of freely traded crude oil would be distributed throughout the United States, and not just in the large oil-producing states: 24% of the future jobs supporting the oil industry would be located in states that produce little or no crude oil. This is due to the vast US network of supply chains that support crude oil production and investment.

Unleashing the supply chain overview

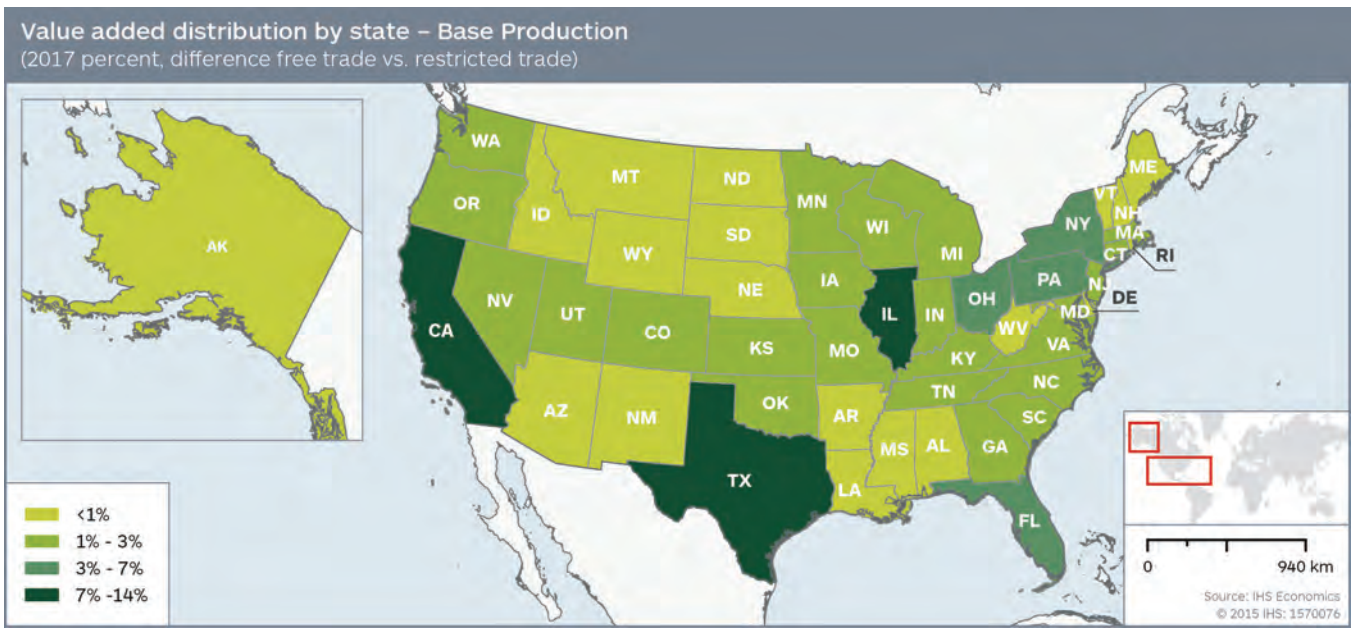
One compelling finding in the *Export Decision* report was that one-quarter of the economic benefits from the free trade of crude oil occurs in non-producing states due to the supply chain network supplying the revival of US oil production.

This report extends and deepens this research, examining the impact of upstream expenditures from lifting the trade ban on a diverse set of industry sectors—from steel and nonferrous metals to engines, pumping equipment, construction and professional services, and railroads. The economic impacts are assessed for four indicators: jobs, associated labor income effects, the value added of goods and services produced, and increased government tax revenue. The economic impacts are presented in terms of what would happen when moving from restricted trade to free trade for each production case.

This study provides detailed analyses of 60 supply chain sectors and also breaks down their contributions in each state and congressional district. The supply chain sectors fall into six core groupings:

- Construction and well services
- Industrial equipment and machinery
- Information technology
- Logistics
- Materials
- Professional and financial services.

Lifting the crude oil export ban will have a far reaching impact on the supply chain across all states. The supply chain across both producing and non-producing states reaps economic benefits. Among the non-producing states, machinery manufacturing in Illinois, information technology in Washington, and financial services and insurance in Connecticut are examples of beneficiaries of the crude oil export supply chain.



Report structure

This report contains four sections:

- **US crude oil analysis and economic inputs** provides a summary of the crude oil production and downstream industry basis for the macroeconomic and supply chain analysis.
- **National supply chain assessment** compares the economic contributions that free trade versus restricted trade would make to the US crude oil export supply chain in terms of employment, GDP, labor income, and government revenue.
- **State supply chain assessment** breaks down the economic contributions to the state level.

- **Congressional district supply chain assessment** presents the economic contributions at the congressional district level.

Additionally, two appendices explain the methodologies, research, and data relied upon for our analysis.

US crude oil analysis and economic inputs

Key insights

- Growth in US crude oil production continued unabated through 2014, reaching preliminary weekly estimates of 9.2 million B/D by January 2015, the highest production level since January 1983.[8] This approaches the peak production month in US history, 10 million B/D achieved in November 1970. The increase in production and drilling activity throughout 2014 confirms the potential provided by the revival of US tight oil.
- The global price of crude oil has fallen by about 50% since mid-2014 largely due to growing US tight oil production and declining US crude imports, which impact global oil markets. US consumers are saving over $700 million per day as a result on gasoline, diesel and heating oil. As the market rebalances, the crude oil price is forecast to recover moderately in the next few years and to nearly $90 per barrel after 2020.[9]
- US tight oil production—a relatively high-cost and price-responsive crude—is now an important marginal supply to balance the global oil market, and. US producers respond to price signals by changing their investments in drilling. However, the US crude oil export ban distorts the global price signal when domestic crude prices become discounted from global prices. The result would be lower US crude oil production and higher prices for global crude oil and gasoline.
- The recent decline in global oil prices increases the potential for economic hardship caused by the export ban—rather than decreasing them, as some might assume. At a lower price, production becomes more sensitive to small price changes—for example, a $3 change in a $50-per-barrel price environment can have the same effect on US production as a $10 change in a $100 environment. However, the US refining constraints and price discounts necessary to process additional volumes of light tight oil are nearly insensitive to crude price. Therefore, the US oil system gridlock is more constrained at a low crude price.
- Each oil well drilled and completed represents a substantial economic investment, with tens of millions of dollars expended both at the well head and in the infrastructure necessary to transport and process the production into usable consumer fuels. The direct capital investment associated with each well supports a vast supply chain covering everything from raw materials, such as sand and steel, to complex manufactured goods, such as engines, motors, and advanced computer and instrumentation systems. To successfully develop the producing wells, all of these industries work in concert across a vast coordinated supply network.

Review of previous findings

The United States currently is at the center of one of the most profound changes in the global oil industry since the 1970s. Advances in horizontal drilling and high-pressure fracturing, combined with improved application of these technologies in the oil field, have revived US crude production. Many believe substantial additional gains in crude output are possible. The dramatic shift in production has also highlighted issues pertaining to a longstanding but, to this point, largely benign set of policies related to the free trade of US crude oil.

In May 2014, IHS released the *US Crude Oil Export Decision* report, documenting an integrated and comprehensive view of the origins, petroleum industry impacts and macroeconomic effects associated

8 The US Energy Information Administration (EIA) began keeping weekly production estimates in January 1983.

9 Brent crude oil price on an annual average, inflation-adjusted basis.

with whether or not the US maintains or revises existing policies related to the export of domestically produced crude oil. The public report evaluated two prospective crude oil production forecasts:

- The Base Production Case
- The Potential Production Case

For each production case, two trade policy alternatives were analyzed:

- Restricted trade, which assumes that the current ban on US crude oil exports is maintained.
- Free trade, which allows exports of US-produced crude oil.

The forecast period for the analysis is 2016-2030. The main conclusion of this analysis is that the free trade of crude oil would have broad and positive impacts on job growth, trade, government revenue, and US economic output. The results of this analysis are summarized as follows:

Impact of free trade (vs. current restricted trade policy)

	Base Production Case	Potential Production Case
Crude oil production, average, 2016-30 (million B/D)	1.2	2.3
US gasoline price, average, 2016-30 (cents per gallon, real)	-8	-12
Fuel cost savings, cumulative, 2016-30 ($ billion)	265	418
Investment		
Peak annual investment ($ billion)	66 in 2017	82 in 2017
Cumulative oil production-related, 2016-30, ($ billion)	751	995
Cumulative refining-related, 2016-30, ($ billion)	-5	-21
Cumulative logistics-related, 2016-30	9	13
Cumulative investment, 2016-30, ($ billion)	755	986
Gross domestic product		
Peak growth (percent)	0.7 in 2018	1.2 in 2018
Peak ($ billion, real)	135	221
Average, 2016-30 ($ billion, real)	86	170
Net petroleum trade, average, 2016-30 ($ billion, real)	67	93
Employment		
Average, 2016-30 (thousand)	394	859
Peak (thousand)	964 in 2018	1,537 in 2018
Disposable income per household		
Average, 2016-30 ($, real)	238	466
Peak ($, real)	391 in 2018	733 in 2021
Cumulative government revenue (2016-30) ($ billion)	1,311	2,804

Source: IHS Energy Insight and IHS Economics

This report, *Unleashing the Supply Chain: Assessing the economic impact of a US crude oil free trade policy,* is organized into five sections that address the following topics related to the export ban and how it impacts both the oil industry and US economy as a whole:

- The historical origins of the existing ban, the policy objectives that it was originally intended to achieve, why these objectives are now irrelevant, and the current framework of US trade policy pertaining to crude oil.
- The outlook of US crude oil production under the Base Production Case and Potential Production Case, and the methodology, techniques, and analysis that IHS employed to develop these two production

forecasts. This section of the report also contains IHS' view of how both the near- and longer-term outlook for US crude oil production would change as the difference between domestic and international crude price widens (under restricted trade) and compresses (under free trade).

- An overview of the US refining system, focusing on how various grades of crude oil are processed using different types of refinery configurations, and the processing inefficiencies that accumulate when a refinery processes a crude oil that it was not designed to process. The limitations of the US and, specifically, the US Gulf Coast refining systems in processing increasing volumes of light crude oil produced from tight shale formations are translated into domestic crude oil price discounts, without the ability to export surplus light oil production to the international market.

- The price relationships between international crude oil, international gasoline, and US gasoline that exist and that remain connected, due to the free flow of trade, but that do not exist for US crude oil due to the lack of free trade. The empirical evidence demonstrates that discounted US crude oil has no impact on reducing US gasoline prices, and counterintuitively, allowing free trade of US crude oil and reestablishing the trade linkage between domestic and international crude oil will increase domestic crude oil prices and reduce US gasoline prices simultaneously.

- A summary of the national and state level economic impacts of moving from restricted to the free trade of US-produced crude oil. Translating the investment impacts of upstream oil and gas industry production under free trade to the broader economy creates material boosts to GDP, employment, disposable income per household, and government revenue and taxes.

- Appendix A of this report provides more detailed discussion and synopsis of the 2014 *US Crude Export Decision*. *Unleashing the Supply Chain* builds from the previous *Export Decision* analysis and evaluates the impact of lifting the ban at the more granular congressional district level. It also analyzes the degree to which the jobs and economic value-added occur within the oil and gas industry itself or how that spreads through the supply chain that supports the industry with material, labor, and goods. To ensure continuity between the two reports, the same analysis and the oil and gas sector impacts associated with the two production cases and the transition from restricted to free trade have been used.

Changes to the energy market outlook since May 2014

Since the IHS *US Crude Oil Export Decision*'s May 2014 release, two notable changes have occurred that bear discussion. First, the global crude price has declined sharply largely due to US production increases, and second, the Bureau of Industry and Standards (BIS) has provided clarification of existing rules to allow certain very light crude oil (condensate) to be exported as a "refined product" in certain situations involving sufficient processing.

The rapid crude oil price decline—by roughly half since mid-2014—is a reminder of the cycles and uncertainty of oil and energy markets and of the disparity between the speed of market and price changes and the oil industry's long-term investment horizon. In less than a year, changes in supply, demand and price have shifted dramatically. In comparison, a large oil-producing project typically takes five to eight years to plan, construct and bring online for a decade or more of production at the site.

Producers are responding to declining cash flow with reduced budgets, smaller drilling programs and cost cutting. The US tight oil drilling response is sensitive to the price decline and will experience a more rapid production impact than most producing areas due to the shorter investment cycle for these onshore plays and the relatively high rates of production declines in the first few years of operation of a tight oil well. This faster rate of decline means that if new drilling is curtailed, production will respond very quickly. While exploration and development costs are expected to also decline (partially offsetting budget cuts), the industry is expected to produce less crude oil as a result of recent oil price declines, and the impact on employment is magnified throughout the supply chain.

Global benchmark crude oil prices downward revision

As discussed in detail in this section and in the *Export Decision* report, a key influence on the development of US tight oil resources and production levels is the absolute price producers receive at the wellhead. If this price is substantially reduced, either through domestic policy or market forces, producers have less available capital for sustaining reinvestment and new well development. Since mid-2014, a number of factors have combined to shift the market and market sentiment, including:

- Continued robust US production growth of over 1 million B/D in 2014;
- Weaker-than-expected global oil demand growth resulting from weaker global economic growth;
- The return of Libyan production in August 2014 (which was later reduced after prices began to fall);
- A decision by OPEC and Saudi Arabia to maintain production and market share in the face of a declining oil price.

IHS estimates global market oversupply in 2014 and 2015 combined to be over 1 million B/D. The oversupply of crude oil, particularly light crude oil, has exerted substantial downward pressure on the fundamental price level of both global and US domestic crude oils, with the price of the Brent benchmark falling from $110 per barrel in June 2014 to around $50 a barrel by January 2015—more than a 50% reduction for all crude oil grades.

OPEC's response to this period of global oversupply represents at least a temporary deviation from its historic response to periods when oil supply exceeds demand. Following a meeting of OPEC member countries in November 2014, the producer group announced that they would hold their production constant and allow markets to find a new balance. Global oil prices are expected to be reduced sufficiently—and for long enough—to allow demand to increase and new production to be curtailed, bringing supply and demand back into equilibrium.

OPEC's logic is based on a view that their production is not the world's marginal supply of crude oil, and many OPEC members have lower investment costs for new production than then investment costs for new production from non-OPEC producers. If OPEC were to reduce production by its member countries to balance the market, raising prices at the same time, it would continue to support incremental production from higher-cost producers, supporting the loss of OPEC's overall market share. Analysis on the part of IHS supports key OPEC members' estimates of new well development breakeven costs that are well below the global average of $60 per barrel (on the basis of Brent crude).

With the majority of the growth in global oil production over the past four years coming from US tight oil, the proven scalability of US tight oil[10] and the relatively high average breakeven cost of US tight oil (about $75 per barrel) has resulted in an unanticipated shift in global oil market dynamics. At least during the current oil commodity cycle, the responsibility for balancing the oil market has been transferred from OPEC to non-OPEC producers, primarily the United States. If prices stay low enough for long enough to discourage some portion of US tight oil and other non-OPEC new well investments, then natural declines in existing production and demand growth are forecast to rebalance the market over the next 18 to 24 months. When demand growth overtakes supply growth, prices will rise to incentivize new US tight oil well investment and production and add supply consistent with incremental demand growth.

This theoretical behavior of how the market will rebalance and respond to the new price environment faces several challenges. First, the time required to bring new supply to market implies that supply responses will lag global demand signals, leading to greater price volatility and more exaggerated price cycles. In addition, the export ban can disrupt the global market price signal for US production. The

10 Unlike many conventional oil projects, such as the Gulf of Mexico and North Sea deep-water projects, US onshore tight oil development occurs by drilling lower productivity wells, rather than investing large amounts in a few expensive, high-producing wells. This results in tight oil being more responsive to changes in global prices as the incremental investment, duration to develop, and production of each new well are much lower than in large projects.

reliance on US tight oil to balance the global market increases the issues created by any disconnects between the price signal being sent by the global market and the one received by US tight oil producers.

US producer response and outlook

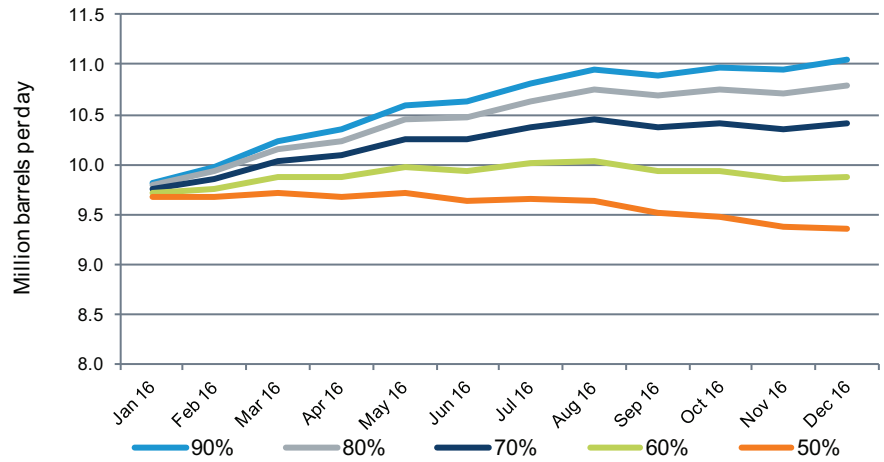
The oil price decline is causing a swift reaction in the 2015 capital investment plans of US tight oil producers. Capital budgets in some cases are being cut in half, and the number of active US land rigs is already down 25% from July 2014. In the previous analysis, IHS determined that an annual average $25 per barrel lower price at the well head between restricted and free trade results in a 25% reduction in US oil and gas upstream investment and a corresponding reduction of 400,000 B/D in US tight oil production after the first full year of lower prices, when the US light oil refining system reaches gridlock. Under the current $50 decrease in global and US crude oil prices, large reductions in upstream capital expenditure are materializing. Based on announcements by large drillers and producers of US tight oil, 2015 capital budgets have been reduced by approximately 35% and could be reduced even further over the course of the next two years if low prices persist. These lower capital budgets of US tight oil producers are predicated to some degree on a modest rebound in US crude prices by the second half of 2015, with announced expectations typically between $60 and $70 per barrel.

Although many US producers are reducing capital expenditures for future new well development, it is not anticipated that US production will immediately fall due to momentum in drilling and well completion programs and investment decisions made over the past few years. This is supported by the large inventory of US wells that have been drilled but not yet hydraulically fractured and completed. With drilling capital already sunk, new wells will continue to be brought online despite lower oil prices. Many producers appear to be employing the strategy of reducing investment in higher cost and developmental plays, while focusing capital on accelerating development plans in lower-cost and more prolific plays—"sweet spots" in various US tight oil formations. This investment shift is likely to delay the point where month-on-month US production growth stops and eventually begins to decline for a period of six to 12 months.

Another key outcome of declining prices—and a change from the previous analysis—is that drilling and completion costs are responding rapidly. The analysis performed for the 2014 report was premised on the assumption that as domestic prices dropped in response to the export ban, drilling costs would stay relatively high and remain tied to global drilling costs, since the price dislocation was specific to the US market. In the current market, however, with lower global prices and drilling activity, drilling and service-provider costs have responded accordingly. Costs have already fallen 10% and further declines are likely as the low price environment persists. Lower drilling costs globally and domestically will lower the breakeven costs for new well development and alter the relationship between wellhead prices and capital investment and production growth. As drilling costs fall, it will take a larger reduction in US wellhead prices to create the same production response as determined in the *US Crude Export Decision* report. This speaks to both the ongoing efficiency gains being realized for US tight oil drilling activity and the constantly shifting interaction between wellhead price, development costs, and overall production activity.

This IHS analysis evaluates this relationship between new well development costs, capital investment level, decline rates of US tight oil wells, and efficiency gains by the US upstream industry in this new era of dramatically lower prices. The chart shows various trend lines for how 2016 US production is expected to respond when 2016 investment in upstream capital projects is at varying percentages of 2014 investment.

US crude oil production outlook sensitivity cases (2016 upstream capital investment as a percent of 2014 upstream capital investment)



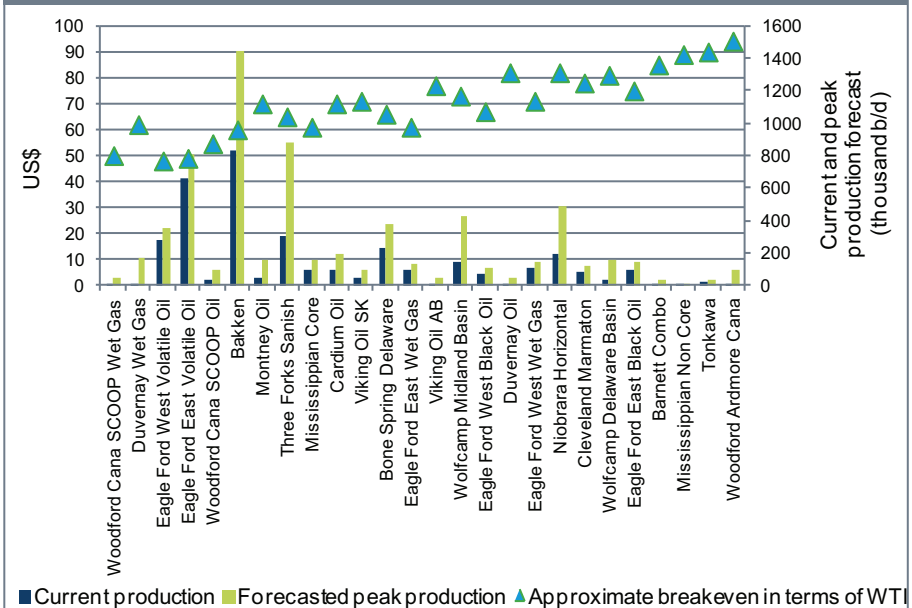
Source: IHS Energy

This outlook for potential 2016 production is premised on the IHS view that the current backlog of drilled, but not completed, wells and continued activity in tight oil formation sweet spots will increase US crude oil production from its current level of 9.2 million B/D to 9.7 million B/D during mid- and late 2015. This increase in production will occur despite the bearish price signals being sent by the global market. IHS' current outlook assumes that 2016 investment levels will be at 60% of 2014 levels and that the export ban is lifted, allowing US producers free trade of crude oil. The chart above points out the sensitivity of US production to upstream capital reinvestment: US production declines by 400,000 B/D when investment changes from 60% to 50% of 2014 investment levels. This difference could result from as small as a $5 dollar disconnect between domestic and international crude oil prices and is a key reason why the results of the first study remain valid in the new, lower price environment.

Another reason that capital investment levels and the US production outlook are more sensitive to small price discounts in the new low price environment is that large amount of US tight oil plays are currently near their breakeven levels. As shown in the chart, a far larger percentage of US tight oil is uneconomic at $50 per barrel than at $75 or $100. Large swaths of current drilling for new tight oil wells is profitable at $75 per barrel but not at $50 per barrel.

In summary, US producers' decisions about investment and production are increasingly sensitive to US price discounts as the price of crude oil becomes lower. Essentially, at lower crude

Production and play breakeven interplay



Note: Calculated with gas price at US$4/MMBtu flat and oil price at US$100/bbl flat.

Source: IHS Supply Analytics

oil prices, the industry has a "flatter" supply curve, which means that smaller changes in crude oil prices result in a larger loss of supply. The implication is that the risk from the export ban is *increased* in the current low price market.

Current US crude prices

The rapid reduction in all global benchmark crude oil prices briefly narrowed the spread between US and international prices. This appears to have only been a transient condition for US producers, since domestic crude prices during the transition did not fall low enough to remain competitive with international imported grades or to cover the logistics costs to deliver domestic crude oil to the proper refining center. There is likely further room for US domestic prices to fall below international prices as equilibrium setting mechanisms are re-established.

This narrowing of the international-domestic price spread, commonly measured by the Brent-WTI price difference, had somewhat muted the US producer response through the end of 2014. As additional US production growth occurs in 2015 (albeit at a reduced rate), a widening of the Brent-WTI spread is projected under the current trade policy for the reasons discussed above and in the *Export Decision* report.

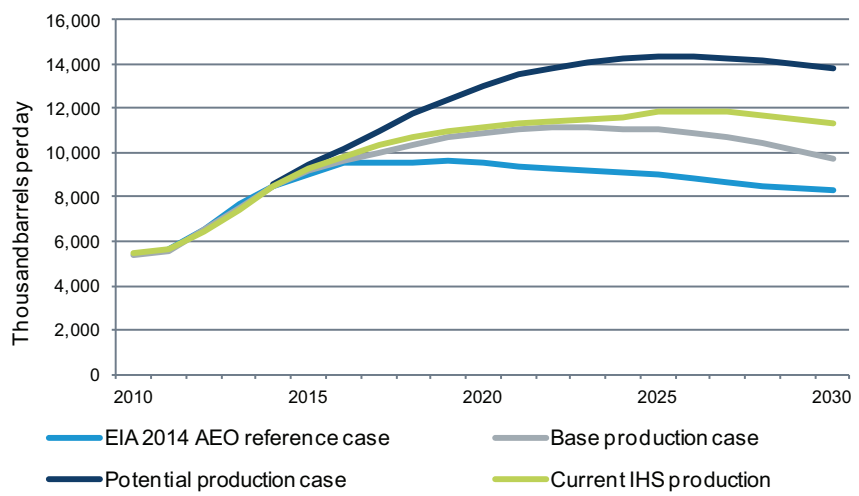
An increase in crude oil being placed in storage also supported a narrower price differential and may have obscured the impact of the export ban as prices declined. At the time of this report's release, US inventories of crude oil have risen to record levels, above 400 million barrels of US commercially available stocks, and the price difference between Brent and lower-priced WTI is again diverging to $8 to $10 per barrel, or a 15-20% discount, which is being incurred only by US producers.[11]

The result: US producers would be facing the doubly punitive impact of low global oil prices and a large domestic crude price discount compared with international prices that could further adversely affect upstream investment in oil and gas production and its associated economic and jobs growth. In short, the decline in global oil prices provides further incentive to remove the market distortions created by the ban on crude oil exports and avoid additional disruption to US crude oil producers.

IHS current US production forecast

IHS maintains US and global crude oil production forecasts, incorporating the latest data and information regarding expected production globally. Particularly in analyzing US unconventional production, where the pace of drilling and technological advancement are moving rapidly, the use of updated assumptions regarding typical well-production type curves, suitable drilling locations, market price signals, and the emergence of new unconventional plays have a large influence on the expected growth and ultimate peak production of US crude oil. IHS' current US crude production

IHS oil production forecasts compared to EIA Annual Energy Outlook (AEO) forecast



Note: EIA 2014 AEO released April 7, 2014

Source: IHS Energy, EIA

11 An additional 700 million barrel of crude oil is held in storage by the US strategic petroleum reserves (SPR).

outlook has been increased from the *Export Decision* Base Production Case developed in 2014, though not yet to the levels forecasted for the Potential Production Case. New projections show US production peaking at 12.9 million B/D in 2029; this 1.7 million B/D increase reflects stronger growth in the Bakken, Eagle Ford, West Texas, and deep-water Gulf of Mexico, as well as large efficiency gains realized during the current low price environment that will ultimately push the current outlook closer to the Potential Production Case.

It is noteworthy that the projection for 2016 of 9.9 million B/D of US production will eclipse the previous peak production year, 1970, which saw 9.6 million B/D of crude oil produced. However, if the lower price environment persists and contributes to a regime in which less investment capital is available, US production growth will eventually slow, putting upwards pressure on global prices in anticipation of lowered US production.

Our analysis supports the view that current, lower crude oil prices are the result of a transient over-supplied market that is likely to correct itself over the next two to three years. Several oil market factors are likely to rebalance the market and increase prices.

- Investment deferrals and cancellation of high-cost sources of production such as ultra-deep water, Canadian oil sands, and US tight oil projects.
- Recovery of economic growth in key regions, including Europe and China.
- Fragility of sustained production from Libya.
- Potential action by OPEC to reduce output.
- Destabilizing effects of lower crude price for high-cost producing nations that rely heavily on oil revenues to fund government budgets. A period of destabilization and unrest in any one of the large producing nations could rebalance markets by reducing supply and changing market sentiment.

Despite the near-term downward price correction, IHS' long term view remains similar to the prior outlook due in part to the expected efficiency gains generated during this current low price environment. Over the long term, as world demand for crude continues to grow and conventional reserves decline, more supplies will be needed from high-cost sources, such as deep-water, ultra-deepwater, extra-heavy oil—including the Canadian oil sands—and from plays in more demanding environments and marginal fields. While growth in US light tight production will be an important supplier to global oil markets in coming years, other supply will also be required to meet demand. Various factors such as project costs suggest that non-OPEC output growth outside of North America will slow and skew toward more expensive, harder-to-produce reserves. As this happens—around 2020 in our forecast—the real dollar Brent price rises to approximately $90 per barrel, the price level necessary to develop these more challenging resources.

The combination of the export ban and the United States as a higher cost crude supplier influenced by global market prices creates a new risk to US consumers. In the context of the export ban, the global crude oil market and recent decisions by OPEC that have shifted market balancing responsibility to non-OPEC producers creates the possibility of a new and large market distortion. As the market rebalances, demand responds to the lower price environment, eventually requiring new production. A higher price signal must emerge to incentivize increased production. Since US tight oil has the demonstrated ability to respond quickly to global price signals, it is reasonable to assume that as prices rise, the market expectation will be that a large portion of new supply will come from the United States. However, if US production of light tight oil is at a level where efficient light oil refining capacity is already being fully utilized, US domestic prices will become increasingly discounted to international prices. As each incremental barrel of US light oil production moves to less and less efficient US refining tiers, global prices will continue to rise until the US refining cost penalty to process US tight oil is fully offset and imports of heavy crude are displaced back into the international market to meet growing global demand.

When this occurs, the US ban on crude exports will be directly responsible for an increase in global crude oil and gasoline prices equal to the discount necessary to incentivize the processing of US light crude oil in US heavy crude oil refineries. This increase would be similar to the price decrease expected if the export ban is removed.

Processed condensate

A recent decision about what constitutes US oil that is eligible for exporting may also play a role in how the export ban discussion develops. In June 2014, it became public that two operating companies (Enterprise Products Partners and Pioneer Natural Resources) had received private rulings from the US Department of Commerce and Bureau of Industry and Security (BIS), that the degree of processing being done to condensate at certain field facilities would be defined as "distillation"—and neither of the resulting products are considered crude oil and thus not subject to the export ban. Under existing US policy, petroleum products that have been separated from whole crude or condensate through a distillation process are no longer subject to the controls that govern whole crude oil or condensate. Thus both the lighter petroleum liquids and heavier bottoms fractions produced when condensate is distilled could be freely exported as "refined products" and would not be subject to the trade controls that apply to crude oil. In the aftermath of this private ruling, the export of condensate product has been occurring, although volumes remain modest.

It has also become public knowledge that other market participants have applied for clarification and rulings on their distilled petroleum products from condensate. In addition, at least one market participant has announced that it will "self-classify" and export condensate product without receiving explicit endorsement from the BIS. However, the definitions of the processing required and what streams qualify remains unclear.

In December 2014, the Department of Commerce also issued a series of clarifications in its Frequently Asked Questions (FAQ) format regarding processed condensate, in an effort to provide further guidance and perhaps to aid operators in self-classifying, avoiding the need for new private rulings. The FAQs somewhat clarify the degree of processing necessary for fractionated streams to qualify for export. They do not, however, provide the technical details necessary to determine if processing is occurring in each situation. Notably, the FAQs did not attempt to define the difference between crude oil and condensate or to limit the application of the processing definitions to one or the other. However, the facilities described are typical of those used in the field to handle condensate, and the materials qualifying under the ruling are most likely to be condensates.

If sufficient volumes of US condensate production fall under this definition, the export of condensate product will loosen the impending market gridlock. However, the amount available for export remains unclear. The largest barriers to widespread adoption of condensate product exports are ongoing regulatory uncertainty.

New infrastructure must also be put into place to segregate this new policy-generated product. Condensate production is significant and estimated to be near 800,000 B/D. Yet, little of this production is coastal and so, to prevent commingling, infrastructure is needed to move the condensate product to export terminals.[12] This new infrastructure must be separate from the three existing infrastructures for crude oil, natural gas and natural gas liquids (NGL).[13] This required segregation creates market and capital inefficiencies. Further, market distortions are likely to arise due to artificial distinctions between similar products (unprocessed condensate and condensate product). This policy-driven investment will likely duplicate more efficient facilities already in place, another example of the economic inefficiencies caused by an outdated US crude oil export policy.

12 Condensate production is estimated due to a lack of an industry and statistical definition.

13 The infrastructure for crude oil can also be used for condensate as long as the condensate is not intended for export.

It is worth noting that condensate product is not a usable fuel but is, rather, a broad boiling range feedstock, like crude oil, that requires further refining to produce finished products for end use. Therefore, most exported condensate product will be sold to the same refiners that would purchase the unprocessed condensate. To date, the majority of US processed condensate exports have gone to refineries located in Northwest Europe and Asia—markets identified as most likely for condensate and light tight oil exports, should the ban be lifted.

Adjustments to energy results

Other than the new mapping to translate the state-level results the *Export Decision* study into congressional district level results for this report, the vast majority of outputs in IHS' energy analysis remain unchanged for the four production-trade cases—Base and Potential Production under restricted and free trade. One exception was a small downward revision (about 3%) in the restricted trade cases for midstream infrastructure spending associated with crude oil assets (pipeline, storage, marine, rail) to reflect the lower crude production brought on by lower prices, requiring less midstream infrastructure spending to support production. This adjustment was not made in the previous report but has been incorporated into these results.

Energy modeling methodology

National-level inputs

A key step in IHS' analysis of the US economic impact of free trade in crude oil is developing the necessary inputs to determine how production, pricing, and investment levels change in response to a policy change. There are six first-order results or outputs from the energy analysis that directly impact macroeconomic and supply chain comparisons of a free versus restricted trade policy environment:

- Changes in production of US crude oil, natural gas liquids, and associated natural gas, determined by applying domestic market price signals to the well head price under free and restricted trade and calculating a reduction in drilling levels associated with lower capital available for reinvestment under the current restricted trade policy in which an oversupply of domestic crude oil in US markets puts downward pressure on US crude prices.

- Changes in the Refiner Acquisition Cost (RAC), which is the average cost paid for domestic and international crude oil by US refiners. The RAC cost is several dollars lower, on average, over the forecast period with the current restricted trade policy in place. It should be noted that the RAC does not affect gasoline or refined product prices, because these prices are tied to international crude and products prices.

- Changes in direct capital investment across the upstream (production), midstream (transportation and logistics), and downstream (processing and marketing) sectors. The lower overall price level of domestic crude oil with restricted trade results in lower upstream direct capital investment by oil and gas producers. This investment is $751 billion less in the Base Production Case and $995 billion less in the Potential Production case during 2016-2030. This effect is only partially offset by more investment in the downstream sector in the restricted trade case; in comparison, downstream investments increase by $5 billion and $21 billion in the Base and Potential Production Cases, respectively. The level of midstream investment change moving from restricted to free trade is also relatively small: $9 billion less in the Base Production Case and $13 billion less in the Potential Production Case).

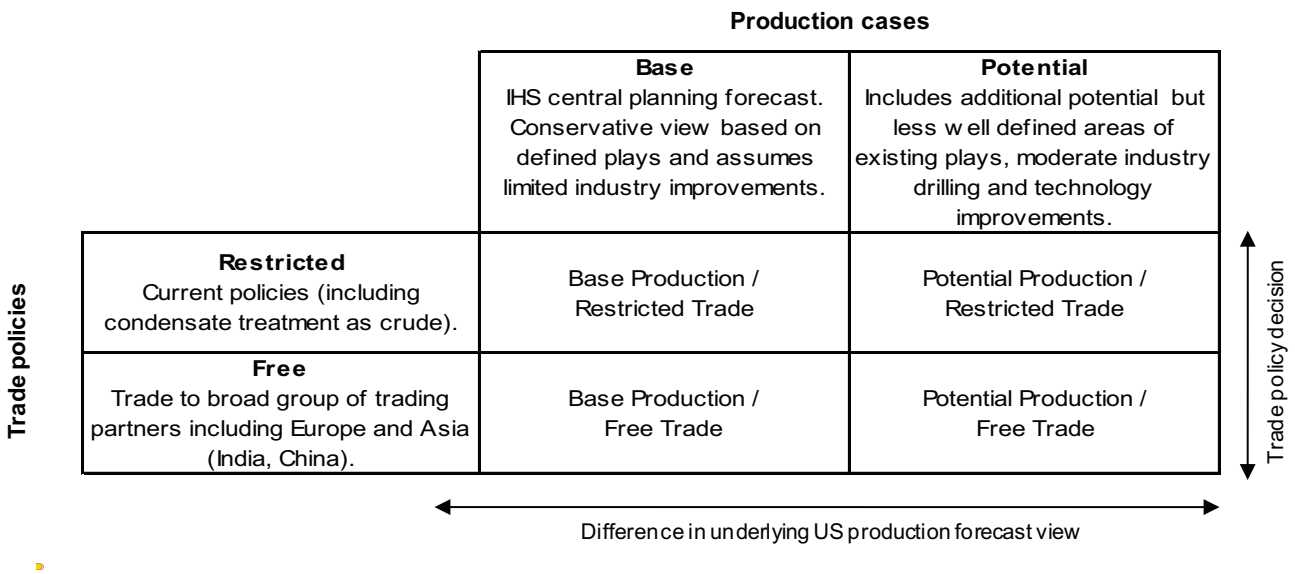
- Changes in the volume of crude oil and refined product imports. These changes are converted to dollar values (import volume multiplied by price). The impact of trade policy on the petroleum trade balance and total US balance of trade is evaluated.

- Changes in the volume of crude oil and refined product exports. Again, this is converted into a dollar value, and the impact on the petroleum trade balance and US trade balance of trade are evaluated.
- Changes in the price of domestic retail gasoline, diesel and other refined products. As discussed above, IHS' analysis concludes that free trade of crude oil lowers US gasoline prices due to the global price impact of higher US crude production on the world oil market.

These six primary energy inputs are developed for each production case (Base and Potential) and then modeled under either a free or restricted trade environment. When viewed in aggregate, this analysis provides a complete view of the petroleum energy landscape at the national level.

In comparing these four cases developed by IHS, it is important to note that the effects of a policy change are not four independent cases. A case must be compared against another case to evaluate how change in the crude oil trade policy or production outlook impacts the US economy. In the figure, cases that are adjacent to each other either horizontally or vertically can be compared, but comparisons cannot be made between cases diagonal to each other. For example, the Base Production/Free Trade Case to the Potential Production/Restricted Trade Case are not comparable and will not produce meaningful results since they start with different fundamental assumptions about how much US crude is produced.

Basis for production cases and trade policies



Note: Each case starts with the same IHS macroeconomic and international crude oil price forecast

This clarification is also important distinction, because many pieces of the petroleum investment and supply outlook are unlikely to change when moving from a restricted to free trade policy environment or when comparing the Base Production and Potential Production cases. For example, the underlying price of natural gas and natural gas liquids and their associated infrastructure investment are not materially impacted by the transition to crude oil free trade. The trade policy associated with natural gas is already largely liberalized.

State-level inputs

The essence of translating the national level energy analysis and results to the state level requires ensuring that the crude oil production is properly allocated to each state. IHS accomplishes this by performing two separate analyses to the production of conventional and unconventional oil and associated natural gas. IHS maintains a detailed database that is regularly updated based on IHS internal analysis and on the history and forecasts of US crude production by type of commercial crude oil stream and by geographic region. Each stream is then allocated to individual states based on each state's historical production levels, expected decline rates (if applicable), and forecasted new well completion activity (mostly from the unconventional plays). For some commercial grades of crude, this is relatively straightforward since the shale formation resides in only one state. For example, Eagle Ford lies entirely within Texas and is allocated entirely to that state. The exact percentage allocation becomes more complex when a play—and its production—spans several states such as the Permian, Bakken, and Utica basins.

Once the state's level of forecasted production is determined, it is used to develop the expected number of new wells that must be drilled and completed. Well numbers assigned to each state are, in turn, used to calculate the direct capital investment in the upstream sector for each state. IHS correlates direct capital investment as a function of well completion level, using proprietary cost estimating tools and escalation factors to develop per-well costs for both new conventional and unconventional wells being drilled. The final step in calculating upstream capital investment for each state is to multiply the number of completed wells by the per-well cost for each broad category of well. Since crude production, which is driven by market price signals, is the piece of the analysis that changes most when moving between restricted and free trade policies, this this change also has the largest influence on economic growth and employment in the analysis.

IHS assumes that each state carries a single price at the well head for crude oil, though in actuality small differences exist across regions, states, and counties. This price is determined by indexing the well head price to the nearest price-benchmarking location and calculating likely logistics costs (for pipe, rail, and truck) to transport the crude oil to that location. When approximating well head crude oil prices at the state level, Texas has several large producing basins and benchmark pricing locations, posing a particular challenge in developing a uniform wellhead price for the state. This is solved by dividing Texas into three sub-regions (Gulf, Central, and West) and developing different wellhead marker prices for each sub-region.

To assess the impact of free trade through the remaining parts of the US energy sector (midstream transportation and logistics, and downstream processing and marketing), IHS developed a project-level database containing investment details, including capital costs and locations, for the majority of energy infrastructure projects currently under development in the United States. This project-level database tracks investments in processing, logistics, and storage across each of the three main hydrocarbon value chains: crude oil, natural gas, and natural gas liquids (NGLs). When evaluating investment trends for petroleum infrastructure, IHS has determined that publicly available information in financial statements and press releases are good sources for the location and volume of infrastructure projects under development for the next three to five years. To assess infrastructure spending required in the medium term through the end of the analysis forecast, IHS performs an assessment of the expected levels and locations of production for each hydrocarbon value chain, the existing capacity for processing and transportation, and whether or not an infrastructure deficit is likely to emerge during the forecast period. When IHS identifies a gap in the infrastructure required to bring production to market, an estimate is developed for the capital investment necessary to close that gap. This assessment of the level of infrastructure deficit (or overbuilding) in the four production-trade scenarios is largely driven by the difference in crude oil production for each scenario.

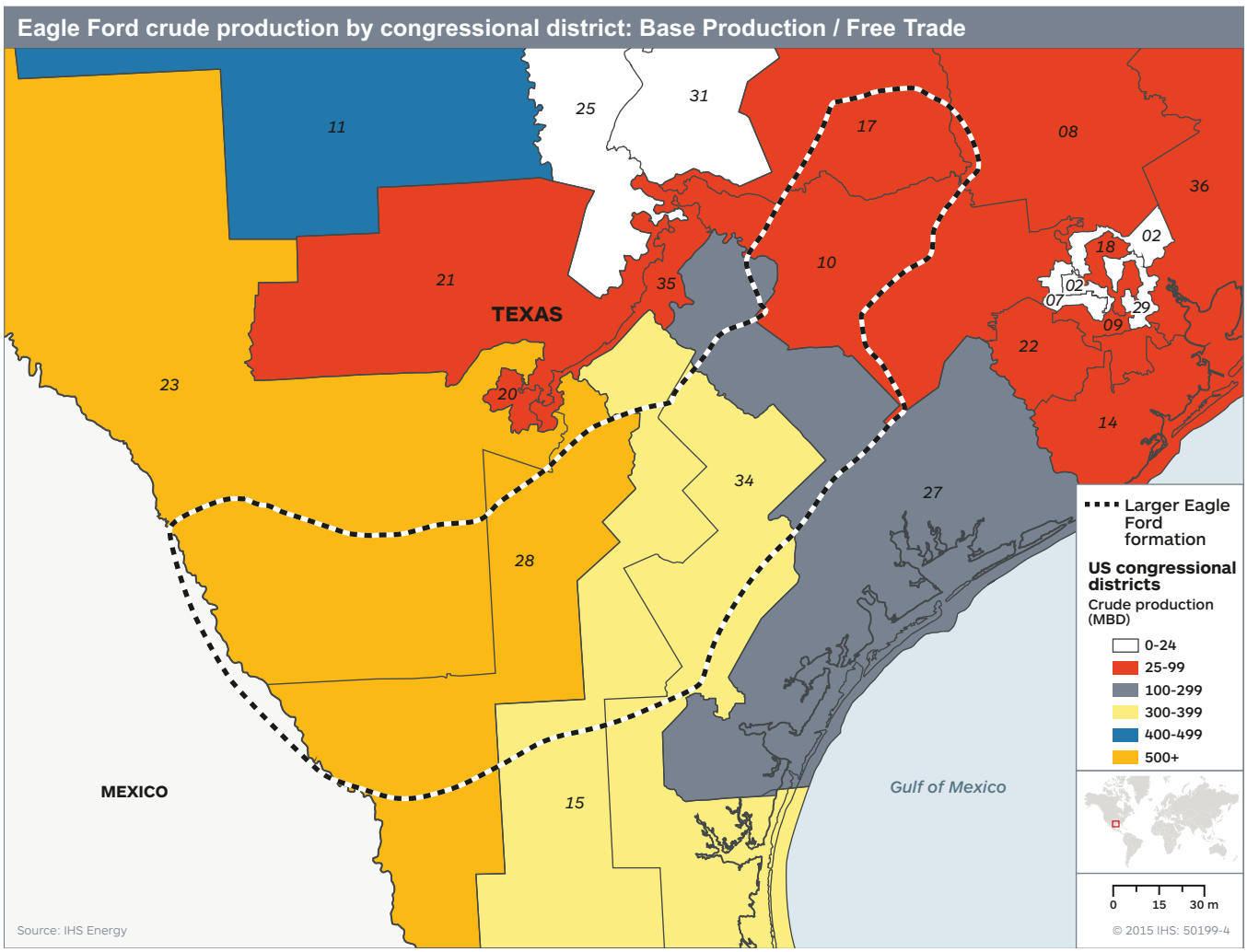
The analysis of where and how much infrastructure will be needed over the longer-term investment horizon is premised on IHS' experience and internal analysis of where infrastructure is likely to be added. Cost estimates of the necessary capital investment to build that infrastructure are developed internally. An example of this process can be found in the restricted trade cases where substantial additional investment is likely to be needed in simple refining capacity to process a surplus of light tight oil production that cannot be exported. Since the investment decisions for these projects have

not yet been made, IHS uses internal estimating practices for the investment to add between 1 million B/D and 3 million B/D of simple crude processing capacity; we then make a determination that this capacity will probably be added in existing refining centers, such as the Louisiana and Texas Gulf Coasts. Similar analyses are performed for other components of the midstream and downstream supply chain for construction of pipelines, storage, loading and unloading facilities, rail car manufacturing, and crude marine tankers.

The remainder of the main energy inputs, such as RAC, crude oil and refined product trade (both imports and exports), and retail gasoline prices are assessed only at the national level and only have an impact on the national-level economic analyses and results. These pieces of the energy analysis are assumed to be evenly distributed across the states. However, an assessment is made of the states would be likely import and export crude oil, based on historic trade patterns and the presence of port and marine infrastructure.

Congressional-level inputs

Similar to converting national data to the state level, converting the state-level energy analysis to the congressional district level involves a similar process of data mapping and proportional allocation among districts. IHS' proprietary production databases and many state government departments monitor existing production on a county level. To convert this into congressional district data requires an assessment of what percentage of a county is contained in each congressional district, based both on the county's land area and the location of production. For the forecast, the detailed analysis of the

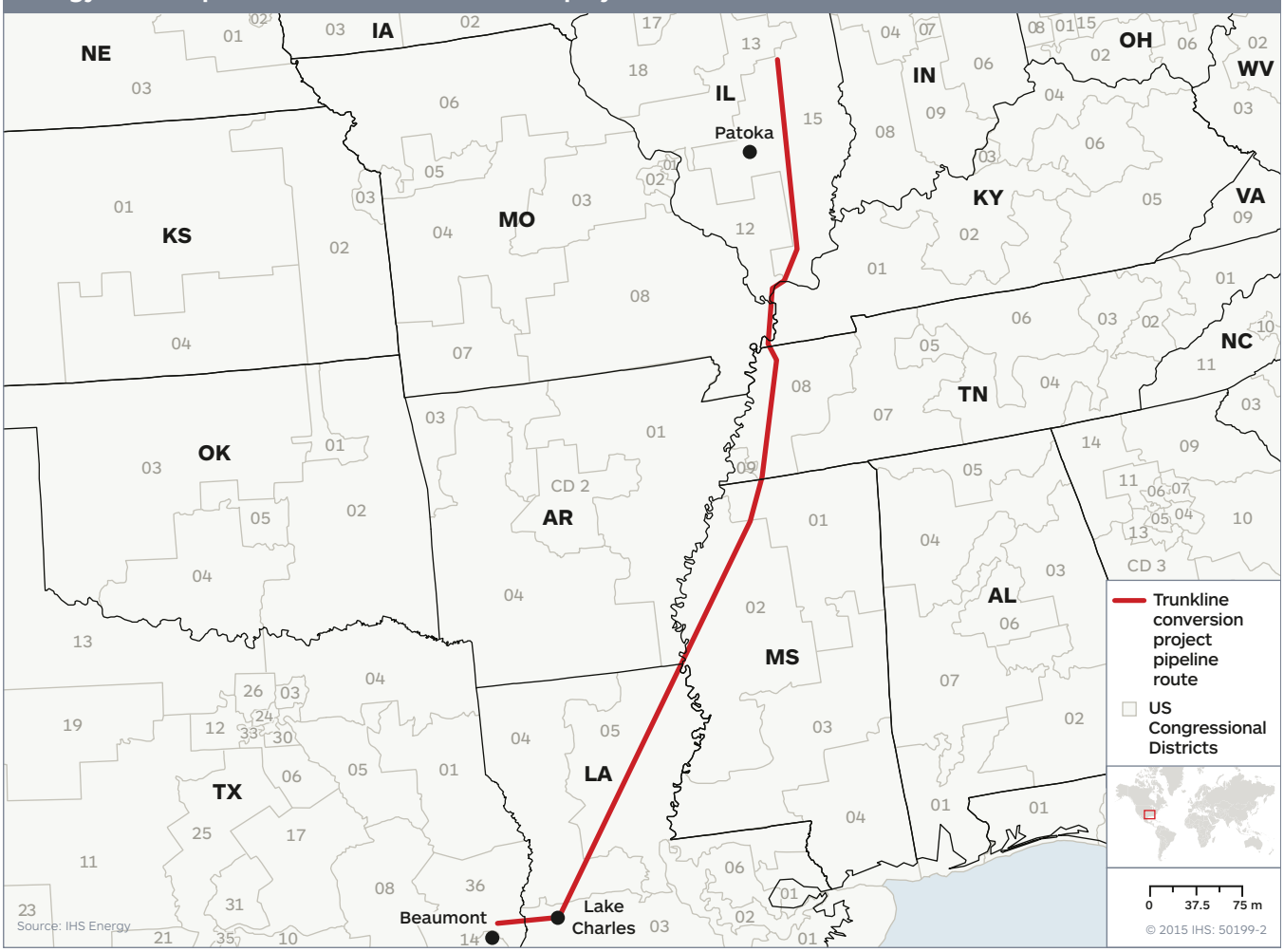


unconventional plays and where future drilling locations are expected to be concentrated are overlaid on a current congressional district map to determine the state-level contribution allocated to each district. For major unconventional tight oil formations such as the Bakken, this is a straightforward exercise in Montana and North Dakota, which each have just one large congressional district. Allocating other tight oil plays is more involved. For example, Eagle Ford has several distinct producing windows (dry gas, wet gas, volatile oil, and black oil) spread across nine congressional districts.

For assessing the impact of crude oil production, once the congressional district allocation is complete, the same translation of changes in both production cases when going from restricted to free trade is calculated to arrive at the resulting changes in direct upstream capital investment. Next, the investment distribution is performed for the midstream and downstream investment databases for both production cases under free and restricted trade. The map below shows a large pipeline project under development to transport surplus light tight oil from the Midwest to refineries and storage terminals in the Gulf Coast. This pipeline crosses numerous congressional districts receiving investment by a single infrastructure project. (It's important to also note that there are situations in which a given project may not be realized if crude production levels are too low, and the project is not economically feasible.

As with the state level analysis, a constant crude oil well head price across congressional districts is assumed. This is identical to the price at the state or sub-region level.

Energy transfer partners—Trunkline conversion project



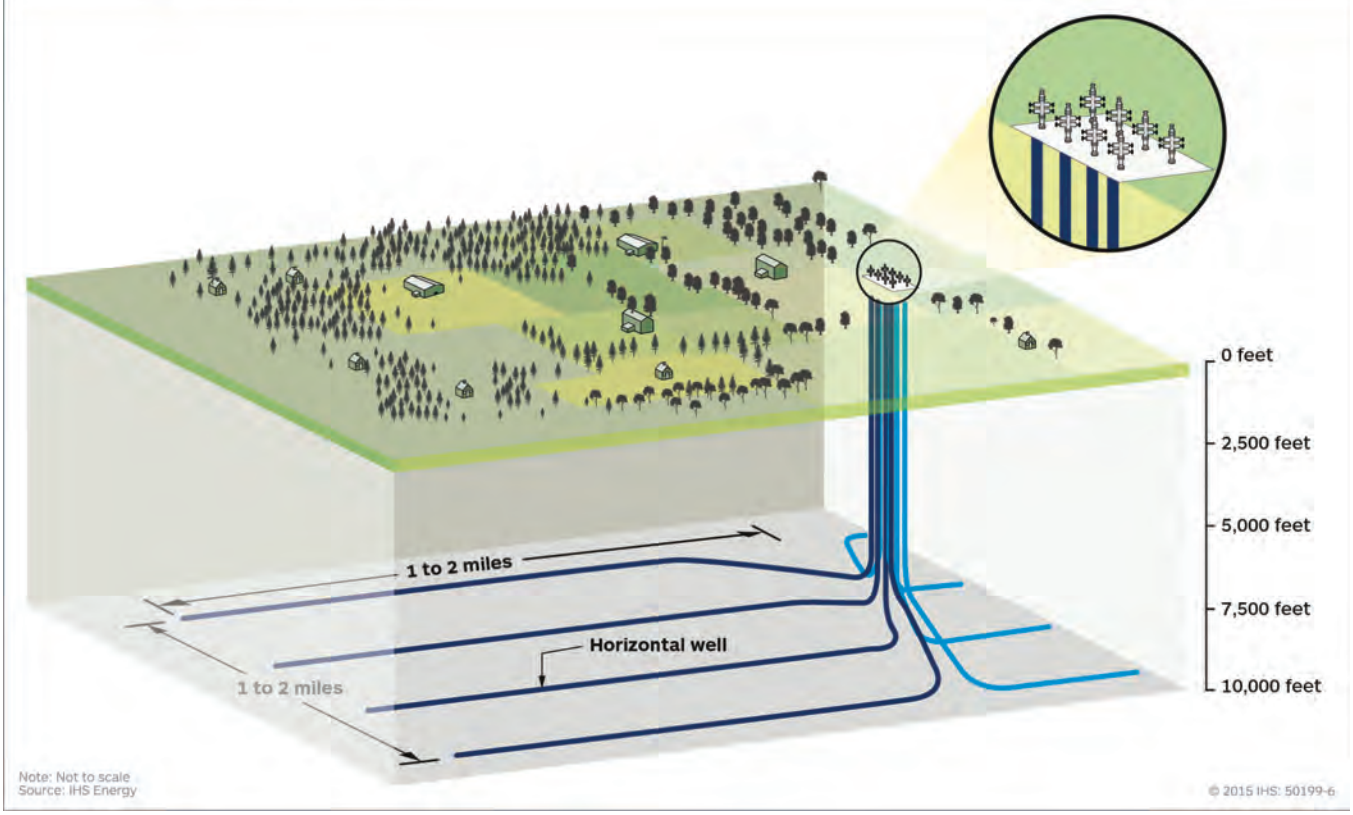
Anatomy of a crude oil well

What does it take to drill a crude oil well, and what kinds of supply chain are required to support it? What does it take to bore a hole and insert a six-inch pipe two miles underground, bending it at a right angle and then extending the pipe another two miles horizontally through a layer of oil-bearing rock with a thickness less than the length of a football field? The answer begins with a high degree of innovation, engineering sophistication and logistics coordination. It is not by coincidence that the economic unconventional oil (or gas) well of today resides in North America. The US oil industry has evolved rapidly over the last few decades, leveraging both high technology and manufacturing efficiencies to allow producers to reduce costs and continually optimize production. Further, the development and application of this technology has a multiplier effect within the supply chain to enable this growth. For both onshore and offshore wells (conventional vertical or horizontal unconventional), hydraulic fracturing stimulation is used to increase production rates and hydrocarbon recovery. An additional level of technical prowess is required at the surface during drilling and completion when a combination of cement, heavy mud, and reinforced steel casing are used to seal the well from the surface environment and from the surrounding water tables, this seal extends a half-mile underground.

The final phase is the "rocking horse" artificial lift system that pumps out the oil, surrounded by storage tanks. This surface-level simplicity masks the technical sophistication and engineering challenge involved in developing each well and obscures the complexity of the supply chain that made each well—and its economic contributions—possible. To illustrate this well-by-well contribution, the following discussion examines the anatomy of an average unconventional well, which is representative of those being drilled and completed in the US today. The analysis examines both the inputs into the typical well—labor, materials, and engineering expertise—and its outputs in terms of the uses of the hydrocarbons produced.

The typical well relevant to this discussion is an onshore unconventional well in the Bakken formation of North Dakota, although in reality there is wide variation in wells drilled in the Bakken and in other tight

Pad drilling typical configuration



oil formations. This typical well requires an $8 million direct capital investment to convert the site into a producing well that can be expected to produce for 10-15 years. This analysis is based on single wells, but it is important to note that a common practice in many tight oil formations is to use pad drilling, where 8 to 10 individual wells are drilled from a single location. Although the well heads are in close proximity on the pad, the process of bending and angling the drill pipe underground provides an average half-mile of spacing between the wells (known as 320 acre spacing), creating the fork pattern in the diagram below. This system lowers the cost of individual wells by allowing only one mobilization and demobilization of one drilling rig to drill multiple wells; at completion of each individual well, the rig "walks" several hundred feet to the adjacent well surface location. The pad concept also provides significant efficiencies by enabling the use of common infrastructure, such as storage tanks, separation and treatment equipment, and oil and gas gathering and compression systems that can be sized to accommodate a cluster of wells. The pad concept reduces the surface footprint required to develop these resources compared to the methods utilized pre-2000's for onshore fields. In some cases, this has reduced the footprint by more than 90%, freeing up surface land for other uses.

Once the drilling or well pad location is selected, the first step in the drilling process is to prepare the drill site. This involves using earthmoving equipment (bulldozers, backhoes, excavators and graders) to prepare, clear and flatten a three to five-acre area (about 2 soccer fields) for the drill rig, stage equipment and materials, stage pressure pumping equipment, and the storage of mud, water, and other drilling fluids. Following site preparation, drilling the well can begin. The drill rig itself is a highly engineered, complex, and sophisticated system of machinery with primary, secondary, and safety systems working to achieve two main objectives:

- **Drilling the bore hole** using a rotary drill bit tipped with ultra-hard cutting material. As drilling occurs, segments of drill pipe, usually 30 feet or so in length, are screwed together, lowered and rotated, pushing on the drill bit to dig the bore hole. Drilling mud, a dense mixture of water, clay, additives, and various chemicals to control specific properties, is injected into the well bore where it is used as a cooling agent, helps circulate and remove rock fragments, stabilizes the well bore, and controls pressure and temperature conditions in the well bore.

- **Successive laying and cementing of production casing** to seal the well bore and, eventually, the producing well from the surrounding environment and to keep the well bore intact through the life of the well. Casing consists of steel pipe held in place and sealed using cement. The casing is placed in a telescoping arrangement consisting of typically four layers. The first and widest casing segment, known as the conductor casing, is 16 inches in diameter (it can be as wide as 3 feet) and extends 100 feet into the ground. Next, the surface casing is installed. Usually a little under 11 inches in diameter and installed to a depth typically set by regulatory agencies, the surface casing provides a steel and cement barrier between the well and groundwater reservoirs. In the Bakken formation, this is installed to a depth of half a mile or 2,200 feet. The third phase, known as the intermediate casing, usually has a diameter of 7-5/8 inches, and it is run for the remainder of the vertical length of the well, through the mitered right angle bend, and into the horizontal lateral—a total length of approximately 2 miles. The final section of casing, the smallest in diameter at 4-1/2 inches, is known as the production casing and extends another mile and a half into the producing formation. After each arrangement of casing and cement is completed, the drill bit is inserted through the casing and begins creating a new borehole, with mud circulating to cool the bit and carry cutting to the surface.

These functions are performed by the drilling rig, which consists of the derrick manifold and drilling assembly used to insert the drill bit, stem, and casing into the bore hole. The rig is typically powered by two or three high horsepower (1000+ HP) diesel or natural gas fueled engines, driving both electrical generators and mechanical drive systems. The primary drilling function is supported by the mud injection and circulation system, which consists of strainers, shakers, mixers, and pumps driven by the rig's engines. Drilling activity is controlled from the primary control center - the "dog house"—where drilling technicians and operators control the speed and depth of drilling using advanced hydraulic-electric control systems. They also monitor conditions inside the well bore using sophisticated instrumentation, measuring downhole characteristics such as pressure, mud flow, and temperature.

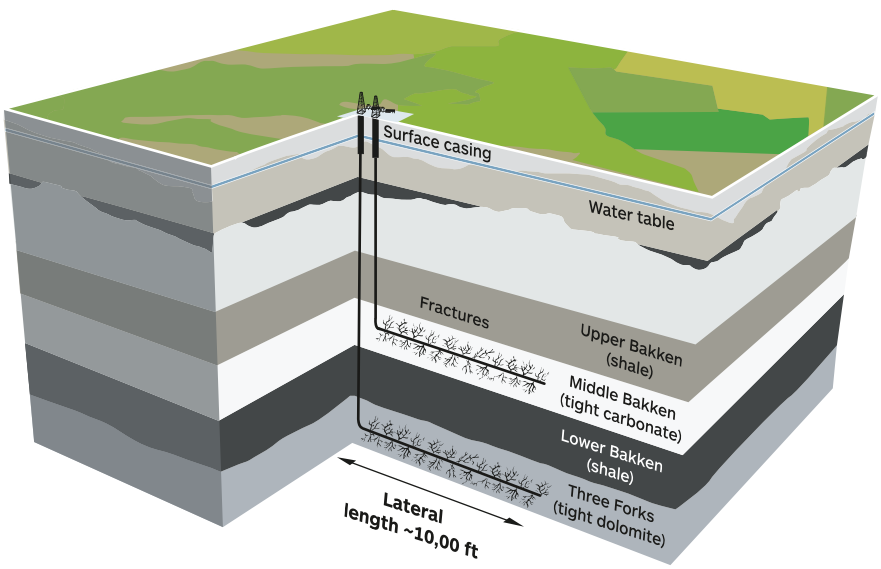
The modern drill rig serves as a command hub that controls the flow of materials and the performance of drilling, casing, and completing the well. The key labor and materials required for this first phase of oil well completion include the following:

- Four to six drill bits, on average, are used per typical well, depending upon casing size and hole conditions.
- In 30-foot increments, 650 drill pipe segments are used for each well, and these segments are strung together and inserted and then extracted as the drill bit is removed.
- Four miles of casing pipe of varying diameters are used for each well. Although smaller in diameter, the amount of total casing pipe in 400 typical wells equals the length of pipe that would be used in the proposed Keystone XL pipeline. The number of new wells drilled in the United States this year would be equal to the length of pipe in perhaps eight Keystone XL pipelines.
- The typical well uses 1,470 bags of cement or 138,180 pounds.[14] To put this in perspective, at the anticipated level of 25,000 to 30,000 oil well completions per year, the drilling industry's annual use is roughly twice the amount of cement used in construction of the Hoover Dam.[15]
- Roughly 17,500 50-pound bags of mud are used in the typical well or almost 900,000 pounds—more than 64 elephants.
- The typical well takes 30 days to complete and employs a crew of approximately 50 individuals, working in rotating 12 hours shifts, 24 hours day. At this level of employment contribution, every 12 wells employ 50 US workers full-time. This figure does not include the indirect support associated with the logistics of bringing materials to and from the drill site.

The second phase of developing a typical unconventional oil well involves production stimulation through hydraulic fracturing and the completion of the well. The hydraulic fracturing phase progresses in several stages. The first stage is the perforation stage: the production case is punctured using a casing gun and explosive charges are used in specific locations along the borehole. These perforations create fractures in the shale rock that allow hydrocarbons to flow into the production casing. Then pressurized pumping pushes a slurry of water, sand or proppant, and other lubricity and corrosion control additives down the well borehole and through the perforations to further open the fracture cracks and hold them open using the proppant as a wedge in the pores of the rock. This is the first fracturing stage.

After the initial fracturing stage is complete, a plug is inserted into the production casing. The process is then repeated up to 36 times, moving down the borehole, creating individual

Bakken formation subsurface geology



Source: IHS Energy

14 At 94 pounds per bag.

15 Five million barrels of cement were used to construct the Hoover Dam, with each barrel assumed to weigh 376 pounds.

isolation and production stages. When all of the individual fracturing stages are complete, the isolation plugs are drilled out, allowing the injection slurry or "flowback" to return to the surface, where it is collected and stored for recycled use or disposal. This flowback of water and sand slurry is followed by oil and natural gas that pushes through the shale rock to the surface where it can be separated and processed. The final stage in the process involves the installation of an isolation valve manifold (typically consisting of six to eight large isolation valves), also known as a "Christmas Tree," which isolates and allows the flow of hydrocarbons into the production casing.

During the fracturing and completion stage, the drilling rig is temporarily replaced with a battery of pressure pumping trucks and portable storage tanks. The tanks both house the injection fluid and receive the flowback at the end stage of the process. The relevant supply chain activities for this phase in the crude oil well development cycle are the following:

- Up to 24 pressure pumping trucks are deployed, each consisting of a heavy duty vehicle, storage container, and high horse power slurry pumps (1500-2500 HP).
- Additional fracturing equipment includes two frac fluid suspension blending units feeding the pressure pumps, a manifold truck, specialized component blending and sand handling trucks feeding the main blenders, and a data acquisition/control van.
- An additional battery of onsite portable storage tanks are deployed to support operations, typically 50 rectangular steel frac tanks each with a capacity of 500 barrels.
- The pressure pumping crew employs an additional eight to 10 individuals to support this phase of the well development.
- On average, 50,000 barrels of fresh water are used during the fracking operation, with 25% or less recovered as very salty water. Typically the recovered water is injected back into the subsurface through a disposal well, adding considerable expense to the drilling. Recently research has focused on methods to recondition the recovered water for continued recycle and use in fracking other wells.
- Added to the water are 3-4 million pounds of sand per lateral. This mixture of sand and water comprises 99.5% of the slurry injection mix.
- The pressure pumping operation is interconnected with a large assembly of valves, steel pipe and hoses.

Once the pressure pumping and completion phase of the well is finished, support and gathering facilities are installed in the vicinity of the well or well pad. Its main purpose is to facilitate the bulk separation and primary treatment of oil from gas and gas from oil. This is done using equipment very similar to equipment found in a petroleum refinery or other hydrocarbon processing facility, such as pressure vessels or separators, heat exchangers, gathering pipelines, valves and isolation manifolds, pumps, compressors, measuring and control instrumentation, flares, stabilizer towers for further fractionation or distillation, and treatment towers to remove contaminants such as water, carbon dioxide, and hydrogen sulfide. The design and configuration of each separation and gathering facility is unique to the expected flow composition of the individual producing well. The end products from this initial processing and collection are typically stabilized crude oil or condensate that can be safely stored in atmospheric storage tanks and a rich or wet gas stream that is collected and compressed prior to transmission to a gas processing plant. The stabilized crude oil is stored and moved either by small gathering pipeline or truck to a central collection hub, usually the origin point of a larger pipeline system. For the rich gas, the next stage of processing involves a gas processing plant where natural gas liquids (NGLs) are separated from dry natural gas (methane).

Another feature usually installed at a producing well after the completion process is an artificial lift to help sustain higher production rates as the well bore pressure begins to decline. This consists of a lift or pumping system to help draw additional volumes of oil to the surface for processing. The most common artificial lift system is the rocking horse—also known as a drinking donkey—pump assembly gently rocking up and down.

So what does this typical well produce? In the first five years of production, a Bakken well will produce 70% of its expected total volume, consisting of the following:

- 220,000 barrels of crude oil, with an API gravity of 40-44 and sulfur below 0.2 wt%.[16]
- 35,000 barrels of mixed NGL (referred to as Y-Grade), consisting of 40% ethane, 25% propane, 20% butanes, and 15% of pentanes and molecules heavier than pentane (the heavy fraction is also commonly referred to as natural gasoline).
- 160 million dry cubic feet of natural gas used in home heating and cooking applications or as a primary power plant fuel for electricity generation.

The next step in the hydrocarbon supply chain is to transport the stabilized crude oil and rich gas through a combination of gathering systems and long-distance transmission lines. The rich gas is separated into dry gas and mixed NGLs in a gas processing plant. The NGLs in turn are fractionated (separated) into their components (ethane, propane, and normal and iso butane) in NGL fractionators. The individual NGL components are used in a wide array of end markets, such as petrochemical feedstocks, home heating and cooking fuel, gasoline blending components, and increasingly as a standalone transportation fuel. The petrochemical feedstocks are primarily used for producing olefins, the basis for a wide variety of plastics and derivatives.

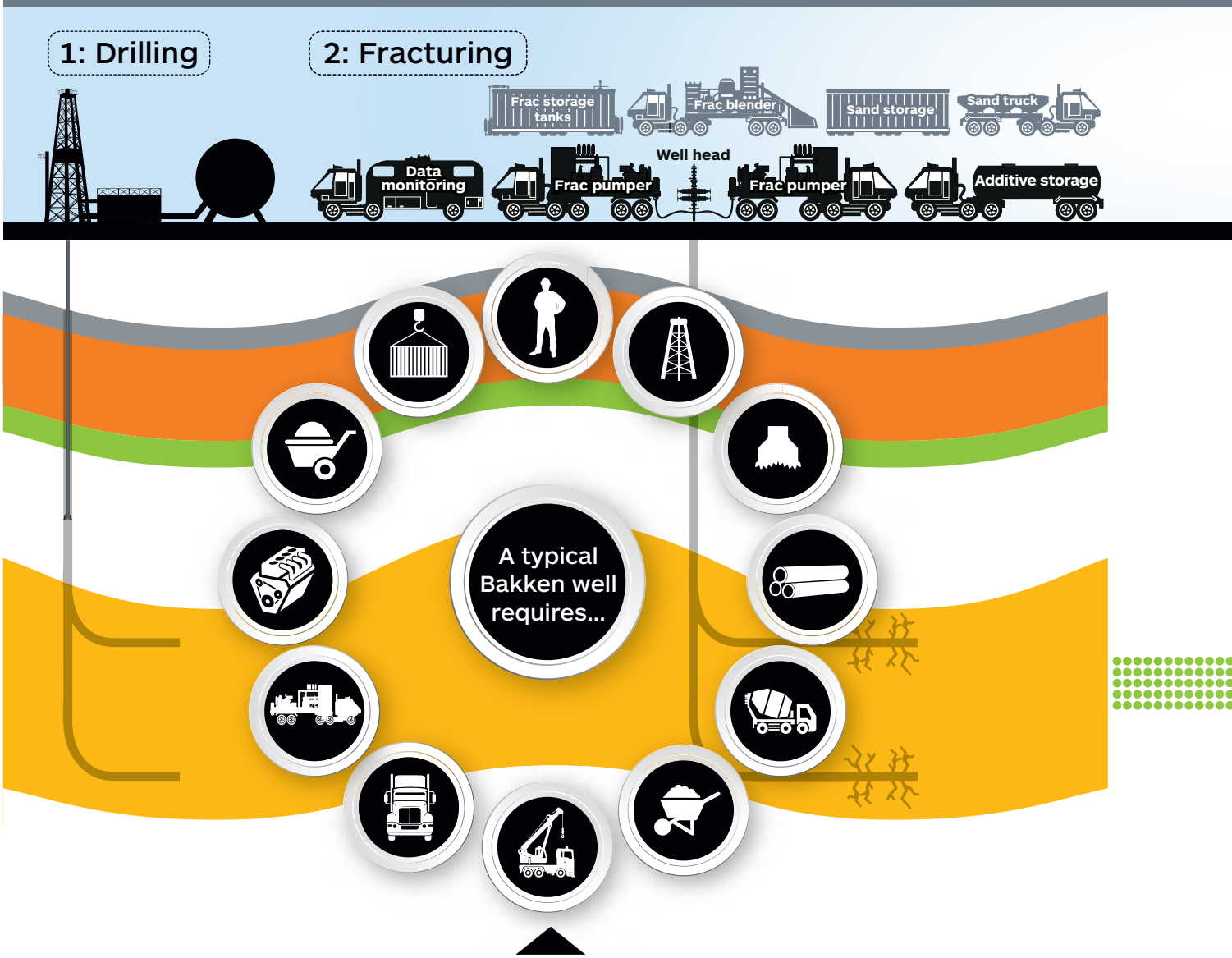
Crude oil and condensate are moved in storage and pipeline infrastructure to refineries where they are processed into clean petrochemical and specialty products. After all the downstream separation and processing occurs, the output of a single Bakken crude oil well is converted into the following energy products:

- Plastics that supply the raw materials for a wide array of construction materials, industrial and consumer products to enable the construction of over 3,700 new homes (PVC piping, fixtures and other building and finishing materials).
- Propane to heat 7,000 New England homes annually.
- Gasoline to supply 1,030 US households annually.
- Jet fuel for 135 cross-country (Manhattan-Los Angeles) passenger jet flights on a Boeing 767 basis.
- Diesel fuel for a fully loaded 18 wheeler to make 4,600 cross-country trips.
- Marine fuel for a fully loaded grain tug barge to make six round trips up and down the Mississippi River.
- Natural gas to heat and provide cooking fuel for 470 US households annually.

Each stage of the process in converting the geological potential of a small plot of land into a producing well that provides US energy needs is supported by an industrial supply chain that extends well past what is delivered and physically consumed at the drill site. This supply chain can be as simple as proppant sand, which is mined in open pit quarries using earth-moving equipment in Minnesota and Wisconsin and then transported by rail in covered hoppers to plays in North Dakota, Oklahoma, and Texas. Other elements of the well development supply chain can be extraordinarily complex, such as the drill rig. A rig integrates detailed engineering and design with steel fabrication and assembly, eight to 16 high-pressure engine, pump, motor, and generator assemblies, fabricated pipe and fittings, electrical supply and distribution, hydraulic power supply and distribution, advanced control and computer systems, state-of the art instrumentation and monitoring devices, lifting and conveyance systems, industrial machinery such and storage tanks, strainers, and shakers, and many other components.

16 Weight percent

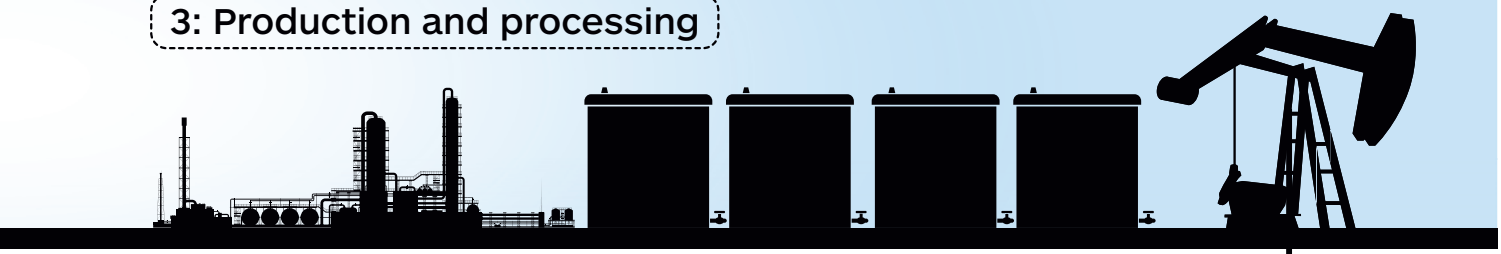
Anatomy and benefits of domestic shale oil well

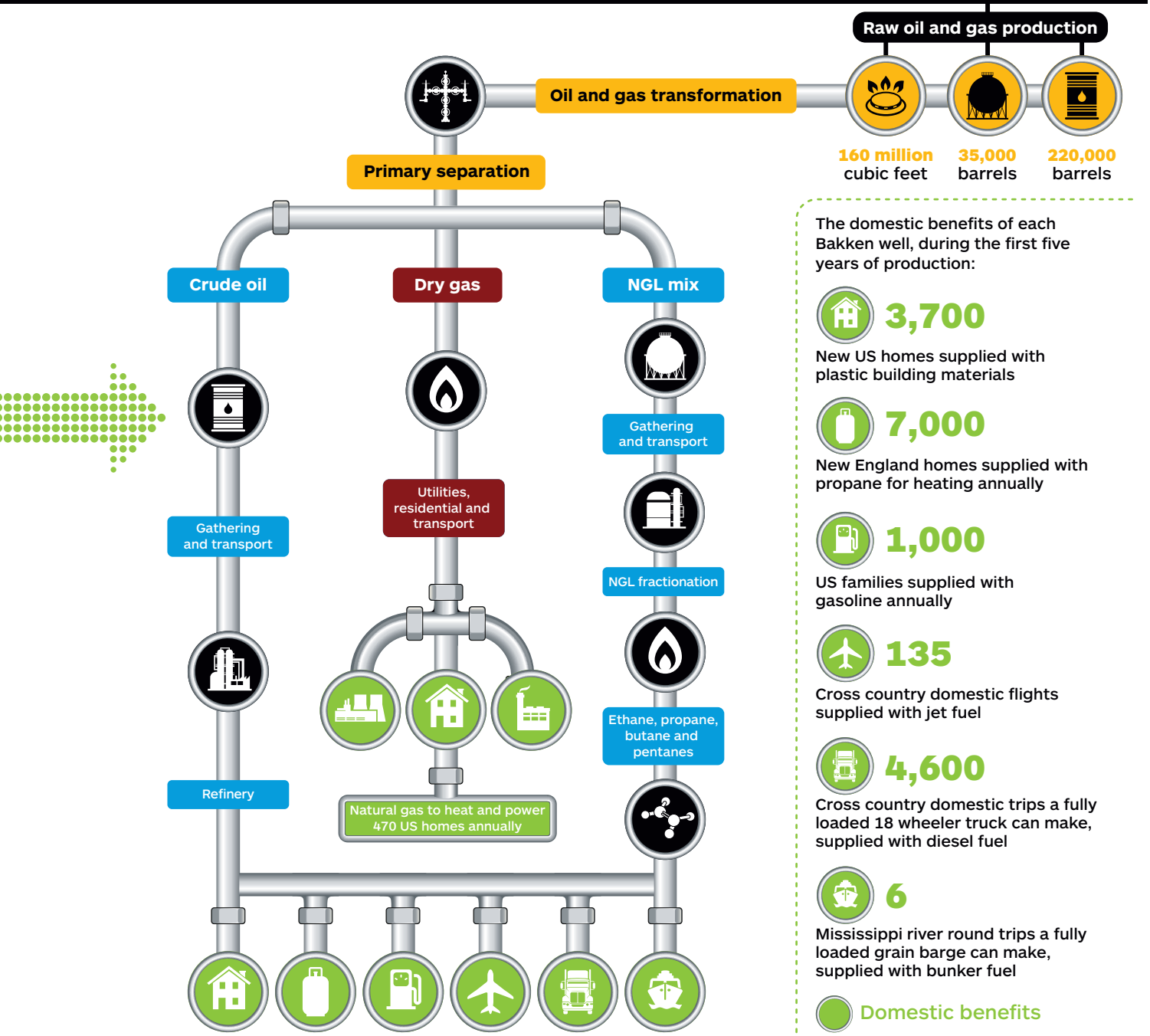


- 50 full time employees
- Modern drilling rig, a $25 million investment to build
- 6 drill bits used per well
- 650-30' drill pipe segments and 4 miles of casing
- 1,500 bags (70 tonnes) of sealing cement
- 17,500 bags (450 tonnes) of drilling mud
- 4 all purpose 20-50 tonne cranes
- At any given time, an average a drill site will have 25 light duty and 35 heavy duty trucks hauling men and materials to and from the work site
- Hydraulic fracturing fleet, consisting of 20 pump trucks, 4 blender trucks, 1 hydration unit, 4 mountain movers, 2 data vans, and an additive skid
- Including the rig, light and heavy duty trucks, and the fracturing fleet, the drill site can have in excess of 125 high horsepower engines, motors and pumps
- 4 million pounds of sand and 50,000 barrels of water
- 50 portable steel, mixing and storage tanks

Source: IHS Energy

3: Production and processing





The domestic benefits of each Bakken well, during the first five years of production:

3,700
New US homes supplied with plastic building materials

7,000
New England homes supplied with propane for heating annually

1,000
US families supplied with gasoline annually

135
Cross country domestic flights supplied with jet fuel

4,600
Cross country domestic trips a fully loaded 18 wheeler truck can make, supplied with diesel fuel

6
Mississippi river round trips a fully loaded grain barge can make, supplied with bunker fuel

Domestic benefits

National supply chain assessment

Key insights

- Lifting the 40-year ban on US crude oil exports will create significant benefits throughout the US crude oil supply chain. This impact is estimated at an additional $26 billion of Gross Domestic Product (GDP) annually, on average, between 2016 and 2030 in the Base Production Case. In the Potential Case, assuming higher levels of production, impact on GDP nearly doubles to over $47 billion annually under a free trade policy.
- As increased economic activity fuels job growth, the benefit to GDP translates to an increase of almost 124,000 supply chain jobs, on average, during 2016-30 in the Base Production Case. In the Potential Production Case, the average supply chain employment increase exceeds 240,000 jobs.
- On a per household basis, the net benefit of a US free trade policy for crude oil translates to an average gain of $158 in labor income per year in the Base Production Case and $285 in the Potential Production Case in 2016-30. These findings are in the absence of the recent drop in global oil prices. Consumer benefits are expected to strengthen as gasoline prices decline.
- The additional cumulative government revenue from corporate and personal income taxes attributed to the supply chain industries is approximately $429 billion in the Base Production Case and more than double that—$868 billion—in the Potential Production Case.
- The benefits of free trade extend across the entire US crude oil supply chain. While direct suppliers such as construction and well services witness the largest impact, indirect suppliers such as information technology and finance emerge as major contributors of additional jobs, value added to GDP, and labor income.
- The supply chain industries involved in upstream oil and gas drilling and production—construction and well services, machinery, and logistics—represent a substantial part of the overall benefits that a crude oil export policy change will have on the US economy. In the Base Production Case, the supply chain comprises 31% of the employment impact, 30% of the value added, 38% of labor income, and 33% of cumulative government revenue over the 2016-30 period. In the Potential Production Case, the supply chain comprises 28% of the employment impact, 28% of the value added, 35% of labor income, and 31% of cumulative government revenue over the 2016-30 period.

Introduction

The enduring message of the US energy renaissance is that all regions of the country partake in this economic transformation, either as a location of hydrocarbon development, as a participant in the upstream supply chain, or both. If the ban on US crude exports is lifted, the effects on the US economy would be immediate and significant. In this national section of the report, we describe the methodology used to assess how a change in crude oil export policy impacts upstream spending on the supply chain to support exploration and production activity. Consistent with the methods employed in the *US Crude Oil Export Decision*, the data and assumptions required to estimate the economic contributions of crude oil export activity include IHS upstream production profiles and the expected upstream capital and operating expenditures of firms engaged in exploration and production activity.

IHS defines the supply chain that supports US crude oil exports as 60 supplier industries classified by the North American Industry Classification System (NAICS).[17] These industries are segmented into six

17 The North American Industry Classification System (NAICS, pronounced "Nakes") was developed under the direction of the Office of Management and Budget as the standard used by federal statistical agencies in classifying business establishments for the collection, tabulation, presentation, and analysis of statistical data describing the US economy. Use of the standard provides uniformity and comparability in the presentation of these statistical data. NAICS is based on a production-oriented concept, meaning that it groups establishments into industries according to their similarities in the processes used to produce goods or services. NAICS replaced the Standard Industrial Classification (SIC) system in 1997. NAICS is a 2- through 6-digit hierarchical classification system, offering five levels of detail. Each digit in the code is part of a series of progressively narrower categories, and the more digits in the code signify greater classification detail.

principal groups (core groups): construction and well services, industrial equipment and machinery, information technology, logistics, materials, and professional, financial, and other services. The economic contributions associated with the US crude oil export supply chain, which are presented at a more detailed industry level, reflect upstream spending on the 60 supply chain industries.

Defining the US crude oil export supply chain

The export supply chain reaches deep into the manufacturing and service sectors of the US economy. The *US Crude Oil Export Decision* analysis focused on the economy-wide impact of increased crude oil exports. This analysis digs deeper to capture the discrete effects on supply chain participants at 4-, 5-, and 6-digit NAICS sector levels. IHS used multiple sources of information to identify the US crude oil export supply chain sectors: 1) extensive IHS research into the purchasing relationships associated with crude oil activity, including capital and operating spending and the goods and services procured; 2) IHS experience in conducting other studies analyzing the supply chain impacts associated with energy development; 3) proprietary IHS databases and analyses across the energy value chain and supply chain sectors; and 4) interviews by IHS researchers with major suppliers.

The sectors within the US crude oil export supply chain were assigned to one of six core groups:

- **Construction and well services**: Construction activity is pervasive in the energy value chain in oil-producing regions. Construction suppliers include general and specialty contractors and building trades. Well services include well drilling and other oil and gas field services performed on a contract basis.
- **Industrial equipment and machinery:** Off-highway equipment and industrial machinery are widely used throughout the value chain, including construction and access machinery; pumps and compressors; drilling and hydraulic fracturing equipment; power generators; and power boilers and heat exchangers. This category also includes component suppliers to equipment manufacturers, as well as equipment distributors and rental companies.
- **Information technology**: The information technology group is comprised of computer hardware, software and services utilized in all tiers of the supply chain. Seismic software technology has been a major innovation for unconventional discovery and exploration.
- **Logistics:** The transportation system supporting crude oil export activity consists of road, rail, water, and pipeline transportation. While truck transportation is, and will continue to be, a very large component of the oil supply chain logistics system, investment in pipeline, water, and rail capacity is expected to increase in the coming years.
- **Materials**: This category includes producers of a wide variety of raw materials such as steel and nonferrous metals sand, gravel, and other aggregates; chemicals and value-added services such as metal fabrication and distribution. Key materials include oil country tubular goods (OCTG) and other pipeline products, concrete for well casing, and sand and chemicals associated with hydraulic fracturing. These raw materials also make up the inputs for finished and semifinished supply chain goods such as the metal forgings and gears in machinery.
- **Professional, financial, and other services**: Typically associated with operational expenditures, the wide range of services includes environmental engineering services; occupational health and safety services; architectural and civil engineering services; and financial, insurance, and real estate services.

The following table shows where each of the 60 NAICS codes falls within the defined core groups.

Supply chain sectors by core group
(NAICS code)

Industrial equipment and machinery

332410	Power Boiler and Heat Exchanger Manufacturing
332420	Metal Tank Manufacturing
3331	Construction, Mining and Agriculture Machinery Manufacturing
333515	Cutting and Machine Tool Manufacturing
333611	Turbine and Turbine Generator Manufacturing
333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing
333613	Mechanical Power Transmission Equipment Manufacturing
333618	Other Engine Equipment Manufacturing
333911	Pump and Pumping Equipment Manufacturing
333912	Air and Gas Compressor Manufacturing
333922	Conveyor and Conveying Equipment Manufacturing
333991	Power-Driven Handtool Manufacturing
334512	Automatic Environmental Control Manufactuirng
334513	Industrial Control and Instrument Manufactuirng
334514	Totalizing Fluid Meter and Counting Device Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334519	Other Measuring and Controlling Device Manufacturing
336112	Light Truck and Utility Vehicle Manufacturing
336120	Heavy Duty Truck Manufacturing
336510	Railroad Rolling Stock Manufacturing
4231	Motor Vehicles and Parts - Wholesale
4234	Professional and Commercial Equipment - Wholesale
4238	Machinery and Equipment - Wholesale

Construction and well services

213111	Drilling Oil and Gas Wells
213112	Support Activities for Oil and Gas Operations
23t	Construction of New Nonresidential Manufacturing Structures
23tt	Construction of Other New Nonresidential Structures

Information technology

3341	Computer Hardware
5112	Computer Software
5415	Computer Services

Logistics

4821	Rail Transportation
483	Water Transportation
4841	General Freight Trucking
486	Pipeline Transportation

Materials

212321	Construction Sand and Gravel Mining
325120	Industrial Gas Manufacturing
325180	Other Basic Inorganic Chemical Manufacturing
327310	Cement Manufacturing
327320	Ready-mix Concrete Manufacturing
327331	Concrete Block and Brick Manufacturing
331110	Iron and Steel Mills and Ferroalloy Manufacturing
3312	Steel Product Manufactuirng
331315	Aluminum Sheet, Plate, and Foil Manufacturing
332996	Fabricated Pipe and Pipefitting Manufacturing
4233	Lumber and Construction Materials - Wholesale
4235	Metal and Minerals - Wholesale
4236	Electrical Goods - Wholesale
4237	Hardware, Plumbing, and Heating Equipment - Wholesale
4246	Chemical and Allied Products - Wholesale
444	Building Material - Retail

Professional, financial, and other services

2213	Water, Sewage and Other Systems
4931	Warehousing and Storage
524	Insurance carriers and related activities
52 ex 524	Finance
532412	Construction and Mining Equipment Rental and Leasing
5413	Architectural, Engineering, and Related Services
5416	Management, scientific, and technical consulting services
5419	Other Professional, Scientific, and Technical Services
562219	Other Nonhazardous Waste Treatment and Disposal
811310	Commercial and Industrial Machinery Repair and Maintenance

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS

National level results in this section are presented for these core supply chain groupings. In subsequent sections of this report, supplier industry results for the state level and selected congressional districts level will be presented.

Economic contribution methodology

Here we present the methodology for measuring the economic contribution of the supply chain impacts under the restricted trade and free trade scenarios. The results are presented in terms of the difference in levels of economic contribution between free trade and restricted trade for each case: the Base Production Case and the Potential Production Case. The findings are analyzed in the context of the national impacts associated with capital spending across the US crude oil export supply chain.

Using data and analyses from proprietary databases and the IMPLAN model,[18] IHS evaluated the impacts to the supply chain by applying a customized industrial structure of the US economy. The data categories in the model were tailored to the specific mix of equipment, materials, and services that characterize the US crude oil supply chain. IHS linked the IMPLAN model to its dynamic US and state macroeconomic models in order to augment the supply chain determination of employment, value added, and labor income impacts with a comprehensive dynamic modeling methodology employed in the *US Crude Oil Export Decision* report. IHS' baseline macroeconomic forecasts for the US and state economies were re-specified to assess the contribution on the 60 supply chain sectors if the export ban on US crude oil were eliminated. All models were run using the initial set of input assumptions and were calibrated. The resulting economic impact is measured in terms of jobs created or sustained, value added contribution to GDP, and employee wages and compensation. The calibration process compared the sum of the direct, indirect, and induced impacts (for all metrics) from the supply chain (IMPLAN) model and scaled it to the total impact from the state macroeconomic models. While all the supply chain sectors were selected from the direct and indirect effects (defined below), the induced effect was left out as it relates to the income effect.

The results are presented for the 60 supply chain sectors selected from direct and indirect contributions and are benchmarked to the total economic contributions obtained from the *US Crude Oil Export Decision*.

Direct Impacts: This is the effect of the core industry's output, employment, and income. For example, removing the US crude oil export ban will have implications for the energy value chain—its upstream (production), midstream (transportation and logistics), and downstream (processing and marketing) elements—in terms of capital expenditures and operating expenditures. These activities directly contribute to exploration (capital expenditures) and production activity (operating expenditures). Others directly involved in US crude oil export activities are midstream processing and pipeline transportation companies, downstream local distribution companies, and onsite construction service providers.

Indirect Impacts: Purchasing patterns of crude oil development indirectly contribute to all of the supplier industries. Changes in demand from the directly impacted industries lead to corresponding changes in output, employment, and labor income throughout each industry's own supply chains via inter-industry linkages. The affected supplier activities span the majority of US industries. For this crude oil export supply chain analysis, IHS has focused on the 60 major supply chain sectors.

18 The IHS modeling methodology for this study was based on IMPLAN (www.implan.com), an industry-standard system for assessing economic impacts, which IHS enhanced with data from its US Regional Economics Service. The IMPLAN system is built using Input-Output techniques that link interindustry and consumer transactions in a social accounting matrix for the region being assessed. This structure provides a foundation upon which models can be built that link sales in one industry sector with resultant sales in supplying sectors.

Economic contribution results

Employment

Higher levels of capital spending and production in the upstream segment translate both directly and indirectly to an increase in US employment. In the Base Case, supply chain jobs represent, on average, 31% of the increase in total US crude oil export-related employment in 2016-30, or about 124,000 jobs on average if the export ban is lifted. In the Potential Production Case, the supply chain contributes 28% of the increase in total US crude oil export-related employment, or about 240,000 jobs annually on average.

Employment: US crude oil export supply chain
(number of workers, difference free trade vs. restricted trade)

	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
US crude oil export supply chain	105,748	250,201	293,140	258,227	212,508	73,384	123,577
US crude oil export total	358,610	811,250	963,720	863,310	699,520	221,532	394,118
Supply chain share of crude oil export total	**29.5%**	**30.8%**	**30.4%**	**29.9%**	**30.4%**	**33.1%**	**31.4%**
Potential Production Case							
US crude oil export supply chain	149,521	351,675	439,578	414,198	371,202	187,413	240,020
US crude oil export total	521,500	1,206,160	1,536,730	1,483,210	1,320,000	681,645	858,932
Supply chain share of crude oil export total	**28.7%**	**29.2%**	**28.6%**	**27.9%**	**28.1%**	**27.5%**	**27.9%**

Source: IHS Economics

Removing the export ban will introduce an initial stimulus to the crude oil value chain and the economy in the early years that will amplify the impact. In the long run, as the system adjusts to the change, the economy is expected to converge to an equilibrium, resulting in a more moderate impact.

Employment contributions are spread across the entire supply chain, but are most prominent in sectors that support oil and natural gas operations and in the construction sector. For example, construction activity and related support services at well sites require architects, engineers, construction machinery, sand, concrete and fabricated metal to build the necessary infrastructure. The singular yet substantial length of the construction supply chain, as it relates to support for upstream activity, amplifies the second- and third-order indirect employment effects that originate with upstream investment under both production cases.

The five supply chain industries gaining the most employment from US crude oil export activity are concentrated in two core supply chain groups: the materials group and the construction and well services group. The top five industries are:

- Support Activities for Oil and Gas Operations (NAICS 213112)
- Construction of Other New Nonresidential Structures (part of NAICS 23 related to upstream construction activity)
- Architectural, Engineering, and Related Services (NAICS 5413)
- Construction Sand and Gravel Mining (NAICS 212321)
- Cutting and Machine Tool Manufacturing (NAICS 333515)

In the Base Production Case, IHS estimates that in 2018—the peak year for employment—the move to a free trade policy will add nearly 112,000 more jobs than the restricted trade policy in these five industries—representing 38% of the total jobs added across the supply chain.

Employment: US crude oil export supply chain – Base Production*
(number of workers, difference free trade vs. restricted trade)

Top-15 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
213112	Support Activities for Oil and Gas Operations	10,344	25,385	29,403	25,026	20,239	6,513	11,702
23tt	Construction of Other New Nonresidential Structures	9,324	23,633	27,316	23,044	18,896	5,945	10,778
5413	Architectural, Engineering, and Related Services	8,836	19,979	23,465	20,486	16,659	5,453	9,597
212321	Construction Sand and Gravel Mining	6,529	14,236	15,901	14,788	12,129	4,165	7,015
333515	Cutting and Machine Tool Manufacturing	6,543	13,952	15,547	13,876	11,304	3,950	6,715
3341	Computer Hardware	4,147	10,513	12,930	11,545	9,731	3,845	5,821
52_ex_524	Finance	4,244	9,842	11,603	10,279	8,402	2,930	4,911
333912	Air and Gas Compressor Manufacturing	3,505	8,887	10,959	9,718	8,111	2,874	4,662
3331	Construction, Mining and Agriculture Machinery Manufacturing	3,896	8,561	9,340	7,969	6,432	2,133	3,836
4841	General Freight Trucking	3,602	8,486	9,927	8,698	7,145	2,431	4,144
4235	Metal and Minerals - Wholesale	3,540	8,036	9,286	8,071	6,619	2,257	3,875
332996	Fabricated Pipe and Pipefitting Manufacturing	3,016	7,437	8,721	7,977	6,775	2,405	3,865
334519	Other Measuring and Controlling Device Manufacturing	2,535	6,480	8,021	7,715	6,676	2,736	3,919
5415	Computer Services	2,886	6,274	7,483	6,794	5,473	1,970	3,241
3312	Steel Product Manufactuirng	2,809	6,194	7,117	6,117	5,020	1,676	2,934
Top-15 US crude oil export supply chain total		**75,756**	**177,891**	**207,020**	**182,103**	**149,609**	**51,286**	**87,016**
US crude oil export supply chain total		**105,748**	**250,201**	**293,140**	**258,227**	**212,508**	**73,384**	**123,577**
US crude oil export total		**358,610**	**811,250**	**963,720**	**863,310**	**699,520**	**221,532**	**394,118**
Supply chain share of crude oil export total		**29.5%**	**30.8%**	**30.4%**	**29.9%**	**30.4%**	**33.1%**	**31.4%**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

In the Potential Production Case, which assumes higher levels of future oil production, IHS estimates that the move to a free trade policy in peak year 2018 will yield 158,000 more jobs than retention of the restricted trade policy in these five industries—representing 36% of the total additional jobs across the supply chain.

Employment: US crude oil export supply chain – Potential Production*
(number of workers, difference free trade vs. restricted trade)

Top-15 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
213112	Support Activities for Oil and Gas Operations	14,766	34,486	41,310	36,916	32,664	15,428	20,961
5413	Architectural, Engineering, and Related Services	12,710	29,975	36,479	34,111	29,347	14,158	18,947
23tt	Construction of Other New Nonresidential Structures	12,376	29,496	35,192	31,013	27,609	12,548	17,411
333515	Cutting and Machine Tool Manufacturing	9,067	19,976	24,870	23,610	21,019	10,180	13,356
212321	Construction Sand and Gravel Mining	8,130	16,502	20,421	19,641	17,964	8,918	11,456
3341	Computer Hardware	5,897	14,931	19,588	19,155	17,652	9,867	11,727
52_ex_524	Finance	5,980	13,816	17,515	16,658	14,935	7,749	9,760
3331	Construction, Mining and Agriculture Machinery Manufacturing	6,174	13,020	15,554	14,341	12,885	6,405	8,402
4841	General Freight Trucking	5,128	11,971	14,954	13,956	12,507	6,289	8,094
333912	Air and Gas Compressor Manufacturing	4,792	11,971	15,768	15,002	13,794	7,224	8,904
4235	Metal and Minerals - Wholesale	5,060	11,632	14,758	13,787	12,197	6,085	7,886
334519	Other Measuring and Controlling Device Manufacturing	3,825	10,253	14,041	14,735	13,726	7,647	8,870
332996	Fabricated Pipe and Pipefitting Manufacturing	4,117	9,853	12,653	12,322	11,480	5,950	7,329
3312	Steel Product Manufactuirng	4,078	9,321	11,807	10,969	9,617	4,707	6,191
327310	Cement Manufacturing	3,707	9,189	11,746	11,455	10,228	4,960	6,395
Top-15 US crude oil export supply chain total		**105,807**	**246,391**	**306,655**	**287,670**	**257,624**	**128,116**	**165,687**
US crude oil export supply chain total		**149,521**	**351,675**	**439,578**	**414,198**	**371,202**	**187,413**	**240,020**
US crude oil export total		**521,500**	**1,206,160**	**1,536,730**	**1,483,210**	**1,320,000**	**681,645**	**858,932**
Supply chain share of crude oil export total		**28.7%**	**29.2%**	**28.6%**	**27.9%**	**28.1%**	**27.5%**	**27.9%**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Value added

Lifting the restrictions on crude oil exports would augment the already sizable share of GDP contributed by the energy value chain. A large supply network serving upstream operators creates a multiplier effect by drawing value from the manufacturing and raw materials sectors that produce the finished goods supporting upstream activities. In the Base Case, the US crude oil export-related supply chain will contribute, on average, an additional $26 billion per year to the US economy over the 2016-30 period under a free trade policy. Under the Potential Case scenario, this nearly doubles to $47 billion annually under a free trade policy.

To put these contributions to GDP into perspective with other US industries, the Base Case contribution of $26 billion is equivalent to the total 2013 value-added contribution of dairy products manufacturers in the United States. The Potential Case value-added contribution is greater than that of the total US rail transportation sector.[19]

19 IHS US Industry Service data

IHS estimates that in the Base Case, the economic value of the supply chain industries, as measured by value added, accounts for nearly 30% of the US crude oil export policy impact between 2016 and 2030. More than a quarter of this impact is concentrated in the top five supplier sectors.

Value added: US crude oil export supply chain – Base Production*
($millions, real 2009, difference free trade vs. restricted trade)

Top-15 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
213112	Support Activities for Oil and Gas Operations	1,243	2,515	2,521	2,038	1,819	1,134	1,432
5413	Architectural, Engineering, and Related Services	1,217	2,242	2,246	1,903	1,719	1,066	1,333
23tt	Construction of Other New Nonresidential Structures	1,033	2,138	2,123	1,694	1,538	938	1,194
3331	Construction, Mining and Agriculture Machinery Manufacturing	1,158	2,120	2,002	1,686	1,515	1,015	1,242
333515	Cutting and Machine Tool Manufacturing	1,143	2,075	2,006	1,770	1,643	1,325	1,459
212321	Construction Sand and Gravel Mining	1,119	2,071	1,989	1,817	1,672	1,195	1,375
52_ex_524	Finance	984	1,819	1,821	1,561	1,426	995	1,171
3341	Computer Hardware	830	1,637	1,688	1,460	1,391	1,009	1,140
4235	Metal and Minerals - Wholesale	859	1,566	1,530	1,282	1,176	790	954
333912	Air and Gas Compressor Manufacturing	761	1,559	1,626	1,365	1,271	830	992
213111	Drilling Oil and Gas Wells	743	1,535	1,519	1,217	1,100	684	864
333611	Turbine and Turbine Generator Manufacturing	760	1,523	1,639	1,474	1,364	885	1,040
325120	Industrial Gas Manufacturing	663	1,244	1,194	964	869	575	712
334519	Other Measuring and Controlling Device Manufacturing	626	1,242	1,279	1,169	1,115	830	916
327310	Cement Manufacturing	624	1,188	1,182	1,030	936	579	716
Top-15 US crude oil export supply chain total		**13,762**	**26,474**	**26,363**	**22,431**	**20,556**	**13,850**	**16,539**
US crude oil export supply chain total		**21,234**	**40,606**	**40,480**	**34,494**	**31,701**	**21,754**	**25,737**
US crude oil export total		**72,770**	**132,895**	**134,950**	**118,655**	**106,298**	**73,013**	**86,380**
Supply chain share of crude oil export total		**29.2%**	**30.6%**	**30.0%**	**29.1%**	**29.8%**	**29.8%**	**29.8%**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Value added: US crude oil export supply chain – Potential Production*
($millions, real 2009, difference free trade vs. restricted trade)

Top-15 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
213112	Support Activities for Oil and Gas Operations	1,686	3,358	3,688	3,133	2,985	2,110	2,396
5413	Architectural, Engineering, and Related Services	1,746	3,350	3,641	3,256	3,018	2,339	2,560
3331	Construction, Mining and Agriculture Machinery Manufacturing	1,797	3,253	3,508	3,133	3,014	2,283	2,502
333515	Cutting and Machine Tool Manufacturing	1,603	2,919	3,207	2,936	2,871	2,538	2,594
23tt	Construction of Other New Nonresidential Structures	1,300	2,628	2,874	2,398	2,304	1,560	1,807
52_ex_524	Finance	1,356	2,541	2,862	2,595	2,515	2,061	2,165
212321	Construction Sand and Gravel Mining	1,432	2,491	2,771	2,586	2,550	2,002	2,123
333611	Turbine and Turbine Generator Manufacturing	1,152	2,317	2,745	2,616	2,565	2,014	2,103
3341	Computer Hardware	1,177	2,317	2,665	2,473	2,476	2,068	2,119
4235	Metal and Minerals - Wholesale	1,214	2,233	2,467	2,186	2,096	1,665	1,790
333912	Air and Gas Compressor Manufacturing	1,013	2,072	2,434	2,171	2,146	1,622	1,737
213111	Drilling Oil and Gas Wells	992	2,002	2,179	1,833	1,762	1,226	1,402
334519	Other Measuring and Controlling Device Manufacturing	938	1,873	2,166	2,093	2,093	1,797	1,809
325120	Industrial Gas Manufacturing	966	1,835	1,968	1,702	1,632	1,290	1,400
327310	Cement Manufacturing	954	1,798	2,010	1,897	1,884	1,381	1,490
Top-15 US crude oil export supply chain total		**19,325**	**36,986**	**41,185**	**37,008**	**35,912**	**27,954**	**29,997**
US crude oil export supply chain total		**29,763**	**56,967**	**63,503**	**57,138**	**55,515**	**44,307**	**47,064**
US crude oil export total		**103,358**	**194,745**	**220,868**	**206,133**	**198,340**	**162,775**	**170,080**
Supply chain share of crude oil export total		**28.8%**	**29.3%**	**28.8%**	**27.7%**	**28.0%**	**27.2%**	**27.7%**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Labor income

The additional production and capital investment prompted by a change in crude oil export policy from restricted trade to free trade will increase labor income in the supply chain. IHS research has found that the wages earned in these supply chain jobs are considerably higher than the average US wage. IHS estimates that labor income for the oil export supply chain will increase under a free trade policy by over $21 billion per year during the 2016-30 period in the Base Case and by over $39 billion per year in the Potential Case.

This export-led labor income contribution is particularly notable at a time when US wage growth remains sluggish, at about 2% annually. Wage austerity is even more pronounced in the broader US construction sector as wages remain flat from year to year due to a slow rebound in US housing starts. On an annual basis, however, lifting the crude export ban translates to a wage increase of $158 per year for each household in the Base Case and $285 in the Potential Case, on average, in the 2016-30 period.

Labor income: US crude oil export supply chain – Base Production*
($millions, real 2009, difference free trade vs. restricted trade)

Top-15 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
213112	Support Activities for Oil and Gas Operations	1,529	3,362	3,388	2,812	2,477	1,559	1,944
5413	Architectural, Engineering, and Related Services	1,269	2,568	2,577	2,204	1,979	1,235	1,530
23tt	Construction of Other New Nonresidential Structures	1,100	2,468	2,463	2,019	1,809	1,120	1,404
212321	Construction Sand and Gravel Mining	834	1,731	1,659	1,532	1,413	1,010	1,151
333515	Cutting and Machine Tool Manufacturing	847	1,692	1,645	1,464	1,365	1,116	1,212
3341	Computer Hardware	731	1,616	1,665	1,455	1,381	995	1,120
333912	Air and Gas Compressor Manufacturing	596	1,340	1,406	1,218	1,125	737	871
3331	Construction, Mining and Agriculture Machinery Manufacturing	643	1,300	1,228	1,035	925	603	744
52_ex_524	Finance	573	1,179	1,182	1,023	932	663	768
4235	Metal and Minerals - Wholesale	568	1,139	1,118	945	865	584	698
334519	Other Measuring and Controlling Device Manufacturing	512	1,127	1,158	1,059	1,007	755	828
5415	Computer Services	525	1,019	1,028	912	819	586	678
327310	Cement Manufacturing	494	1,009	1,004	877	797	485	602
325120	Industrial Gas Manufacturing	414	845	803	645	579	375	469
332996	Fabricated Pipe and Pipefitting Manufacturing	379	833	833	736	696	528	584
Top-15 US crude oil export supply chain total		**11,013**	**23,228**	**23,158**	**19,937**	**18,167**	**12,351**	**14,601**
US crude oil export supply chain total		**16,171**	**34,029**	**34,030**	**29,298**	**26,745**	**18,301**	**21,552**
US crude oil export total		**43,554**	**88,160**	**89,322**	**78,481**	**70,434**	**48,650**	**57,097**
Supply chain share of crude oil export total		**37.1%**	**38.6%**	**38.1%**	**37.3%**	**38.0%**	**37.6%**	**37.7%**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Labor income: US crude oil export supply chain – Potential Production*
($millions, real 2009, difference free trade vs. restricted trade)

Top-15 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
213112	Support Activities for Oil and Gas Operations	2,049	4,793	5,297	4,664	4,423	3,148	3,513
5413	Architectural, Engineering, and Related Services	1,616	3,750	4,093	3,672	3,398	2,669	2,881
23tt	Construction of Other New Nonresidential Structures	1,350	3,200	3,516	3,047	2,910	1,991	2,262
333515	Cutting and Machine Tool Manufacturing	1,024	2,311	2,559	2,365	2,323	2,080	2,092
3341	Computer Hardware	884	2,217	2,544	2,382	2,384	1,975	2,011
212321	Construction Sand and Gravel Mining	958	2,047	2,283	2,145	2,123	1,653	1,739
3331	Construction, Mining and Agriculture Machinery Manufacturing	916	2,010	2,192	1,975	1,908	1,413	1,542
333912	Air and Gas Compressor Manufacturing	717	1,781	2,083	1,919	1,899	1,454	1,529
334519	Other Measuring and Controlling Device Manufacturing	640	1,632	1,880	1,816	1,813	1,564	1,561
52_ex_524	Finance	700	1,627	1,836	1,681	1,627	1,347	1,396
4235	Metal and Minerals - Wholesale	697	1,580	1,757	1,578	1,510	1,195	1,271
327310	Cement Manufacturing	622	1,445	1,623	1,550	1,533	1,109	1,191
5415	Computer Services	626	1,408	1,608	1,516	1,461	1,242	1,269
325120	Industrial Gas Manufacturing	509	1,190	1,268	1,095	1,048	815	884
333611	Turbine and Turbine Generator Manufacturing	474	1,170	1,395	1,321	1,300	1,038	1,070
Top-15 US crude oil export supply chain total		**13,783**	**32,161**	**35,934**	**32,725**	**31,661**	**24,692**	**26,212**
US crude oil export supply chain total		**20,208**	**47,340**	**52,874**	**48,107**	**46,578**	**36,988**	**38,999**
US crude oil export total		**55,918**	**128,607**	**145,917**	**136,170**	**130,935**	**107,351**	**111,404**
Supply chain share of crude oil export total		**36.1%**	**36.8%**	**36.2%**	**35.3%**	**35.6%**	**34.5%**	**35.0%**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Government revenue

New investment in exploration and production stimulated by lifting export restrictions on US crude oil will flow through the supply chain and, as a consequence, will drive increases in federal, state and local tax receipts around the country. IHS estimates that total government revenues generated by crude oil export-related supply chain activity will roughly double, from $7 billion in 2016 to over $13.6 billion in 2020 in the Base Production Case and from $10 billion in 2016 to over $25 billion in 2020 in the Potential Production Case. To place these revenue totals in context, the president's budget in fiscal year 2014 provided $71.2 billion in discretionary funding for the Department of Education—and the additional government revenue from lifting the export ban could fund nearly 10% of this budget.[20]

Supply chain industries will account for nearly one-third of the total increases in government revenues resulting from a US crude oil export policy change to free trade. Over the entire 2016-30 forecast period, the following table shows that lifting the trade restrictions will generate government revenue in excess of $428 billion in the Base Production Case—enough to fund the president's fiscal year 2015 budget for the US Department of the Interior. And it will generate over $868 billion in the Potential Production Case;

20 http://www.whitehouse.gov/sites/default/files/omb/budget/fy2014/assets/budget.pdf

these cumulative crude oil export supply chain-related revenues will not only fund the Department of Interior but could also fund a four-year reauthorization of surface transportation infrastructure projects, with additional revenue remaining to fully fund the Department of Veterans Affairs in fiscal year 2015.[21]

Government Revenue: US crude oil export supply chain
($millions, nominal)

	2016	2017	2018	2019	2020	2021-30 total	2016-30 total
Base Production Case							
Federal personal and corporate taxes	6,011	14,710	15,734	12,961	10,643	273,737	333,797
State personal and corporate taxes	920	3,262	3,716	2,920	2,693	71,805	85,316
Local personal and corporate taxes	169	406	364	265	276	8,124	9,603
US crude oil export supply chain government revenue	**7,100**	**18,378**	**19,814**	**16,146**	**13,612**	**353,666**	**428,717**
US crude oil export government revenue total	**28,888**	**55,769**	**58,188**	**48,891**	**42,124**	**1,077,224**	**1,311,085**
Supply chain share of crude oil export total	**24.6%**	**33.0%**	**34.1%**	**33.0%**	**32.3%**	**32.8%**	**32.7%**
Potential Production Case							
Federal personal and corporate taxes	8,579	20,859	24,998	22,556	20,232	571,906	669,131
State personal and corporate taxes	1,220	4,302	5,434	5,044	4,723	158,136	178,859
Local personal and corporate taxes	267	593	621	512	508	17,947	20,448
US Crude oil export supply chain government revenue	**10,066**	**25,754**	**31,053**	**28,112**	**25,463**	**747,990**	**868,438**
US crude oil export government revenue total	**41,535**	**83,682**	**97,373**	**89,015**	**81,541**	**2,410,900**	**2,804,045**
Supply chain share of crude oil export total	**24.2%**	**30.8%**	**31.9%**	**31.6%**	**31.2%**	**31.0%**	**31.0%**

Source: IHS Economics

Economic contribution by core industry groups

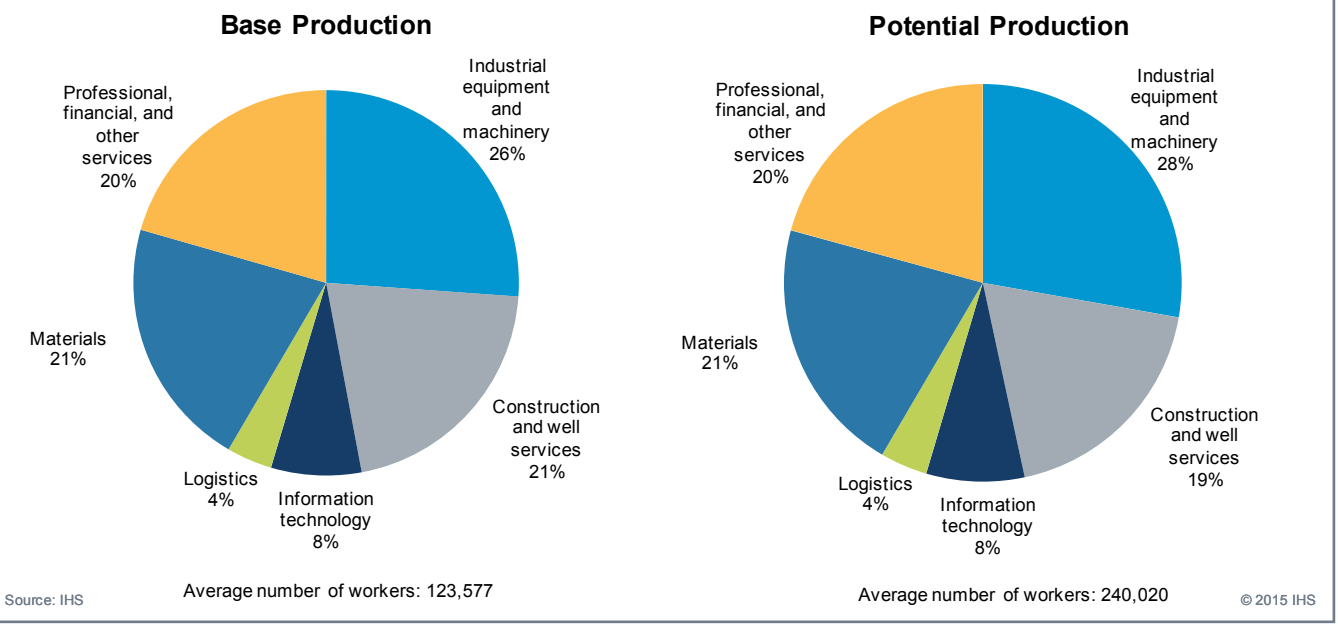
IHS also identified and analyzed the economic effects on 60 supply chain sectors impacted by US crude oil capital expenditures. These sectors were divided into the same six core groups for analysis:

- Industrial equipment and machinery
- Construction and well services
- Information technology
- Logistics
- Materials
- Professional, financial, and other services

21 US Office of Management and Budget

While the impact of lifting the export ban on each group varies significantly, the *distribution* of impacts among the groups is very similar in the Base Production and Potential Production cases, as can be seen in the following charts.

Employment share by core group
(2016–30 average, difference free trade vs. restricted trade)



The following section examines each of these core groups in terms of their individual contributions to employment, value added, and labor income.

Construction and well services

Companies in the construction and well services core group provide an array of specialized services to the crude oil industry, including well pad access, drilling support, and construction and maintenance of gathering systems and infrastructure. Construction and well services includes four supply chain sectors: Support Activities for Oil and Gas Operations (213112), Construction of Other New Nonresidential Structures (part of NAICS 23—construction of upstream facilities and structures), Construction of New Nonresidential Manufacturing Structures (part of NAICS 23—construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures), and Drilling Oil and Gas Wells (NAICS 213111).

Employment: US crude oil export supply chain – Construction and well services*
(number of workers, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
213112	Support Activities for Oil and Gas Operations	10,344	25,385	29,403	25,026	20,239	6,513	11,702
23tt	Construction of Other New Nonresidential Structures	9,324	23,633	27,316	23,044	18,896	5,945	10,778
213111	Drilling Oil and Gas Wells	1,448	3,552	4,061	3,447	2,807	902	1,622
23t	Construction of New Nonresidential Manufacturing Structures	1,642	3,527	4,342	3,805	3,140	947	1,728
Construction and well services total		**22,760**	**56,096**	**65,121**	**55,322**	**45,082**	**14,307**	**25,830**
Potential Production Case								
213112	Support Activities for Oil and Gas Operations	14,766	34,486	41,310	36,916	32,664	15,428	20,961
23tt	Construction of Other New Nonresidential Structures	12,376	29,496	35,192	31,013	27,609	12,548	17,411
23t	Construction of New Nonresidential Manufacturing Structures	2,734	6,906	8,213	7,971	6,460	2,848	4,051
213111	Drilling Oil and Gas Wells	2,001	4,704	5,587	4,931	4,360	2,010	2,779
Construction and well services total		**31,877**	**75,591**	**90,302**	**80,831**	**71,092**	**32,834**	**45,202**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Value added: US crude oil export supply chain – Construction and well services*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
213112	Support Activities for Oil and Gas Operations	1,243	2,515	2,521	2,038	1,819	1,134	1,432
23tt	Construction of Other New Nonresidential Structures	1,033	2,138	2,123	1,694	1,538	938	1,194
213111	Drilling Oil and Gas Wells	743	1,535	1,519	1,217	1,100	684	864
23t	Construction of New Nonresidential Manufacturing Structures	189	340	358	314	287	143	195
Construction and well services total		**3,208**	**6,529**	**6,521**	**5,262**	**4,744**	**2,900**	**3,684**
Potential Production Case								
213112	Support Activities for Oil and Gas Operations	1,686	3,358	3,688	3,133	2,985	2,110	2,396
23tt	Construction of Other New Nonresidential Structures	1,300	2,628	2,874	2,398	2,304	1,560	1,807
213111	Drilling Oil and Gas Wells	992	2,002	2,179	1,833	1,762	1,226	1,402
23t	Construction of New Nonresidential Manufacturing Structures	356	717	765	714	633	472	527
Construction and well services total		**4,334**	**8,705**	**9,506**	**8,078**	**7,684**	**5,368**	**6,133**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Labor income: US crude oil export supply chain – Construction and well service*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
213112	Support Activities for Oil and Gas Operations	1,529	3,362	3,388	2,812	2,477	1,559	1,944
23tt	Construction of Other New Nonresidential Structures	1,100	2,468	2,463	2,019	1,809	1,120	1,404
213111	Drilling Oil and Gas Wells	220	496	500	414	368	233	289
23t	Construction of New Nonresidential Manufacturing Structures	167	327	346	298	273	134	184
Construction and well services total		**3,016**	**6,653**	**6,697**	**5,543**	**4,927**	**3,046**	**3,820**
Potential Production Case								
213112	Support Activities for Oil and Gas Operations	2,049	4,793	5,297	4,664	4,423	3,148	3,513
23tt	Construction of Other New Nonresidential Structures	1,350	3,200	3,516	3,047	2,910	1,991	2,262
213111	Drilling Oil and Gas Wells	287	688	762	669	637	450	503
23t	Construction of New Nonresidential Manufacturing Structures	241	595	622	566	492	365	411
Construction and well services total		**3,927**	**9,275**	**10,197**	**8,944**	**8,462**	**5,954**	**6,690**

*The rank for all years is based on the 2017 ranking.

t Construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures.

tt Construction of upstream facilities and structures.

Source: IHS Economics

Extraction, drilling, and supply chain industries expanded despite slow US growth[22]

The obvious beneficiaries of the unconventional oil and natural gas boom have been the firms behind oil and gas extraction, drilling, operations support, pipeline construction and field machinery and equipment. Less obvious, however, is the remarkable employment growth in oil and gas industry subsectors. Jobs in the extraction sector grew by 46% between 2005 and 2012, a time when total US employment declined by 0.3%. Drilling jobs also expanded rapidly—by 61%—while employment more than doubled in the support services for oil and gas operations. Field machinery and equipment manufacturing employment grew by 67%, and pipeline and related structures construction employment expanded by 66%. It is notable that most of these are well-paying jobs. Wage growth in the oil and gas extraction sector also increased 6% in 2013. The number of firms in these key sectors has also grown as the total number of US employers declined between 2005 and 2012. The following is the growth in numbers of firms in four sectors:

- Oil and gas extraction, 4.9%
- Drilling oil and gas wells, 11.3%
- Support for oil and gas operations, 31.3%
- Pipeline and related structures construction, 14.3%

22 http://www.sbecouncil.org/2014/11/14/who-benefits-from-americas-energy-revolution-small-businesses-and-consumers/ and http://www.sbecouncil.org/2014/11/13/small-business-growth-from-natural-gas-production-and-exports/

Industrial equipment and machinery

Industrial equipment and machinery consists of a number of critical subgroups ubiquitous throughout the crude oil supply chain. They are also archetypes of how the impact of upstream capital investment cascades through the US manufacturing sector—far beyond the energy value chain and deep into the various equipment sectors that maintain lengthy supply chain networks of their own. Examples of major products in this category include drilling rigs, power systems, pumps, compressors, valves, well-monitoring instrumentation, and off-highway equipment such as excavators. Companies in this core group supply essential and highly sophisticated technology for crude oil extraction. Advanced information technology is often integrated into these capital goods to achieve greater drilling productivity, efficiency, and sustainability, while sophisticated process control and other automation technologies enable end-users to maximize equipment utilization and throughput. Equipment distribution, either through sales or rentals of machinery, is often accompanied by a variety of high-value services, including skilled operators, maintenance, and logistics. Many small and medium-sized enterprises are responsible for manufacturing and distributing machinery and equipment that is, in turn, supplied by even larger numbers of component suppliers and metal fabrication shops.

The largest industrial equipment and machinery sector of the upstream supply chain is Cutting and Machine Tool Manufacturing (NAICS 333515). This sector, under a free trade policy, is forecast to generate an additional 6,700 jobs per year over the 2016-30 period in the Base Case and an additional 13,400 jobs per year from 2016-30 in the Potential Case. This sector and the Air and Gas Compressor Manufacturing (NAICS 333912) are also the largest contributors of labor income to the supply chain; their combined contribution is estimated at an average $2.1 billion annually from 2016-30 in the Base Case and over $3.6 billion annually in the Potential Case.

Employment: US crude oil export supply chain – Industrial equipment and machinery*
(number of workers, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
333515	Cutting and Machine Tool Manufacturing	6,543	13,952	15,547	13,876	11,304	3,950	6,715
333912	Air and Gas Compressor Manufacturing	3,505	8,887	10,959	9,718	8,111	2,874	4,662
3331	Construction, Mining and Agriculture Machinery Manufacturing	3,896	8,561	9,340	7,969	6,432	2,133	3,836
334519	Other Measuring and Controlling Device Manufacturing	2,535	6,480	8,021	7,715	6,676	2,736	3,919
333611	Turbine and Turbine Generator Manufacturing	2,163	5,537	7,065	6,476	5,511	1,903	3,052
Top-5 total		**18,642**	**43,416**	**50,934**	**45,753**	**38,033**	**13,597**	**22,183**
US total		**26,437**	**62,536**	**73,645**	**66,000**	**55,084**	**20,076**	**32,298**
Potential Production Case								
333515	Cutting and Machine Tool Manufacturing	9,067	19,976	24,870	23,610	21,019	10,180	13,356
3331	Construction, Mining and Agriculture Machinery Manufacturing	6,174	13,020	15,554	14,341	12,885	6,405	8,402
333912	Air and Gas Compressor Manufacturing	4,792	11,971	15,768	15,002	13,794	7,224	8,904
334519	Other Measuring and Controlling Device Manufacturing	3,825	10,253	14,041	14,735	13,726	7,647	8,870
333611	Turbine and Turbine Generator Manufacturing	3,293	8,424	11,405	11,335	10,548	5,438	6,625
Top-5 total		**27,152**	**63,644**	**81,638**	**79,023**	**71,972**	**36,893**	**46,157**
US total		**38,186**	**91,051**	**116,812**	**112,711**	**102,908**	**53,866**	**66,689**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Value added: US crude oil export supply chain – Industrial equipment and machinery*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
3331	Construction, Mining and Agriculture Machinery Manufacturing	1,158	2,120	2,002	1,686	1,515	1,015	1,242
333515	Cutting and Machine Tool Manufacturing	1,143	2,075	2,006	1,770	1,643	1,325	1,459
333912	Air and Gas Compressor Manufacturing	761	1,559	1,626	1,365	1,271	830	992
333611	Turbine and Turbine Generator Manufacturing	760	1,523	1,639	1,474	1,364	885	1,040
334519	Other Measuring and Controlling Device Manufacturing	626	1,242	1,279	1,169	1,115	830	916
Top-5 total		**4,447**	**8,518**	**8,551**	**7,465**	**6,909**	**4,885**	**5,649**
US total		**6,615**	**12,699**	**12,738**	**11,055**	**10,291**	**7,471**	**8,541**
Potential Production Case								
3331	Construction, Mining and Agriculture Machinery Manufacturing	1,797	3,253	3,508	3,133	3,014	2,283	2,502
333515	Cutting and Machine Tool Manufacturing	1,603	2,919	3,207	2,936	2,871	2,538	2,594
333611	Turbine and Turbine Generator Manufacturing	1,152	2,317	2,745	2,616	2,565	2,014	2,103
333912	Air and Gas Compressor Manufacturing	1,013	2,072	2,434	2,171	2,146	1,622	1,737
334519	Other Measuring and Controlling Device Manufacturing	938	1,873	2,166	2,093	2,093	1,797	1,809
Top-5 total		**6,502**	**12,433**	**14,060**	**12,950**	**12,689**	**10,253**	**10,744**
US total		**9,532**	**18,322**	**20,678**	**18,910**	**18,605**	**15,474**	**16,052**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Labor income: US crude oil export supply chain – Industrial equipment and machinery*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
333515	Cutting and Machine Tool Manufacturing	847	1,692	1,645	1,464	1,365	1,116	1,212
333912	Air and Gas Compressor Manufacturing	596	1,340	1,406	1,218	1,125	737	871
3331	Construction, Mining and Agriculture Machinery Manufacturing	643	1,300	1,228	1,035	925	603	744
334519	Other Measuring and Controlling Device Manufacturing	512	1,127	1,158	1,059	1,007	755	828
333611	Turbine and Turbine Generator Manufacturing	365	793	858	767	712	471	547
Top-5 total		**2,963**	**6,251**	**6,296**	**5,543**	**5,134**	**3,683**	**4,201**
US total		**4,431**	**9,388**	**9,420**	**8,250**	**7,676**	**5,634**	**6,367**
Potential Production Case								
333515	Cutting and Machine Tool Manufacturing	1,024	2,311	2,559	2,365	2,323	2,080	2,092
3331	Construction, Mining and Agriculture Machinery Manufacturing	916	2,010	2,192	1,975	1,908	1,413	1,542
333912	Air and Gas Compressor Manufacturing	717	1,781	2,083	1,919	1,899	1,454	1,529
334519	Other Measuring and Controlling Device Manufacturing	640	1,632	1,880	1,816	1,813	1,564	1,561
333611	Turbine and Turbine Generator Manufacturing	474	1,170	1,395	1,321	1,300	1,038	1,070
Top-5 total		**3,772**	**8,904**	**10,109**	**9,396**	**9,244**	**7,549**	**7,795**
US total		**5,534**	**13,210**	**14,911**	**13,750**	**13,574**	**11,412**	**11,673**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Information technology

Information technology is essential to the efficient operation and management of all industrial systems, and the crude oil export sector is no exception. Companies in the export supply chain provide software, hardware, and technology services to achieve higher asset reliability, productivity, and systems performance, often under hazardous conditions in remote areas. Applications of these technologies range from analysis and visualization of seismic and drilling log data, aggregating data from subterranean sensors, managing the volume of injected hydraulic fracturing fluids to more routine enterprises, such as accounting, risk management, legal, and programming.

Employment: US crude oil export supply chain – Information technology*
(number of workers, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
3341	Computer Hardware	4,147	10,513	12,930	11,545	9,731	3,845	5,821
5415	Computer Services	2,886	6,274	7,483	6,794	5,473	1,970	3,241
5112	Computer Software	212	532	654	622	533	215	313
Information technology total		**7,244**	**17,318**	**21,068**	**18,961**	**15,738**	**6,030**	**9,375**
Potential Production Case								
3341	Computer Hardware	5,897	14,931	19,588	19,155	17,652	9,867	11,727
5415	Computer Services	3,945	8,949	11,587	11,388	10,193	5,484	6,727
5112	Computer Software	313	824	1,116	1,157	1,072	595	696
Information technology total		**10,156**	**24,703**	**32,291**	**31,700**	**28,918**	**15,947**	**19,149**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Value added: US crude oil export supply chain – Information technology*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
3341	Computer Hardware	830	1,637	1,688	1,460	1,391	1,009	1,140
5415	Computer Services	511	901	908	798	722	519	602
5112	Computer Software	119	235	241	217	205	148	166
Information technology total		**1,460**	**2,773**	**2,837**	**2,475**	**2,318**	**1,676**	**1,908**
Potential Production Case								
3341	Computer Hardware	1,177	2,317	2,665	2,473	2,476	2,068	2,119
5415	Computer Services	681	1,247	1,420	1,324	1,282	1,095	1,127
5112	Computer Software	175	348	401	382	379	319	325
Information technology total		**2,034**	**3,911**	**4,486**	**4,179**	**4,137**	**3,483**	**3,572**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Labor income: US crude oil export supply chain – Information technology*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
3341	Computer Hardware	731	1,616	1,665	1,455	1,381	995	1,120
5415	Computer Services	525	1,019	1,028	912	819	586	678
5112	Computer Software	58	126	130	117	110	79	88
Information technology total		**1,314**	**2,761**	**2,823**	**2,484**	**2,310**	**1,660**	**1,886**
Potential Production Case								
3341	Computer Hardware	884	2,217	2,544	2,382	2,384	1,975	2,011
5415	Computer Services	626	1,408	1,608	1,516	1,461	1,242	1,269
5112	Computer Software	72	181	208	199	197	164	167
Information technology total		**1,582**	**3,806**	**4,361**	**4,096**	**4,042**	**3,382**	**3,447**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Logistics

The record volume of current crude oil production is testing US transportation infrastructure as operators seek to get their product to market. Logistics services within the crude oil export sector move crude oil and associated natural gas via truck, rail, pipeline, or water from oil-producing regions to commercial centers for storage, refining or export. More than one mode of transportation is often necessary, requiring the services of a specialized logistics provider, particularly in remote areas where pipeline or rail transport capacity is limited or non-existent. Within the logistics core group, General Freight Trucking (NAICS 4841) accounts for the largest employment contributions stemming from crude oil export activity. In the Base Production Case, the net increase in the total number of logistics workers expected under a change to a free trade policy nearly doubles, from over 4,000 in 2016 to 8,000 in 2020. In the Potential Production Case, the net increase exceeds 5,800 in 2016 and swells to over 14,000 in 2020. Another significant economic impact comes from General Freight Trucking's value added contribution to GDP, which is estimated to average nearly $512 million more per year between 2016 and 2030 in the Base Case under free trade, compared to restricted trade, and almost $1 billion more per year during the same period in the Potential Case.

Employment: US crude oil export supply chain – Logistics*
(number of workers, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
4841	General Freight Trucking	3,602	8,486	9,927	8,698	7,145	2,431	4,144
4821	Rail Transportation	384	892	1,044	909	741	259	437
486	Pipeline Transportation	94	202	246	224	178	62	104
483	Water Transportation	15	34	40	36	29	10	17
Logistics total		**4,094**	**9,614**	**11,258**	**9,867**	**8,092**	**2,761**	**4,703**
Potential Production Case								
4841	General Freight Trucking	5,128	11,971	14,954	13,956	12,507	6,289	8,094
4821	Rail Transportation	552	1,286	1,624	1,525	1,358	710	896
486	Pipeline Transportation	130	286	372	368	330	187	224
483	Water Transportation	21	49	62	59	52	28	35
Logistics total		**5,832**	**13,592**	**17,012**	**15,909**	**14,247**	**7,214**	**9,249**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Value added: US crude oil export supply chain – Logistics*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
4841	General Freight Trucking	434	829	824	697	637	427	512
4821	Rail Transportation	121	223	221	188	171	116	139
486	Pipeline Transportation	55	96	98	87	76	53	63
483	Water Transportation	7	14	14	12	11	7	9
Logistics total		**618**	**1,161**	**1,156**	**983**	**895**	**603**	**723**
Potential Production Case								
4841	General Freight Trucking	604	1,153	1,282	1,140	1,104	856	923
4821	Rail Transportation	171	320	357	323	312	250	265
486	Pipeline Transportation	72	133	157	149	143	121	125
483	Water Transportation	10	20	22	20	19	16	17
Logistics total		**857**	**1,625**	**1,818**	**1,632**	**1,578**	**1,243**	**1,329**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Labor income: US crude oil export supply chain – Logistics*
($millions, real 2009, difference free trade vs. restricted trade)

		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
4841	General Freight Trucking	367	767	765	656	595	396	474
4821	Rail Transportation	85	174	172	146	133	90	107
486	Pipeline Transportation	77	147	153	139	119	81	96
483	Water Transportation	4	8	8	7	6	4	5
Logistics total		**533**	**1,096**	**1,098**	**948**	**853**	**571**	**683**
Potential Production Case								
4841	General Freight Trucking	464	1,075	1,202	1,087	1,049	806	862
4821	Rail Transportation	107	245	274	248	239	191	201
486	Pipeline Transportation	105	230	275	268	254	213	217
483	Water Transportation	5	11	13	11	11	9	9
Logistics total		**680**	**1,561**	**1,764**	**1,615**	**1,553**	**1,218**	**1,291**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Materials

A diverse set of companies provide a variety of materials to the crude oil export sector, either for use in drilling operations or indirectly as part of the supplier networks to other suppliers. These materials are classified as consumables that are directed to exploration and production operations or materials or material inputs used in manufacturing goods.

Consumables are used on a daily basis to support upstream, midstream, and downstream operations. They include steel tubing, drill bits, drilling mud, clay, sand, chemicals and other additives. They are used over the entire lifecycle of a well, from exploration, drilling, completion, production, and intervention to abandonment. The grueling nature of oil and gas exploration and production activity necessitates that the capital equipment used in drilling operations meet the demanding conditions of the drill site. For example, the metallic components within the drilling apparatus are often made of corrosion-resistant alloys, such as martensitic stainless steels (chromium-based alloys) and austenitic stainless steel (chromium and nickel-based alloys). Applications of these materials include downhole tubing and safety critical elements, wellhead and Christmas tree components, valves, pipelines, vessels, heat exchangers, and other pieces of equipment.

Within the materials core group, the subsectors with the largest economic contributions to labor income and value added are: Construction Sand and Gravel Mining (NAICS 212321), Wholesale Metals and Minerals (NAICS 4235), Cement Manufacturing (NAICS 327310), Industrial Gas Manufacturing (NAICS 325120), and Fabricated Pipe and Pipefitting (NAICS 332996). The subsectors with the largest economic contributions to employment are slightly different with Steel Product Manufacturing (NAICS 3312) replacing Industrial Gas Manufacturing.

The Construction Sand and Gravel Mining (NAICS 212321) sector benefits the most from crude oil export activity in terms of value added, employment, and labor income. Total sector employment supported by free trade under the Base Case is projected to increase from just over 6,500 additional workers in 2016 to more than 12,100 additional workers in 2020. In the Potential Case, employment is expected to increase from just over 8,100 additional workers in 2016 to nearly 18,000 additional workers by 2020. Value added in Construction Sand and Gravel Mining is expected to increase from an additional $1.1 billion in 2016 to an additional $1.7 billion in 2020 in the Base Case and from an additional $1.4 billion in 2016 to an additional $2.6 billion in 2020 in the Potential Case.

The companies operating in the wholesale trade sectors in Metals and Minerals (NAICS 4235) are also expected to steadily increase their employment under a free trade scenario. The number of these workers supported by free trade will increase from an average of over 3,500 in 2016 to over 6,600 in 2020 in the Base Case, and from an average of 5,100 workers in 2016 to over 12,200 workers in 2020 in the Potential Case.

Employment: US crude oil export supply chain – Materials*
(number of workers, difference free trade vs. restricted trade)

Top-5 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
212321	Construction Sand and Gravel Mining	6,529	14,236	15,901	14,788	12,129	4,165	7,015
4235	Metal and Minerals - Wholesale	3,540	8,036	9,286	8,071	6,619	2,257	3,875
332996	Fabricated Pipe and Pipefitting Manufacturing	3,016	7,437	8,721	7,977	6,775	2,405	3,865
3312	Steel Product Manufactuirng	2,809	6,194	7,117	6,117	5,020	1,676	2,934
327310	Cement Manufacturing	2,438	6,164	7,464	6,722	5,432	1,790	3,075
Top-5 total		**18,333**	**42,065**	**48,489**	**43,675**	**35,974**	**12,294**	**20,765**
US total		**22,774**	**52,632**	**60,853**	**54,366**	**44,718**	**15,402**	**25,957**
Potential Production Case								
212321	Construction Sand and Gravel Mining	8,130	16,502	20,421	19,641	17,964	8,918	11,456
4235	Metal and Minerals - Wholesale	5,060	11,632	14,758	13,787	12,197	6,085	7,886
332996	Fabricated Pipe and Pipefitting Manufacturing	4,117	9,853	12,653	12,322	11,480	5,950	7,329
3312	Steel Product Manufactuirng	4,078	9,321	11,807	10,969	9,617	4,707	6,191
327310	Cement Manufacturing	3,707	9,189	11,746	11,455	10,228	4,960	6,395
Top-5 total		**25,092**	**56,496**	**71,384**	**68,173**	**61,487**	**30,621**	**39,256**
US total		**31,689**	**72,058**	**90,499**	**85,911**	**77,316**	**39,165**	**49,941**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Value added: US crude oil export supply chain – Materials*
($millions, real 2009, difference free trade vs. restricted trade)

Top-5 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
212321	Construction Sand and Gravel Mining	1,119	2,071	1,989	1,817	1,672	1,195	1,375
4235	Metal and Minerals - Wholesale	859	1,566	1,530	1,282	1,176	790	954
325120	Industrial Gas Manufacturing	663	1,244	1,194	964	869	575	712
327310	Cement Manufacturing	624	1,188	1,182	1,030	936	579	716
332996	Fabricated Pipe and Pipefitting Manufacturing	513	1,018	1,012	886	851	655	722
Top-5 total		**3,778**	**7,088**	**6,907**	**5,980**	**5,505**	**3,794**	**4,480**
US total		**4,997**	**9,343**	**9,136**	**7,862**	**7,224**	**4,954**	**5,873**
Potential Production Case								
212321	Construction Sand and Gravel Mining	1,432	2,491	2,771	2,586	2,550	2,002	2,123
4235	Metal and Minerals - Wholesale	1,214	2,233	2,467	2,186	2,096	1,665	1,790
325120	Industrial Gas Manufacturing	966	1,835	1,968	1,702	1,632	1,290	1,400
327310	Cement Manufacturing	954	1,798	2,010	1,897	1,884	1,381	1,490
332996	Fabricated Pipe and Pipefitting Manufacturing	710	1,374	1,558	1,444	1,479	1,374	1,353
Top-5 total		**5,275**	**9,731**	**10,773**	**9,815**	**9,641**	**7,712**	**8,157**
US total		**6,998**	**12,970**	**14,350**	**13,003**	**12,693**	**10,164**	**10,777**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Labor income: US crude oil export supply chain – Materials*
($millions, real 2009, difference free trade vs. restricted trade)

Top-5 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
212321	Construction Sand and Gravel Mining	834	1,731	1,659	1,532	1,413	1,010	1,151
4235	Metal and Minerals - Wholesale	568	1,139	1,118	945	865	584	698
327310	Cement Manufacturing	494	1,009	1,004	877	797	485	602
325120	Industrial Gas Manufacturing	414	845	803	645	579	375	469
332996	Fabricated Pipe and Pipefitting Manufacturing	379	833	833	736	696	528	584
Top-5 total		**2,688**	**5,558**	**5,417**	**4,735**	**4,348**	**2,981**	**3,504**
US total		**3,586**	**7,369**	**7,209**	**6,258**	**5,733**	**3,911**	**4,618**
Potential Production Case								
212321	Construction Sand and Gravel Mining	958	2,047	2,283	2,145	2,123	1,653	1,739
4235	Metal and Minerals - Wholesale	697	1,580	1,757	1,578	1,510	1,195	1,271
327310	Cement Manufacturing	622	1,445	1,623	1,550	1,533	1,109	1,191
325120	Industrial Gas Manufacturing	509	1,190	1,268	1,095	1,048	815	884
3312	Steel Product Manufactuirng	506	1,133	1,252	1,114	1,057	855	908
Top-5 total		**3,292**	**7,395**	**8,183**	**7,482**	**7,271**	**5,627**	**5,993**
US total		**4,371**	**9,929**	**11,031**	**10,100**	**9,842**	**7,782**	**8,206**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Oil and gas activity supports US steel industry[23]

The US steel industry had high hopes of benefitting from the unconventional oil and natural gas boom, as evidenced by multiple examples of expansion in the steel tube and pipe manufacturing sector. More than 1.3 million metric tons of new OCTG production capacity has been commissioned in the USA since 2007, and total capacity is now approaching 10.5 million metric tons. According to the president of North American operations for Tenaris, Germán Curá, a fundamental reason for building a pipe plant in Texas, expected to be completed in 2016, is the proximity to the Eagle Ford Shale play. "It is one of the most promising fields in the industry," Curá said. The plant will have an annual production capacity of 600,000 tons of seamless pipe used in drilling, producing, and transporting oil and gas. Sewickley, Pennsylvania-based Esmark, Inc. announced plans to convert a recently closed steel finishing mill into an industrial services manufacturing center to support oil and gas activities in September 2014. The company anticipates adding 50 to 75 jobs as part of its new endeavor.

However, domestic steel producers have struggled to compete with a growing influx of cheap imports, a situation that will only be made worse with the sharp reduction in demand now expected in 2015. In August 2014, the US International Trade Commission ruled in favor of the domestic steel industry in a case against foreign competitors that the United States had accused of dumping low-priced steel on US shores. The ruling paves the way for additional duties the Commerce Department levied on imported steel tubing from six countries: India, Korea, Taiwan, Turkey, Ukraine, and Vietnam. These trade sanctions will support the domestic steel industry's efforts to capitalize on oil and gas sector spending, provided that upstream investment continues at 2013/2014 levels.

The ripple effects of the fall in the price of oil are already being felt across the oil and gas supply chain. OCTG suppliers across the country are idling capacity as demand drops and imports continue to flood the market. Major suppliers including Tenaris, Vallourec, US Steel, TMK Ipsco have all announced mill closures and layoffs, with declining oil prices cited among the reasons. As demonstrated in this study and in the Export Decision study, the entire supply chain depends on the health of the oil and gas industry. Policies that potentially impair industry activities, including the export ban, could produce similar ripple effects across the country.

Professional, financial, and other services

The energy value chain requires a diverse set of skills, starting with the standard array of accounting, insurance, Internet, legal, programming, and other professional services firms. This sector also includes highly specialized firms that provide remote catering, life support, temporary lodging, environmental site assessment and remediation services, soil and groundwater testing services, physical security, and analytical support services.

In the professional and other services core group, Architectural, Engineering, and Related Services (NAICS 5413) is the top sector in terms of both the number of workers and the value added to GDP under a free trade scenario, compared to the restricted status quo. This sector is estimated to add over 8,800 workers in 2016 in the Base Case, rising to a peak of nearly 23,500 in 2018. Potential Case employment expands from over 12,700 in 2016, peaking two years later at nearly 36,500 additional jobs. In terms of value added contribution, this sector is expected to increase more than $1.2 billion in 2016 and more than $1.7 billion in 2020 in the Base Case. In the Potential Case, the sector will increase its value added contribution by $1.7 billion in 2016 and by $3.0 billion in 2020 in a free trade environment.

23 http://www.mysanantonio.com/news/local_news/article/Tenaris-announces-1-5B-Eagle-Ford-pipe-plant-4282058.php; http://powersource.post-gazette.com/powersource/energyforum/2014/09/17/Is-shale-the-new-steel/stories/201409170003; http://triblive.com/business/headlines/7174309-74/solutions-steel-company#ixzz3JVKfOTUC; http://www.reuters.com/article/2014/08/22/usa-trade-steel-idUSL2N0QS10W20140822; http://www.usitc.gov/press_room/news_release/2014/er0822mm1.htm; http://www.cleveland.com/business/index.ssf/2015/01/us_steel_to_temporarily_lay_of.html.

Banking and finance sector invests in energy value chain[24]

The banking and finance sector has made numerous investments in the energy value chain in response to the ongoing boom in oil production. The significant cost to recover crude oil and sustain higher levels of production requires a range of finance vehicles. Specifically, private equity funds have appreciably increased their stake in unconventional oil and gas development since 2009, raising $157 billion to invest in energy, according to data from the intelligence firm, Preqin. Even five years into the resurgence of domestic oil and gas, private equity continues to attract new capital, raising nearly $32 billion in 2014 alone. Private equity executives said they believe that crude oil will continue to be an important source of power and fuel in 25 years.

The remaining industries ranked in the top five services sectors are expected to follow similar trends in terms of the employment, value added, and labor income generated by crude oil export-related activity. These industries include Management, Scientific, and Technical Consulting Services (NAICS 5416), Other Professional, Scientific and Technical Services (NAICS 5419), Insurance Carriers and Related Activities (NAICS 524), Water, Sewage and Other Systems (NAICS 2213), and Finance (NAICS 52 excluding 524).

Employment: US crude oil export supply chain – Professional, financial, and other services* (number of workers, difference free trade vs. restricted trade)

Top-5 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
5413	Architectural, Engineering, and Related Services	8,836	19,979	23,465	20,486	16,659	5,453	9,597
52_ex_524	Finance	4,244	9,842	11,603	10,279	8,402	2,930	4,911
524	Insurance Carriers and Related Activities	1,814	4,423	5,099	4,310	3,473	1,135	2,031
5416	Management, Scientific, and Technical Consulting Services	1,755	4,141	4,938	4,413	3,634	1,296	2,123
2213	Water, Sewage and Other Systems	1,303	3,298	3,862	3,345	2,747	892	1,565
Top-5 total		**17,952**	**41,683**	**48,967**	**42,833**	**34,915**	**11,706**	**20,227**
US total		**22,440**	**52,004**	**61,194**	**53,710**	**43,793**	**14,807**	**25,414**
Potential Production Case								
5413	Architectural, Engineering, and Related Services	12,710	29,975	36,479	34,111	29,347	14,158	18,947
52_ex_524	Finance	5,980	13,816	17,515	16,658	14,935	7,749	9,760
5416	Management, Scientific, and Technical Consulting Services	2,483	5,902	7,526	7,245	6,515	3,440	4,272
524	Insurance Carriers and Related Activities	2,438	5,722	6,918	6,209	5,453	2,635	3,540
2213	Water, Sewage and Other Systems	1,909	4,607	5,563	5,023	4,497	2,126	2,858
Top-5 total		**25,519**	**60,022**	**74,001**	**69,245**	**60,746**	**30,109**	**39,375**
US total		**31,782**	**74,678**	**92,661**	**87,136**	**76,721**	**38,388**	**49,790**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

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Value added: US crude oil export supply chain – Professional, financial, and other services*
($millions, real 2009, difference free trade vs. restricted trade)

Top-5 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
5413	Architectural, Engineering, and Related Services	1,217	2,242	2,246	1,903	1,719	1,066	1,333
52_ex_524	Finance	984	1,819	1,821	1,561	1,426	995	1,171
524	Insurance Carriers and Related Activities	424	821	799	646	580	377	470
5419	Other Professional, Scientific, and Technical Services	444	815	820	707	646	458	534
2213	Water, Sewage and Other Systems	327	671	667	547	499	323	396
Top-5 total		**3,397**	**6,367**	**6,353**	**5,364**	**4,870**	**3,219**	**3,903**
US total		**4,336**	**8,101**	**8,092**	**6,857**	**6,230**	**4,151**	**5,008**
Potential Production Case								
5413	Architectural, Engineering, and Related Services	1,746	3,350	3,641	3,256	3,018	2,339	2,560
52_ex_524	Finance	1,356	2,541	2,862	2,595	2,515	2,061	2,165
5419	Other Professional, Scientific, and Technical Services	610	1,144	1,291	1,179	1,141	955	994
524	Insurance Carriers and Related Activities	553	1,058	1,145	974	924	689	770
2213	Water, Sewage and Other Systems	458	919	1,005	857	831	598	670
Top-5 total		**4,722**	**9,013**	**9,943**	**8,861**	**8,430**	**6,641**	**7,159**
US total		**6,008**	**11,434**	**12,664**	**11,336**	**10,818**	**8,576**	**9,201**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Labor income: US crude oil export supply chain – Professional, financial, and other services*
($millions, real 2009, difference free trade vs. restricted trade)

Top-5 sectors		2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case								
5413	Architectural, Engineering, and Related Services	1,269	2,568	2,577	2,204	1,979	1,235	1,530
52_ex_524	Finance	573	1,179	1,182	1,023	932	663	768
5416	Management, Scientific, and Technical Consulting Services	302	625	629	546	499	348	405
524	Insurance Carriers and Related Activities	257	550	542	445	395	253	315
5419	Other Professional, Scientific, and Technical Services	241	486	489	427	387	275	319
Top-5 total		**2,641**	**5,408**	**5,419**	**4,646**	**4,193**	**2,774**	**3,336**
US total		**3,292**	**6,763**	**6,782**	**5,815**	**5,246**	**3,478**	**4,178**
Potential Production Case								
5413	Architectural, Engineering, and Related Services	1,616	3,750	4,093	3,672	3,398	2,669	2,881
52_ex_524	Finance	700	1,627	1,836	1,681	1,627	1,347	1,396
5416	Management, Scientific, and Technical Consulting Services	373	877	986	907	879	720	748
524	Insurance Carriers and Related Activities	311	721	789	687	648	477	528
5419	Other Professional, Scientific, and Technical Services	293	677	766	709	684	574	591
Top-5 total		**3,293**	**7,653**	**8,470**	**7,656**	**7,236**	**5,786**	**6,144**
US total		**4,114**	**9,559**	**10,610**	**9,601**	**9,105**	**7,240**	**7,692**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

In the next chapter, IHS' analysis of the economic contributions of US crude oil export activity reveals the geographical diversity of the supply chain. While the largest economic benefits accrue to supply chain sectors located in major oil-producing states, particularly especially California and Texas, considerable employment, value-added, and labor income is supported across most of the 50 states, including those with no economically recoverable hydrocarbons.

State supply chain assessment

Key insights

- The oil-producing states of California and Texas are expected to reap the largest benefits from a free trade crude oil export policy, together accounting for about 25% of total supply chain employment and labor income contributions and about 23% of the government revenue contributions over the 2016-30 period in both the Base Production and Potential Production Cases. California is ranked third in terms of capital spending, which, along with its strong diversified supply chain sectors, is expected to highly benefit the state under a free trade policy.

- Washington, Massachusetts and other states that do not produce crude oil still rank high in employment, labor income, and value-added economic contributions under free trade. In terms of labor income, Washington and Massachusetts contribute nearly 7% of the free trade's impact on the US supply chain in both the Base Production Case and the Potential Production Case.

- The supply chain accounts for nearly 50% of the overall economic impact of a free trade policy in several oil-producing and non-producing states. In Washington State, for example, the technology and manufacturing sectors are expected to grow rapidly in both the Base Production Case and Potential Production Case, and its supply chain contribution to GDP is expected to comprise 47% of the state's total impacts from higher crude oil exports over the 2016-30 period. Even a state like Illinois, a small oil-producing state with a diverse set of supplier industries, will derive 58% and 54% of the total value added impacts from the supply chain in the Base and Potential Production Cases, respectively.

- As previously indicated, the additional government revenue contributed by the supply chain is sizable under a free trade policy. The supply chain impact on cumulative government revenues represents nearly one-third of the total impact on oil export revenue, at $429 billion and $868 billion in the Base Case and Potential Case, respectively, over 2016-30 period. While California and Texas experience the largest net impacts of supply chain on their government revenue, non-oil producing states such as Massachusetts and Maryland will see supply chain-associated government revenues more than double over the 2016-30 time period in the Base Production Case and more than triple over that same period in the Potential Production Case.

- New York State has a diversified economy with a strong financial sector and many mature manufacturing industries that are expected to benefit from removing the crude oil export ban. In the long-term (2016-30), supply chain activity under free trade is expected to contribute an additional $2.1 billion on average per year to value added in the Base Production Case, while the average in the Potential Production Case exceeds $4 billion per year. New York's state and local governments are also expected to benefit: between 2016 and 2030, the cumulative impact on government revenue in the Base Production Case will exceed $37 billion and will reach almost $81 billion in the Potential Production Case.

Introduction

The effect of eliminating the ban on the export of crude oil will have far-reaching consequences for the US economy and within virtually every state. The effects of this policy change will go beyond crude oil exploration and development and will include manufacturing and service-related sectors present in every region. Some industries that stand to benefit—transportation, steel, professional and financial services—are dispersed across many states regardless of their proximity to active crude oil plays. Large and diverse state economies such as California, Texas, Illinois and New York are clear beneficiaries by virtue of their ability to fulfill supply-chain requirements. Other states, such as Ohio, Michigan and Pennsylvania, have large capital equipment manufacturing sectors, which are supported by their local materials and components suppliers.

This section of the report details the state-by-state economic impacts stemming from the first-order supply chain effects related to a prospective change in US crude oil export policy. As with the national analysis, this section presents the supply chain's economic contribution from the upstream (production), midstream (transportation and logistics), and downstream (processing and marketing) sectors after a change to US crude oil export policy. These supply chain impacts of changing to a free trade policy are presented in terms of their economic contributions under the Base Production Case and Potential Production Case. These supply chain networks reach into all regions of the United States, and the findings are presented for producing or non-producing states.

The first section presents the states that are expected to have the largest supply chain contributions under free trade to employment, value added, labor income, and government revenue.

The second section presents the main supplier industries benefitting from free trade of US crude oil and the selected detailed 6-digit NAICS sectors present in key states.

Methodology

While the first study, *US Crude Oil Export Decision*, used macroeconomic state models to assess the total economic impact of lifting the US crude oil export ban under two projection trajectories, this study utilizes Input/Output models to trace and assess the impacts at the sector- and supplier-industry levels. IHS has integrated and calibrated the two modeling approaches by embedding and linking the sectoral model within the IHS macroeconomic modeling system.

The model framework utilized in this analysis was established as a system of linked state economies to capture the flow of trade across state borders. As a result, the sourcing of supplies requisite for crude oil development activity impacts states that do not have an oil play within their borders. For example, oil development in North Dakota relies on companies that provide banking, financial, and insurance services in Chicago and New York City as well as professional services firms that might be located in Dallas, San Francisco and Boston. Capturing these connections highlights the indirect economic contribution even in non-producing states.

By focusing on the interaction of economic activity among the states, IHS provides a more careful analysis of state-level impacts resulting from a change in crude oil export policy. In addition, while the economic value created by oil production is attributed solely to states with plays, the allocation of capital expenditures across the 50 states is interconnected. Capital spending may be incurred at an oil production site, but the machinery and equipment, architectural and engineering services, materials, and other expenditures may occur in other locations far from production. To ensure that these effects are fully captured in the analysis, insights from the IHS Economics and IHS Energy teams, web-based primary research, and IHS proprietary databases were employed to appropriately allocate capital expenditures to the individual states.

IHS integrated information from a number of different proprietary and public sources to determine interstate trade flows. The analysis was supported by multiple industry sources, the IHS TRANSEARCH© Business Market Insight databases, and IHS expert judgment. For example, unconventional oil extraction employing hydraulic fracturing techniques requires sand with unique properties produced primarily in Wisconsin, Minnesota, Ohio, and Arkansas. Since not all states with unconventional oil or gas plays produce these distinctive sands, they must procure them from suppliers elsewhere (and are assumed to do so in the sectoral model). The IHS TRANSEARCH© trade-flow database was one of several sources used to determine the origin and destination of the various materials and equipment on a state level. This process was undertaken for all of the detailed capital expenditure categories (defined as various products and services). The set of products and services, and — in a producing state — the value of production, were input into the corresponding state model to assess the impact of the supply chain in each individual state's economy as determined by the multi-regional analysis capability and related coefficients of the IMPLAN model. The net result is an assessment of the supply chain across all state economies.

Unconventional oil activity impacts North Dakota and neighbor state's infrastructure

The advent of improved horizontal drilling and hydraulic fracturing techniques has resulted in unprecedented economic growth in North Dakota. Beginning in earnest around 2008, development of the Bakken and Three-Forks shale plays in North Dakota's Williston Basin resulted in a large influx of drilling operators and workers. Despite producing oil since the 1950s, this remote and sparsely populated region historically did not have a supply chain of the necessary scale to support drilling and production. As a result, energy supply chain growth was limited by inadequate infrastructure and housing, and the lack of availability of labor.

Due to the size and potential of the Bakken, an outsize share of the economic contributions in recent years has come from the upstream production sector of the energy supply chain. The massive increase in well drilling resulted in large economic contributions from Support Activities for Oil and Gas Operations (NAICS 213112). In addition, the region's lack of sufficient infrastructure led to large gains in Construction of New Nonresidential Manufacturing Structures and Other New Nonresidential Structures. Rapid development of new pipelines, rail, storage facilities, manufacturing facilities, and export facilities was needed to bring in supplies and ship out extracted crude and natural gas.

While the Bakken spans 16 counties on the western side of the state, all of North Dakota as well as some neighboring states have benefitted from the energy boom. The uptick in activity has transformed the city of Fargo, where manufacturing and business services firms weathered the recession very well and have seen a resurgence in activity as they supply the Bakken with needed inputs. Large numbers of new jobs have also been created in residential construction as homebuilding takes off to house the influx of new workers. Contractors in Fargo have seen a huge uplift in activity not only from the Williston Basin, but also from the city itself. Many construction firms in neighboring Minnesota are also acquiring work from their western neighbor. Finance, health services, and leisure/hospitality services have shown large employment gains necessary to keep pace with consumer demand from a swelling population. North Dakota's unemployment rate is by far the lowest among the states. In fact, labor shortages are one of the largest constraints for supply chain expansion, despite huge advances in wage growth.

The mining sectors of other states have also benefitted due to the fact that sand is input into the hydraulic fracturing process. A particularly hardy type of sand called "frac sand" is supplied by mines in Illinois, Minnesota, Wisconsin, and other states. Moving the sand and other inputs requires the expertise of shipping and logistics companies and has resulted in significant hiring in the transportation and warehousing sector. Operators in Minnesota and many other states in the region that supply North Dakota have seen a surge in business as a result.

Although the need for rig and wellhead workers is obvious, less visible is the need to fill many of the positions that support drilling operations. Everything from licensed commercial truck drivers to office workers are necessary to ensure the steady flow of crude and natural gas from the region. Power Fuels, a division of Nuverra Environmental Solutions, is the largest of many companies that provide support and services to drilling operations in the Williston Basin. Power Fuels announced the hiring of 300 new employees at the end of last year.

Economic contribution results

Employment

Our analysis shows that while the supply chain's economic contributions tend to be concentrated in oil-producing states such as California and Texas, other states, such as Washington and Massachusetts, also benefit significantly. For example, in the Base Production Case, the supply chain's contribution to employment under a free trade policy in Washington State was 3,600 more workers per year in 2016-2030. This supply chain share is nearly 47% of the total economic impact in the Base Production Case, which registers at just over 7,700 more workers per year. In the Potential Production Case, Washington State is expected to add an average of about 7,700 workers per year over 2016-30 under a free trade policy—about 45% of the total crude oil export employment impact of over 17,000 workers per year. The majority of the supply chain impact in Washington State is driven by computer software and hardware.

New York State supply chain sectors benefits despite a ban on hydraulic fracturing

New York State receives economic benefits through its supply chain, since the broader benefits commonly found in producing states have been diminished by New York's decision to maintain a ban on developing its own substantial natural gas resources. The Marcellus Shale play includes nearly the entire length of New York's southern border with Pennsylvania, and the Utica play extends into the western part of the state. For now, supplier industries within New York State can only supply products and services to support energy exploration and production in places like Pennsylvania, Ohio, and North Dakota.

Oil and natural gas production requires a significant financial investment, and New York City's extensive financial services sector is certainly playing a role in unconventional energy development. The rapid advances in energy exploration and production also require high-tech support, such as database management tools, big data analytics, visualization programs, and IT support functions provided by companies in the state.

The vast increase in oil and natural gas production, especially in Pennsylvania, has given rise to new logistics and an expansion of product distribution for New York and New England. Prior to the unconventional energy boom, this area had traditionally experienced markedly higher natural gas prices than other parts of the country due to its distance from supplies. Beyond the benefit to consumers, the expansion of the midstream pipeline network in New York has also led to jobs for construction workers and for suppliers of steel pipe and related support services.

California and Texas, home to significant onshore and offshore oil reserves and production, are the largest beneficiaries of new and ongoing crude oil activity. As they escalate their upstream activities with a removal of the crude oil export ban, their full-service supply chains have a considerable impact on the economies of these two states. Oil and gas support services, engineering and technical services, and finance, are expected to be among top-performing industries that benefit from lifting the export ban. In Base and Potential Production Cases, these two states together contribute a sizable amount—23% (Potential Case) to 25% (Base Case)—of the entire US supply chain's additional jobs over the 2016-30 period.

Top-10 employment contributions: US crude oil export supply chain – Base Production*
(number of workers, difference free trade vs. restricted trade)

	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Supply chain employment contribution							
California	11,832	33,639	43,129	35,864	29,787	10,828	17,502
Texas	10,086	26,549	32,279	28,931	23,990	7,656	13,226
Illinois	8,138	16,590	17,644	15,052	12,106	4,010	7,309
New York	4,908	11,769	13,956	12,548	10,361	3,867	6,147
Ohio	5,346	10,504	10,475	8,469	7,019	2,404	4,390
Florida	4,238	10,075	12,213	11,956	10,458	4,313	6,138
Michigan	4,066	7,783	8,109	6,744	5,337	1,695	3,266
Pennsylvania	3,418	7,244	7,325	6,061	4,857	1,475	2,911
Oklahoma	3,016	6,759	7,628	6,596	5,192	1,416	2,890
Washington	2,769	6,743	8,204	7,347	6,064	2,295	3,605
Top-10 total	**57,816**	**137,656**	**160,961**	**139,568**	**115,173**	**39,959**	**67,384**
US total	**105,748**	**250,201**	**293,140**	**258,227**	**212,508**	**73,384**	**123,577**
Total crude oil export employment contribution**							
California	33,460	88,040	110,860	101,020	81,090	28,693	46,760
Texas	39,380	94,520	117,370	107,040	86,130	27,498	47,961
Illinois	18,290	35,880	39,140	33,830	27,540	8,783	16,167
New York	16,360	37,310	44,860	40,420	32,920	11,800	19,325
Ohio	15,110	30,150	33,290	28,890	23,700	7,735	13,899
Florida	22,440	47,660	56,160	51,440	42,960	16,718	25,856
Michigan	14,880	27,740	28,970	24,070	18,950	4,773	10,823
Pennsylvania	11,530	24,650	28,200	24,830	20,300	5,738	11,126
Oklahoma	8,690	18,790	22,440	19,950	15,600	4,156	8,469
Washington	6,000	14,510	17,800	16,270	13,330	4,766	7,705
Top-10 total	**186,140**	**419,250**	**499,090**	**447,760**	**362,520**	**120,660**	**208,091**
US total	**358,610**	**811,250**	**963,720**	**863,310**	**699,520**	**221,532**	**394,118**
Total state employment***							
California	16,096,504	16,342,006	16,541,530	16,713,653	16,894,796	17,594,008	17,235,238
Texas	12,163,160	12,407,719	12,620,211	12,821,439	13,032,535	13,931,590	13,490,731
Illinois	5,973,287	6,033,050	6,072,485	6,109,673	6,147,849	6,251,120	6,189,836
New York	9,226,393	9,297,202	9,332,432	9,355,131	9,387,961	9,509,108	9,446,013
Ohio	5,419,442	5,462,497	5,483,118	5,499,387	5,524,574	5,599,340	5,558,828
Florida	8,157,384	8,314,869	8,432,205	8,539,724	8,655,498	9,170,261	8,920,153
Michigan	4,225,864	4,256,515	4,274,943	4,289,212	4,306,502	4,361,901	4,331,470
Pennsylvania	5,924,842	5,977,881	6,007,078	6,031,570	6,067,636	6,149,923	6,100,549
Oklahoma	1,716,859	1,739,664	1,755,645	1,768,571	1,785,286	1,844,328	1,813,954
Washington	3,154,481	3,191,911	3,217,228	3,241,311	3,272,379	3,362,995	3,313,818
Top-10 total	**72,058,214**	**73,023,314**	**73,736,875**	**74,369,671**	**75,075,017**	**77,774,573**	**76,400,589**
US total	**143,787,425**	**145,272,475**	**147,731,000**	**150,800,050**	**153,014,100**	**156,645,980**	**153,804,323**

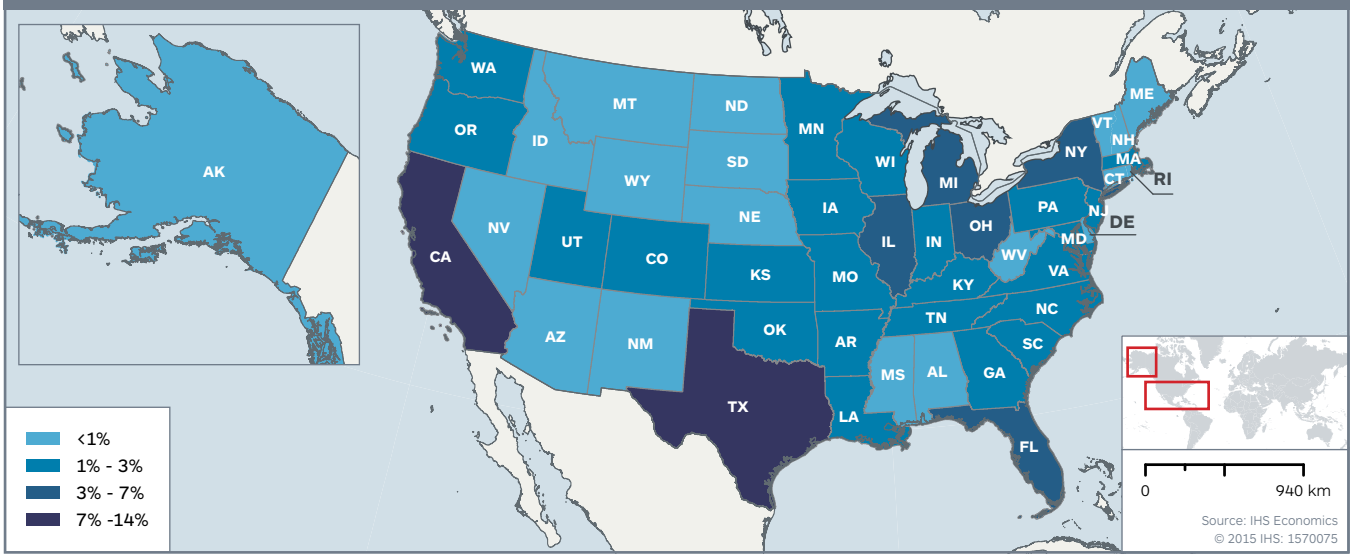
*The rank for all years is based on the 2017 ranking.

** Data are from the *US Crude Export Decision* report

*** Data are from the IHS US Regional Service forecast, November 2014

Source: IHS Economics

Employment distribution by state – Base Production
(2017 percent, difference free trade vs. restricted trade)



Many state economies will benefit from additional investment if the crude oil export ban is removed, though not all benefit equally. In the Potential Production Case, many of the same state economies that benefit from additional investment in production capacity thrive, but we also see newly emerging states that benefit from the free trade scenario, such as Georgia, due to their logistics and other midstream transport capabilities. California's supply chain sectors are expected to benefit on two fronts. First, its capital spending ranks third (after Texas and Oklahoma) and will have a strong impact on construction, well services, and related sectors. Second, California's diverse economic base will support intrastate oil activity and give it an edge in competing to provide information technology, professional services, and machinery and equipment to other states. While Midwestern states, including Ohio and Illinois, are among major producing states with strong supply chains that provide materials, machinery, equipment, and professional services, Washington, with its diversified industrial base and information technology, is heavily linked to oil and gas drilling and extraction. These second tier states will benefit from the removal of the crude oil export ban.

Top-10 employment contributions: US crude oil export supply chain – Potential Production*
(number of workers, difference free trade vs. restricted trade)

	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Supply chain employment contribution							
California	12,678	39,430	57,338	52,765	47,314	23,072	29,349
Texas	17,185	36,562	40,599	37,187	35,087	22,179	25,894
Illinois	10,716	22,667	26,909	24,138	20,969	9,444	13,323
New York	7,414	18,725	24,605	24,222	21,613	10,853	13,674
Florida	6,341	16,423	22,481	23,840	22,279	12,308	14,296
Ohio	5,673	11,996	13,601	12,081	10,778	4,946	6,906
Pennsylvania	5,725	11,884	13,251	11,851	10,444	4,402	6,478
Michigan	5,415	11,227	13,256	11,926	10,339	4,370	6,391
Georgia	4,388	10,220	13,271	12,849	11,479	6,181	7,601
Washington	4,104	10,027	12,903	12,673	11,488	6,414	7,689
Top-10 total	**79,639**	**189,161**	**238,215**	**223,531**	**201,791**	**104,170**	**131,602**
US total	**149,521**	**351,675**	**439,578**	**414,198**	**371,202**	**187,413**	**240,020**
Total crude oil export employment contribution**							
California	46,940	134,880	189,380	188,880	164,210	81,466	102,597
Texas	50,500	103,200	119,800	113,200	105,700	72,879	81,413
Illinois	25,370	53,240	64,770	60,500	53,550	26,953	35,131
New York	25,410	61,390	80,910	79,230	70,130	35,413	44,747
Florida	33,880	78,840	103,160	101,480	91,620	48,847	59,830
Ohio	21,200	46,730	58,600	55,610	49,290	24,025	31,445
Pennsylvania	19,300	43,890	55,780	53,570	47,260	21,934	29,276
Michigan	20,380	41,720	49,910	45,620	39,760	16,789	24,352
Georgia	19,740	46,020	59,620	58,210	52,200	27,811	34,260
Washington	9,120	22,150	28,730	28,390	25,590	14,305	17,135
Top-10 total	**271,840**	**632,060**	**810,660**	**784,690**	**699,310**	**370,422**	**460,185**
US total	**521,500**	**1,206,160**	**1,536,730**	**1,483,210**	**1,320,000**	**681,645**	**858,932**
Total state employment**							
California	16,096,504	16,342,006	16,541,530	16,713,653	16,894,796	17,594,008	17,235,238
Texas	12,163,160	12,407,719	12,620,211	12,821,439	13,032,535	13,931,590	13,490,731
Illinois	5,973,287	6,033,050	6,072,485	6,109,673	6,147,849	6,251,120	6,189,836
New York	9,226,393	9,297,202	9,332,432	9,355,131	9,387,961	9,509,108	9,446,013
Florida	8,157,384	8,314,869	8,432,205	8,539,724	8,655,498	9,170,261	8,920,153
Ohio	5,419,442	5,462,497	5,483,118	5,499,387	5,524,574	5,599,340	5,558,828
Pennsylvania	5,924,842	5,977,881	6,007,078	6,031,570	6,067,636	6,149,923	6,100,549
Michigan	4,225,864	4,256,515	4,274,943	4,289,212	4,306,502	4,361,901	4,331,470
Georgia	4,291,497	4,360,412	4,417,294	4,469,430	4,528,697	4,731,135	4,625,245
Washington	3,154,481	3,191,911	3,217,228	3,241,311	3,272,379	3,362,995	3,313,818
Top-10 total	**74,632,853**	**75,644,062**	**76,398,524**	**77,070,530**	**77,818,428**	**80,661,380**	**79,211,881**
US total	**143,787,425**	**145,272,475**	**147,731,000**	**150,800,050**	**153,014,100**	**156,645,980**	**153,804,323**

*The rank for all years is based on the 2017 ranking.

** Data are from the *US Crude Export Decision* report

*** Data are from the IHS US Regional Service forecast, November 2014

Source: IHS Economics

Labor income

Employment growth will also drive growth in labor income, amplifying consumer spending. In the Base Production Case, US crude oil supply chain activities will contribute nearly $22 billion in additional labor income per year between 2016 and 2030. Under a free trade policy, California has the most jobs in the crude oil supply chain sector, and it will enjoy the largest growth in labor income. Labor income under free trade is expected to increase from about $2.2 billion in 2016 to over $4.2 billion in 2020. Despite limited crude oil production activities, Massachusetts, Pennsylvania, and Washington will experience growing impacts related to labor income over the 2016-30 period, a function of their high-paying financial, professional services, and technology jobs.

As a consequence of the state employment impact, IHS expects labor income and value added to GDP to also exhibit similar rankings across states. However, due to varying wage rates across industries and across regions, some expected shifts are apparent in the state rankings.

Top-10 labor income contributions: US crude oil export supply chain – Base Production*
($millions, real 2009, difference free trade vs. restricted trade)

	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Supply chain labor income contribution							
California	2,242	5,327	5,711	4,627	4,270	2,773	3,327
Texas	1,641	3,769	3,921	3,410	2,966	1,782	2,235
New York	1,076	2,235	2,153	1,901	1,842	1,861	1,854
Illinois	1,118	2,190	2,101	1,812	1,650	1,233	1,413
Florida	723	1,474	1,506	1,378	1,285	814	967
Ohio	677	1,228	1,045	834	789	557	677
Massachusetts	498	1,125	1,149	1,012	928	621	728
Pennsylvania	567	1,068	893	722	663	410	534
Washington	500	1,028	1,041	923	877	721	772
Maryland	449	881	864	746	678	422	523
Top-10 total	**9,489**	**20,325**	**20,385**	**17,365**	**15,948**	**11,194**	**13,030**
US total	**16,171**	**34,029**	**34,030**	**29,298**	**26,745**	**18,301**	**21,552**
Total crude oil export labor income contribution**							
California	5,378	11,820	12,429	11,050	9,848	6,554	7,737
Texas	5,739	11,932	12,716	11,262	9,440	6,081	7,460
New York	2,950	5,934	5,820	5,194	4,997	5,113	5,068
Illinois	1,942	3,724	3,635	3,147	2,886	2,273	2,538
Florida	2,331	4,520	4,563	4,064	3,718	2,314	2,822
Ohio	1,446	2,671	2,495	2,127	1,995	1,509	1,722
Massachusetts	1,075	2,412	2,450	2,147	1,956	1,303	1,538
Pennsylvania	1,511	2,882	2,705	2,316	2,170	1,475	1,756
Michigan	1,353	2,430	2,256	1,874	1,680	1,180	1,426
Washington	926	1,896	1,936	1,749	1,650	1,349	1,443
Top-10 total	**24,650**	**50,221**	**51,006**	**44,931**	**40,341**	**29,151**	**33,511**
US total	**43,554**	**88,160**	**89,322**	**78,481**	**70,434**	**48,650**	**57,097**

*The rank for all years is based on the 2017 ranking.

** Data are from the *US Crude Export Decision* report

Source: IHS Economics

Top-10 labor income contributions: US crude oil export supply chain – Potential Production*
($millions, real 2009, difference free trade vs. restricted trade)

	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Supply chain labor income contribution							
Texas	2,920	6,930	7,940	7,336	7,000	5,171	5,589
California	2,168	5,872	7,098	6,162	6,055	4,823	5,039
New York	1,316	3,203	3,489	3,229	3,233	3,518	3,310
Illinois	1,342	2,978	3,261	2,912	2,776	2,299	2,417
Florida	903	2,173	2,491	2,398	2,368	1,820	1,902
Massachusetts	634	1,622	1,839	1,709	1,655	1,296	1,361
Washington	618	1,482	1,665	1,576	1,567	1,477	1,446
Pennsylvania	708	1,425	1,338	1,127	1,101	763	889
Ohio	643	1,307	1,275	1,078	1,061	857	929
Maryland	562	1,261	1,380	1,261	1,210	878	964
Top-10 total	**11,815**	**28,253**	**31,775**	**28,789**	**28,027**	**22,902**	**23,845**
US total	**20,208**	**47,340**	**52,874**	**48,107**	**46,578**	**36,988**	**38,999**
Total crude oil export labor income contribution**							
Texas	7,758	17,577	21,175	20,290	19,166	15,589	16,124
California	6,835	17,054	19,859	18,728	17,859	14,568	15,067
New York	3,736	8,821	9,692	9,027	9,016	9,926	9,303
Illinois	2,472	5,492	6,074	5,560	5,350	4,791	4,857
Florida	2,972	6,804	7,659	7,171	6,989	5,278	5,625
Massachusetts	1,402	3,557	4,014	3,720	3,582	2,796	2,949
Washington	1,181	2,813	3,185	3,033	3,003	2,832	2,769
Ohio	1,832	3,872	4,143	3,731	3,656	3,188	3,274
Michigan	1,683	3,456	3,672	3,246	3,109	2,511	2,685
Pennsylvania	1,920	4,214	4,479	4,041	3,959	3,092	3,302
Top-10 total	**31,792**	**73,660**	**83,952**	**78,549**	**75,688**	**64,570**	**65,956**
US total	**55,918**	**128,607**	**145,917**	**136,170**	**130,935**	**107,351**	**111,404**

*The rank for all years is based on the 2017 ranking.

** Data are from the *US Crude Export Decision* report

Source: IHS Economics

In each of the 10 states ranked highest for their contributions to labor income, their contributions under the Potential Production Case are about two times higher than in the Base Production Case over the 2016-30 period.

Illinois poised to benefit from oil and gas production

Based on new assessments of the New Albany Shale play and the potential for higher investment in a free trade scenario, Illinois is now considered a major producing state, with an annual average of more than 10,000 barrels per day of crude oil production. While production is all conventional, the IHS study assumes unconventional production emerges in Illinois in the 2016–2020 timeframe.

The economic benefits as unconventional drilling expands throughout the country can clearly be seen in Illinois' economy and throughout its multitude of supply-chain industries. The impacts are most noticeable in durable manufacturing, including construction and mining machinery, machine tools and engines and frac sand, as well as in wholesale trade and professional and financial services.

Illinois' diversified economy has the smallest concentration of manufacturing jobs—10% of Illinois' non-farm employment—among states in the East North Central. In fact, the state boasts the most diverse mix of industries in the region, including machinery manufacturing, which contributes to the unconventional supply chain throughout the country.

Chicago has a strong presence in fabricated metals, printing and publishing, food processing, chemicals, and rubber and plastics. These sectors don't necessarily contribute to the supply chain of the crude oil sector, but they do benefit from increased supply of oil and gas for fuel and feedstock.

Outside the Chicago metro area, Illinois' economic structure is dramatically different, with farming and food processing dominating the southern part of the state, and transportation and distribution centers served by the Mississippi River in the west. However, LaSalle County, which is 80 miles southwest of Chicago, is home to many sand mines, a valuable input into the hydraulic fracturing process. In recent years, companies such as U.S. Silica and Mississippi Sand have expanded operations and increased production to meet increased demand from the oil and gas boom.

With its diverse economic landscape, Illinois is well situated to reap many of the direct and indirect benefits of unconventional oil and gas extraction. The state has already experienced gains in terms of jobs and higher incomes as a result of supplying manufactured goods and services throughout the country—a trend that will continue as unconventional production develops in the state in the near term.

Government revenue

Sustained investment in US crude oil development has helped lift state economies and tax receipts since it began in earnest over the past decade. In response, many states have adjusted their economic development strategies to capitalize on growth opportunities associated with upstream, midstream, and downstream infrastructure. In this analysis of government tax receipts, the federal and state corporate and personal income taxes are combined to reflect the state-level tax impacts in each state. While major oil-producing states such as California and Texas will lead the way, the supply-chain industries in states lacking oil production such as Massachusetts and Maryland will experience even higher rates of growth in government revenues. In the Base Production Case, both Massachusetts and Maryland will see the impact from the move to free trade on total government revenue more than double in four years, 2016-. In the Potential Production Case, the impact from the move to free trade on total government revenue more than triples in that time.

State-level government revenue: US crude oil export supply chain*
($millions, nominal, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 total	2016-30 total
Base Production Case							
California	897	2,914	3,484	2,682	2,275	59,700	71,952
Texas	615	1,556	1,596	1,252	991	21,955	27,965
New York	464	1,286	1,436	1,211	1,072	31,555	37,024
Illinois	559	1,266	1,264	1,024	869	22,428	27,411
Ohio	334	730	680	516	440	10,827	13,527
Florida	264	621	677	594	501	14,332	16,987
Massachusetts	200	588	695	601	517	15,222	17,822
Pennsylvania	237	564	537	427	366	9,431	11,562
Maryland	178	497	563	479	414	12,483	14,614
Arizona	182	482	524	440	373	10,557	12,558
Top-10 total	**3,930**	**10,504**	**11,455**	**9,226**	**7,818**	**208,490**	**251,423**
US crude oil export supply chain total	**7,100**	**18,378**	**19,814**	**16,146**	**13,612**	**353,666**	**428,717**
US crude oil export total	**28,888**	**55,769**	**58,188**	**48,891**	**42,124**	**1,077,224**	**1,311,085**
Supply chain share of crude oil export total	**24.6%**	**33.0%**	**34.1%**	**33.0%**	**32.3%**	**32.8%**	**32.7%**
Potential Production Case							
California	950	3,347	4,668	4,102	3,719	108,895	125,680
Texas	1,090	2,384	2,493	2,143	1,998	55,715	65,822
New York	716	2,012	2,527	2,395	2,209	71,667	81,526
Illinois	792	1,812	2,090	1,842	1,658	46,284	54,478
Florida	415	1,029	1,288	1,223	1,097	32,353	37,404
Massachusetts	315	941	1,234	1,185	1,075	34,278	39,028
Pennsylvania	396	895	956	829	743	19,295	23,114
Ohio	374	848	917	780	698	18,554	22,171
Maryland	281	807	1,027	975	877	28,508	32,476
Virginia	248	693	859	782	684	20,881	24,148
Top-10 total	**5,576**	**14,768**	**18,057**	**16,256**	**14,759**	**436,431**	**505,847**
US crude oil export supply chain total	**10,066**	**25,754**	**31,053**	**28,112**	**25,463**	**747,990**	**868,438**
US crude oil export total	**41,535**	**83,682**	**97,373**	**89,015**	**81,541**	**2,410,900**	**2,804,045**
Supply chain share of crude oil export total	**24.2%**	**30.8%**	**31.9%**	**31.6%**	**31.2%**	**31.0%**	**31.0%**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Economic contribution by core industry groups within states

The crude oil supply chain is a complex and extensive group of industries permeating many sectors of the US economy. As previously stated, the 60 NAICS-based supply chain industries were broadly assigned to the following six core industry groups:

- Industrial equipment and machinery
- Construction and well services
- Information technology
- Logistics
- Materials
- Professional, financial, and other services

Construction and well services

Construction activity within the energy value chain has been one of the brightest areas of growth in the broader US construction market, particularly as the residential and commercial construction sectors have recovered slowly from the lingering effects of the Great Recession. Upstream site preparation and rigging and midstream pipeline development and capacity additions to downstream processing are stimulating robust demand for the skilled labor and materials required to build out the US energy infrastructure. Moreover, the US chemical manufacturing industry, reinvigorated by low-cost feedstocks produced in the unconventional oil and natural gas boom, continues to invest and upgrade manufacturing facilities throughout the United States.

The construction sector is among the first to benefit from new capital spending by oil and gas operators that must put the infrastructure in place before extraction activity can commence. As such, many economic impacts related to construction activity are front-loaded since once the infrastructure is built; future investment is generally limited to maintenance or retrofit.

In oil-producing states, growth in crude oil-related construction spending is limited to the construction required for oil exploration and production. Certain sectors within the construction industry are expected to decline in 2016-30 as they come off of peak development of midstream and downstream infrastructure; this includes the Construction of New Nonresidential Manufacturing Structures sector (part of NAICS 23—construction of pipelines, rail, marine structures, storage facilities, LNG export facilities, and manufacturing structures). However, most upstream construction activities that create demand within the US crude oil supply chain are expected to continue to grow steadily in oil-producing states, as upstream investment continues under a free trade policy. Value added in Construction of Other New Nonresidential Structures (another part of NAICS 23—construction of upstream facilities and structures) is forecast to grow throughout the 2016-30 period in both crude oil production cases.

Value added: US crude oil export supply chain – Support Activities for Oil and Gas Operations Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
California	317	710	754	541	508	324	405
Texas	263	543	562	482	412	235	307
Ohio	110	190	167	137	131	95	113
Oklahoma	82	152	148	123	99	37	65
Kentucky	70	136	126	113	103	68	82
Indiana	62	106	97	81	73	50	61
Kansas	49	97	94	77	64	38	50
Utah	42	88	87	71	64	38	49
Colorado	37	79	80	67	59	46	52
Louisiana	30	77	80	76	72	62	64
Top-10 total	**1,061**	**2,177**	**2,194**	**1,767**	**1,585**	**991**	**1,246**
US total	**1,243**	**2,515**	**2,521**	**2,038**	**1,819**	**1,134**	**1,432**
Potential Production Case							
Texas	410	877	994	919	874	593	667
California	335	758	924	710	705	543	591
Pennsylvania	140	222	204	171	169	116	138
Ohio	125	215	215	187	188	155	165
Kentucky	96	174	169	135	125	81	100
Oklahoma	88	174	193	172	152	72	100
Indiana	86	147	149	123	114	80	95
Kansas	63	118	121	102	92	61	74
Utah	56	113	120	100	93	61	73
Illinois	56	100	107	93	89	80	83
Top-10 total	**1,455**	**2,899**	**3,197**	**2,712**	**2,601**	**1,841**	**2,085**
US total	**1,685.7**	**3,358.2**	**3,688.1**	**3,132.8**	**2,985.3**	**2,109.6**	**2,396.4**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Support Activities for Oil and Gas Operations (NAICS 213112), which include exploration services, excavating, and services related to well surveying, preparation, and clean-up, are expected to grow even more rapidly than construction activities. Support activities in California, Texas, and Ohio are among the largest beneficiaries of the free trade policy in both production cases, an obvious function of the fact these states are home to some of the nation's largest oil producers.

Value added: US crude oil export supply chain – Drilling Oil and Gas Wells Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
California	191	437	471	334	317	204	253
Texas	150	319	332	286	246	139	182
Pennsylvania	71	127	96	70	65	37	53
Ohio	63	109	91	71	69	48	59
Kentucky	45	88	83	76	69	46	55
Oklahoma	46	86	84	70	57	21	37
Illinois	37	67	63	53	49	39	44
Kansas	25	51	48	39	33	19	26
Colorado	22	49	50	41	37	28	32
Utah	22	47	47	38	34	20	26
Top-10 total	**673**	**1,382**	**1,362**	**1,079**	**976**	**602**	**766**
US total	**743**	**1,535**	**1,519**	**1,217**	**1,100**	**684**	**864**
Potential Production Case							
Texas	241	525	592	548	525	349	395
California	207	480	595	453	454	354	382
Pennsylvania	119	181	150	118	117	71	93
Ohio	75	127	120	100	101	79	88
Kentucky	63	116	112	88	81	50	64
Oklahoma	51	102	112	101	89	42	58
Illinois	54	98	105	91	87	76	80
Kansas	34	63	63	51	46	28	36
Utah	31	62	66	55	51	33	40
Colorado	29	62	65	55	52	40	44
Top-10 total	**903**	**1,815**	**1,980**	**1,660**	**1,605**	**1,122**	**1,279**
US total	**992**	**2,002**	**2,179**	**1,833**	**1,762**	**1,226**	**1,402**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Texas shale boom has major economic impact

Upstream oil and gas development in Texas is centered in the state's two largest shale plays: the Permian basin in West Texas and the Eagle Ford shale, spanning from south Texas through the eastern central part of the state. These plays have attracted billions of dollars in investment and are the state's largest economic development stories. Their impacts have also reverberated across many industries and counties in Texas. Employment has surged in the primary and fabricated metals and machinery manufacturing industries clustered within close proximity to the shale plays to meet energy sector demand for steel, fabricated pipes, pumps and turbines. There is also high demand for construction workers, transportation services, and engineers. Houston is a hub for energy services, boasting one of the highest concentrations of engineers in the country. The energy sector's presence is being increasingly felt in the state's other major metro areas too, including San Antonio and Austin, which have proximity to the Eagle Ford.

The state's energy supply chain will continue to experience immense growth in the coming years. NuStar Energy and Plains All American Pipelines have multi-year plans in place to expand their Texas pipeline capacity in the Eagle Ford shale and the Permian Basin, respectively. LyondellBasell will boost production of ethylene at its Corpus Christi plant and invest $400 million to increase its feedstock capacity by the end of 2015.

ExxonMobil Chemical Company is building an ethane cracker at its Baytown complex to provide ethylene feedstock for downstream chemical processing, including high-performance polyethylene lines at its Mont Belvieu plastics plant, which is also being expanded. Together, these projects represent a multibillion dollar investment that will support about 10,000 construction workers and add 350 permanent positions at the Baytown complex. It will also add long-term economic value to the region, with estimates of a roughly $870 million annual impact.[25]

Continued development in the energy sector will create new jobs, support strong wage growth, and create enormous wealth for the state. These impacts will be widely felt across the state and be a driving force behind Texas' enduring growth.

In Midwestern states such as Kentucky, Ohio, and Indiana—all with proximity to the New Albany and Utica Shale plays—the Construction of Other New Nonresidential Structures (part of NAICS 23) sector is estimated to benefit from the free trade policy in both production cases. Together, the top 10 states benefitting from this non-residential construction sector will contribute just over $1.0 billion each year on average to national GDP under the Base Production Case and more than $1.6 billion under the Potential Production Case between 2016 and 2030.

25 http://news.exxonmobil.com/press-release/exxonmobil-chemical-company-begins-multi-billion-dollar-expansion-project-baytown-texa

Value added: US crude oil export supply chain – Construction of Other New Nonresidential Structures Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
California	274	628	672	472	451	282	354
Texas	202	428	443	379	329	182	240
Kentucky	67	133	123	112	103	67	80
Ohio	73	126	106	84	82	56	69
Indiana	70	121	112	94	85	57	70
Oklahoma	59	112	108	90	73	26	47
Pennsylvania	57	102	78	59	55	31	44
Kansas	41	84	79	64	54	30	41
Utah	38	82	80	65	59	34	44
Illinois	44	80	75	63	57	45	51
Top-10 total	**926**	**1,897**	**1,877**	**1,482**	**1,347**	**810**	**1,042**
US total	**1,033**	**2,138**	**2,123**	**1,694**	**1,538**	**938**	**1,194**
Potential Production Case							
Texas	307	664	749	688	660	426	489
California	282	649	802	604	607	457	501
Kentucky	89	163	157	122	113	67	88
Indiana	95	163	166	136	127	86	103
Ohio	83	142	135	114	117	90	99
Pennsylvania	92	140	118	95	95	57	74
Oklahoma	62	124	137	122	108	49	69
Illinois	61	109	116	100	96	81	86
Utah	50	102	107	88	82	51	63
Kansas	52	98	97	78	71	42	55
Top-10 total	**1,173**	**2,354**	**2,583**	**2,148**	**2,075**	**1,407**	**1,627**
US total	**1,300**	**2,628**	**2,874**	**2,398**	**2,304**	**1,560**	**1,807**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Industrial equipment and machinery

The US crude oil export supply chain for industrial equipment and machinery generates economic activity and value across all oil-producing states, and the ripple effects extend to many other industries in oil-producing and non-oil producing states. Industrial equipment and machinery companies require sophisticated and specialized tools and automated process control systems, as well as high-performance machinery capable of withstanding harsh environments. The supplier sector experiencing the most growth in the industrial equipment and machinery core group will be Construction, Mining and Agriculture Machinery Manufacturing (NAICS 3331).

Steady increases in their business due to growth in the oil and gas sector have prompted equipment manufacturers to dedicate more resources to growing their market share within the upstream production sector, awakening a market that had been in a 40-year decline. The growth in capital spending in the energy value chain also partly explains why some domestic equipment manufacturers to repatriate manufacturing back to the United States from lower-cost countries. Moreover, non-US producers of capital goods cite the booming US energy market as a reason to expand their operations in the United States.

Firms throughout the Midwest states support equipment manufacturing largely through an integrated network of suppliers clustered around capital goods activity. Ohio, Indiana, Wisconsin and Michigan, where manufacturing employment represents 15% to 20% of total state employment, are centers for making the raw materials (steel), components (gearing, electronics) and finished goods (compressors, earth-moving equipment) deployed at oil production sites. While the nameplate original equipment manufacturer is the most visible supplier to any well site, hundreds of suppliers that contributed to the finished piece of equipment are invisible beneficiaries of the energy value chain.

Within the industrial equipment and machinery core group, the Construction, Mining and Agriculture Machinery Manufacturing sector makes the largest single sector contribution to the growth in state value added under the free trade of crude oil. The top 10 states in this sector –five of them in the Midwest— are expected to contribute an additional $1.2 billion per year to GDP between 2016 and 2030 under a free trade policy in the Base Production Case. Due to the high concentration of off-highway machinery production in the Midwest, the 10 states together account for over 99% of the total GDP growth resulting from free trade. Similarly in the Potential Production Case, this sector in these 10 states is expected to contribute an additional $2.5 billion per year to GDP from 2016-30. Illinois, Missouri, Texas, and Wisconsin are expected to be the biggest beneficiaries of free trade in both production cases.

Value added: US crude oil export supply chain – Construction, Mining, and Agriculture Machinery Manufacturing Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
Illinois	464	839	791	673	611	470	539
Texas	125	268	274	230	204	133	162
Missouri	140	252	243	199	177	75	117
Wisconsin	105	199	195	179	165	100	122
Minnesota	99	169	150	124	109	74	93
Pennsylvania	92	144	99	69	58	27	48
Washington	68	125	124	109	101	91	96
Oklahoma	30	57	55	45	36	13	24
Virginia	18	37	39	36	33	20	24
Indiana	4	8	8	7	7	5	6
Top-10 total	**1,146**	**2,098**	**1,980**	**1,670**	**1,500**	**1,007**	**1,231**
US total	**1,158**	**2,120**	**2,002**	**1,686**	**1,515**	**1,015**	**1,242**
Potential Production Case							
Illinois	689	1,242	1,348	1,180	1,122	944	1,001
Wisconsin	249	443	500	487	491	356	382
Texas	190	415	458	421	411	311	334
Missouri	219	395	415	366	345	183	238
Washington	111	208	228	217	212	218	210
Minnesota	129	205	229	188	174	121	143
Pennsylvania	128	179	145	110	103	54	80
Oklahoma	36	74	81	70	62	28	41
Virginia	26	53	63	61	60	45	48
Indiana	7	12	13	11	11	8	9
Top-10 total	**1,784**	**3,227**	**3,480**	**3,110**	**2,992**	**2,269**	**2,485**
US total	**1,797**	**3,253**	**3,508**	**3,133**	**3,014**	**2,283**	**2,502**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

The second largest supply chain sector in the industrial equipment core group is Cutting and Machine Tool Manufacturing (NAICS 333515). An indispensable part of the supply chain, these companies transform essential metals and materials into the machinery and equipment used in the energy value chain. Under the Base Production Case, the top 10 states in the machine tool sector will add $1.4 billion more output annually in under free trade than under the current restricted trade between 2016 and 2030. Under the Potential Production Case, the top 10 states will add $2.6 billion in annual output over the same period. The top 10 states for Cutting and Machine Tool Manufacturing that will benefit are primarily located in the Midwest, with Michigan ranked first.

Value added: US crude oil export supply chain – Cutting and Machine Tool Manufacturing Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
Michigan	359	614	576	488	439	310	371
New York	201	410	446	448	458	522	478
Illinois	224	400	364	296	265	189	229
Colorado	87	190	197	176	155	114	130
Missouri	86	144	137	120	105	44	69
Wisconsin	57	95	82	69	60	31	45
New Jersey	39	76	81	77	74	53	59
Ohio	46	70	51	35	32	19	28
Indiana	18	31	28	24	22	16	19
Iowa	15	24	21	18	17	18	18
Top-10 total	**1,132**	**2,053**	**1,984**	**1,750**	**1,626**	**1,315**	**1,446**
US total	**1,143**	**2,075**	**2,006**	**1,770**	**1,643**	**1,325**	**1,459**
Potential Production Case							
Michigan	508	893	946	838	799	620	679
New York	329	669	801	832	877	1,071	948
Illinois	304	532	560	466	433	334	376
Colorado	112	240	264	241	226	170	186
Missouri	126	216	243	219	209	107	139
Wisconsin	70	105	120	98	91	51	66
New Jersey	49	95	113	112	112	92	94
Ohio	49	75	63	47	44	30	39
Indiana	24	40	41	35	32	23	27
Iowa	19	29	30	26	25	26	26
Top-10 total	**1,589**	**2,894**	**3,180**	**2,914**	**2,851**	**2,525**	**2,578**
US total	**1,603**	**2,919**	**3,207**	**2,936**	**2,871**	**2,538**	**2,594**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Colorado is branching out from its energy base

Colorado is well-situated to serve as a supplier for the crude oil sector. The northeastern corner of the state sits atop much of the Niobrara Shale basin. Colorado already had a rich history in mineral and petroleum extraction industries, which have thrived in recent years due to the rise in global energy prices. The state has also been very successful at branching out from its energy roots, and today it has one of the most diverse state economies in the country. Especially notable are the service industries in the Denver area that provide substantial support for Colorado's oil and gas boom. Given its history, Colorado has proved capable of ramping up production of oil and natural gas and getting product to end-users.

The majority of activity at the Niobrara Shale basin resides in Weld County. The Niobrara Shale basin area is expected to produce a large amount of oil and economic activity. Production and development started in 2007, and the economy of Weld County is showing tremendous growth. The labor market in Weld County is tightening, with unemployment reaching record lows and labor shortages being reported for non-energy jobs. Drilling, construction, materials and transportation jobs are all in high demand and are pushing up wages in the region. Companies from other regions are not only moving in to drill but also to support the supply chain. Halliburton, for example, has expanded its Colorado operations and hired 500 employees for a sand terminal to serve energy production demand, while A&W Water Service Inc., a Colorado company serving the oil and gas industry, has also shown significant growth from the drilling boom in the state.

The following is an excerpt from an article on Colorado Public Radio's website:[26]

> A&W Water Service in Fort Lupton, Colo., transports a lot of water through the oil fields -- more than 23,000 gallons a minute, around the clock. The company, a subsidiary of publicly traded Superior Energy Services, is the largest water transport business in the state.
>
> Gary Wright, president of A&W Water, says his family started the company in 1954. Business has ebbed and flowed over the years, he says, but today the company is at an all-time high. Wright says it has tripled in size over the last three years; today it employs 593 people—and is still hiring.
>
> Wright says the company's growth is good for the economy. In the last five years, A&W has spent $50 million on equipment alone. "So that creates jobs for manufacturing, the diesel fuel people that supply our fuel to us, the restaurants that the people go to and eat. Simple as something as work boots," Wright says.

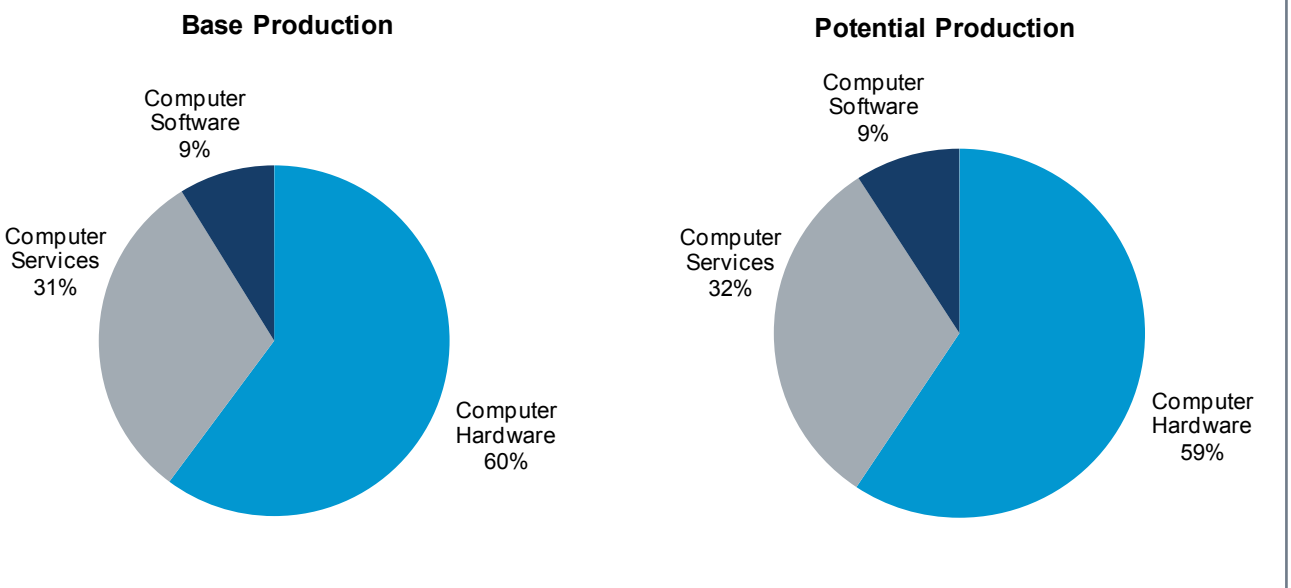
Denver—situated in the neighboring county—is also a linchpin in Colorado's oil and gas boom. The state has over 50,000 active wells, and the Denver metropolitan area employs a significant portion of all oil and gas jobs in the state due to its proximity to the drilling activity and its status as a regional business hub. Many of the jobs are in managerial, administrative, engineering, financial, and insurance companies that plan, develop and support field operations in oil and gas producing areas such as Weld County. Some of the nation's highest-earning oil and gas companies are headquartered in Denver, including DCP Midstream, QEP Resources, Whiting Petroleum, Cimarex Energy, SM Energy and MarkWest Energy. As new workers move into downtown Denver, higher occupancy rates and rising rents for commercial and residential properties are attracting investors. New commercial developments are being built outside of the city to help service rising demand. In addition, conference and meeting activity for these firms is a boon to the city's hospitality industry, with hotel and accommodation services adding new jobs as their vacancy rates shrink.

26 http://www.cpr.org/news/story/drilling-oil-and-gas-drives-colo-trucking-boom

Information technology

The information technology (IT) category includes three supply chain sectors: Computer Hardware (NAICS 3341), Computer Software (NAICS 5112), and Computer Services (NAICS 5415). Computer Hardware includes servers, personal computers and laptops, is the IT sector that will benefit most from the free trade policy under both production cases. In the Base Production Case, for example, computer hardware will account for 60% of the total IT impact under the free trade scenario. In the Potential Production Case, the figure is 59%. Washington, Massachusetts, and California, which have strong technology sectors, benefit from the US crude exports, adding more than $1.6 billion to US GDP on average each year between 2016 and 2030 under the Potential Production Case.

Information technology core group: Value added share by sector
(2016–30 average, difference free trade vs. restricted trade)



Source: IHS

Value added: US crude oil export supply chain – Computer Hardware Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
Washington	325	619	625	544	522	419	455
Massachusetts	230	447	465	417	390	262	305
California	84	200	231	180	178	109	131
Texas	39	85	90	79	72	42	52
New York	43	77	70	56	53	48	52
Illinois	33	63	64	58	55	41	45
Oregon	19	36	37	33	31	30	31
Florida	11	22	22	21	20	13	15
Colorado	9	20	22	20	19	14	16
Pennsylvania	10	17	13	10	9	5	7
Top-10 total	**801**	**1,586**	**1,638**	**1,418**	**1,351**	**983**	**1,108**
US total	**830**	**1,637**	**1,688**	**1,460**	**1,391**	**1,009**	**1,140**
Potential Production Case							
Washington	478	912	1,023	969	972	883	879
Massachusetts	346	676	782	739	730	574	601
California	93	223	301	250	261	191	202
Texas	54	119	138	129	128	85	95
New York	58	105	109	92	91	88	89
Illinois	49	95	108	103	104	86	88
Oregon	28	53	61	57	56	62	59
Florida	16	33	39	39	39	30	31
Colorado	11	25	29	27	28	22	23
Pennsylvania	12	19	16	13	14	8	10
Top-10 total	**1,146**	**2,261**	**2,604**	**2,419**	**2,424**	**2,031**	**2,077**
US total	**1,177**	**2,317**	**2,665**	**2,473**	**2,476**	**2,068**	**2,119**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Logistics

The logistics core group has four supply chain sectors: General Freight Trucking (NAICS 4841), Pipeline Transportation (NAICS 486), Rail Transportation (NAICS 4821), and Water Transportation (NAICS 481). States with oil production account for more than 80% of the total increase in economic benefits to GDP from logistics under a free trade policy. However, states without oil production are more dynamic—their value added contribution from logistics increased at a higher annual rate than the states with oil production.

Within logistics, the largest beneficiaries in every state of a change in US crude oil export policy will be companies involved in General Freight Trucking. This sector will continue to experience steady growth throughout the 2016-30 period. Major oil-producing states, especially Texas and California, will continue to drive this sector. But other states with General Freight Trucking sectors that will benefit from the free trade policy include North Carolina, Ohio, Illinois, and Pennsylvania. Nationwide, trucking's supply chain will bring over $500 million more, on average, each year to US GDP under the Base Production Case and almost $1 billion more under the Potential Production Case throughout the forecast period if the export ban is lifted.

Value added: US crude oil export supply chain – General Freight Trucking Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
California	49	112	123	92	87	57	69
Texas	43	89	93	81	71	42	53
North Carolina	31	55	55	49	45	25	32
Ohio	32	53	45	36	34	24	30
Illinois	25	45	43	37	34	27	30
Pennsylvania	26	44	35	27	25	15	20
Michigan	17	28	26	22	20	14	17
Oregon	12	23	23	21	19	19	19
Virginia	12	22	22	19	17	10	13
Indiana	13	22	21	18	16	11	14
Top-10 total	**258**	**493**	**488**	**402**	**370**	**244**	**297**
US total	**434**	**829**	**824**	**697**	**637**	**427**	**512**
Potential Production Case							
Texas	67	146	167	156	150	108	118
California	56	130	165	132	131	104	110
North Carolina	45	83	93	87	85	60	66
Illinois	37	67	74	66	64	55	57
Ohio	36	61	60	50	50	40	44
Pennsylvania	35	55	49	40	39	26	32
Michigan	23	41	43	38	36	28	31
Virginia	18	34	38	35	33	24	27
Oregon	17	33	38	35	34	36	35
Indiana	19	33	34	29	28	20	23
Top-10 total	**354**	**683**	**761**	**668**	**650**	**502**	**542**
US total	**604**	**1,153**	**1,282**	**1,140**	**1,104**	**856**	**923**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Materials

The materials core group includes manufacturers and suppliers of various raw material products such as iron and steel, non-ferrous metals, sand, gravel, cement, industrial gas, chemicals, and fabricated metals. Materials production output in the crude oil supply chain is expected to grow steadily throughout the 2016-30 period, with larger growth rates occurring in non-oil-producing states but with higher levels of value added contributions in the oil-producing states. Within materials, the largest value added contribution to GDP growth will come from the Construction Sand and Gravel Mining (NAICS 212321) sector. Other top-ranked sectors include Industrial Gas Manufacturing (NAICS 325120), used both in construction and in manufactured capital goods, and Cement Manufacturing (NAICS 327310).

The Construction Sand and Gravel Mining sector benefits both producing and non-producing states—but Minnesota, Illinois, and Wisconsin are the largest beneficiaries of a change in crude oil export policy. The top 10 state to benefit in this sector comprise about 97% of the total supply chain impact, adding more than $1.3 billion on average each year to US GDP under the Base Production Case in 2016-30 and adding more than $2.0 billion under the Potential Production Case.

Value added: US crude oil export supply chain – Construction Sand and Gravel Mining Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
Minnesota	250	471	473	448	425	368	383
Illinois	218	401	398	361	323	222	261
Wisconsin	181	316	293	262	231	125	169
Texas	102	219	228	196	173	110	135
Iowa	132	214	196	174	167	174	175
Tennessee	64	137	106	125	130	72	86
Arkansas	45	91	96	91	77	36	51
Missouri	37	63	61	53	47	21	32
Ohio	39	60	44	30	27	17	25
California	14	32	35	25	24	16	19
Top-10 total	**1,083**	**2,005**	**1,928**	**1,764**	**1,624**	**1,161**	**1,334**
US total	**1,119**	**2,071**	**1,989**	**1,817**	**1,672**	**1,195**	**1,375**
Potential Production Case							
Minnesota	336	602	710	694	701	657	641
Illinois	276	511	582	538	509	384	417
Wisconsin	231	381	442	408	395	256	295
Texas	122	267	301	280	273	198	215
Iowa	142	232	254	229	228	246	237
Tennessee	148	185	161	170	192	109	130
Arkansas	48	86	85	69	60	25	40
Missouri	43	76	86	78	76	42	52
Ohio	34	53	44	32	31	22	28
Indiana	18	31	32	28	27	20	23
Top-10 total	**1,398**	**2,425**	**2,698**	**2,527**	**2,492**	**1,959**	**2,076**
US total	**1,432**	**2,491**	**2,771**	**2,586**	**2,550**	**2,002**	**2,123**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Demand for cement, which is an input to concrete, is expected to experience solid growth under a change in crude oil export policy. Concrete is a critical material used at oil and gas well production sites, particularly for encasing wells. It is also essential to the construction of loading terminals, storage facilities, and pipelines. Cement Manufacturing (NAICS 327310) in Maryland is the largest beneficiary of the free trade policy under both production cases, adding over $500 million annually to US GDP in the Base Production Case and almost $1 billion in the Potential Production Case.

Value added: US crude oil export supply chain – Cement Manufacturing Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
Maryland	457	842	827	714	649	404	502
Idaho	92	195	208	185	161	60	96
California	10	23	25	17	16	11	13
Oregon	9	16	17	15	14	14	14
Alabama	6	15	15	16	18	11	12
Washington	8	15	14	12	12	11	11
Texas	7	15	15	13	11	6	8
South Dakota	5	11	10	12	11	14	12
New York	4	8	9	8	8	10	9
Illinois	4	7	7	5	5	4	4
Top-10 total	**603**	**1,148**	**1,146**	**998**	**905**	**545**	**683**
US total	**624**	**1,188**	**1,182**	**1,030**	**936**	**579**	**716**
Potential Production Case							
Maryland	699	1,288	1,409	1,287	1,236	896	992
Idaho	145	297	346	328	305	154	197
California	11	25	30	23	23	18	20
Washington	13	24	26	24	24	25	24
Oregon	12	23	26	24	24	26	25
Texas	11	23	25	23	22	15	17
South Dakota	14	22	45	88	139	128	106
Alabama	9	22	25	31	35	29	28
New York	8	16	18	18	18	22	20
Illinois	6	10	10	9	8	7	7
Top-10 total	**926**	**1,748**	**1,960**	**1,853**	**1,835**	**1,320**	**1,435**
US total	**954**	**1,798**	**2,010**	**1,897**	**1,884**	**1,381**	**1,490**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Professional, financial, and other services

Professional, financial, and other services are typically associated with operational expenditures, but these services represent a wide range of functions including environmental engineering, occupational health and safety, and financial, insurance, and real estate services.

Professional, financial, and other services identified as part of the US crude oil export supply chain are expected to expand through 2030, especially in Finance (NAICS 52_ex_54) and Architectural, Engineering, and Related Services (NAICS 5413)—another indication of the significance of construction activity within the US crude oil export supply chain. Architectural, Engineering, and Related Services is the largest sector in the professional, financial, and other services core group of the US crude oil export supply chain. Under the Base Production Case, this sector in California, Georgia, and Texas alone will add about $480 million to US GDP, on average, each year in 2016-30, following a move from restricted to free trade. Under the Potential Production Case, the crude oil export policy will bring $910 million on average each year in Georgia, Arizona, and California.

Value added: US crude oil export supply chain – Architectural, Engineering, and Related Services Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
California	141	320	332	232	214	135	173
Georgia	164	304	295	285	257	134	176
Texas	114	210	215	195	182	107	132
Ohio	81	138	129	111	105	79	90
Pennsylvania	79	136	122	106	98	64	79
Illinois	66	114	112	90	84	66	75
Tennessee	64	105	115	85	67	20	42
New York	48	78	81	80	72	64	67
Virginia	35	61	65	63	53	26	36
Florida	39	60	59	50	42	25	33
Top-10 total	**830**	**1,527**	**1,525**	**1,296**	**1,172**	**720**	**904**
US total	**1,217**	**2,242**	**2,246**	**1,903**	**1,719**	**1,066**	**1,333**
Potential Production Case							
Georgia	229	425	453	447	433	287	324
Arizona	182	356	410	388	368	329	333
California	155	337	426	328	296	225	253
Texas	153	329	372	325	300	262	273
Tennessee	100	192	202	193	174	73	106
Illinois	89	169	171	150	141	131	136
Pennsylvania	94	156	157	138	135	101	113
Ohio	87	153	164	148	146	127	131
New York	71	116	135	138	127	120	119
Florida	56	90	96	82	75	53	62
Top-10 total	**1,217**	**2,323**	**2,586**	**2,336**	**2,195**	**1,708**	**1,849**
US total	**1,746**	**3,350**	**3,641**	**3,256**	**3,018**	**2,339**	**2,560**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Finance (NAICS 52_ex_524) is the second-largest sector within professional services. The financial sectors in California, Texas, and New York are expected to benefit most from a new crude oil export policy. Together, the top 10 states ranked in terms of their financial sector contributions will add more than $770 million each year to US GDP between 2016 and 2030 under the Base Production Case and more than $1.4 billion under the Potential Production Case.

Value added: US crude oil export supply chain – Finance Sector*
($millions, real 2009, difference free trade vs. restricted trade)

Top-10 states	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Base Production Case							
California	108	237	257	200	186	120	146
Texas	84	163	171	149	128	79	99
New York	85	150	146	128	123	125	126
North Carolina	75	134	134	119	111	61	79
Ohio	72	122	113	97	91	69	79
Illinois	63	111	107	93	86	69	77
Pennsylvania	53	91	82	69	64	42	52
Florida	52	90	90	78	71	43	54
Georgia	29	52	56	44	39	24	31
Connecticut	23	43	42	37	34	29	31
Top-10 total	**644**	**1,193**	**1,198**	**1,014**	**933**	**663**	**774**
US total	**984**	**1,819**	**1,821**	**1,561**	**1,426**	**995**	**1,171**
Potential Production Case							
California	123	273	339	282	277	219	232
Texas	126	265	309	289	274	209	224
New York	129	229	249	227	226	248	236
North Carolina	111	203	227	211	207	146	161
Illinois	91	164	183	167	161	148	149
Ohio	78	136	145	130	128	111	115
Florida	76	136	150	137	132	97	107
Pennsylvania	62	104	105	92	90	68	75
Georgia	45	85	101	88	83	65	70
Connecticut	35	64	71	65	64	61	61
Top-10 total	**877**	**1,658**	**1,878**	**1,689**	**1,642**	**1,372**	**1,431**
US total	**1,356**	**2,541**	**2,862**	**2,595**	**2,515**	**2,061**	**2,165**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

Congressional district supply chain assessment

Key insights

- The impact of a free trade policy will be distributed across suppliers in congressional districts with crude oil activity as well as adjacent districts with supporting supply chain sectors. The average annual value-added impact over 2016-30 in 25 congressional districts—or 6% of all congressional districts—ranges from $150 million to $540 million. While about one in three districts have average impacts ranging from $50 million to $150 million, the remaining districts' impacts are less than $50 million.
- Future investment and future expected production, along with mature crude oil supply chain sectors, make Texas' and California's congressional districts the leaders in total impact. However, impacts will be felt in clusters of congressional districts in Illinois, Florida, New York, and other states mainly due to presence of diversified manufacturing and services. In Massachusetts, the impact will be felt in its information technology and professional and financial services.

Introduction

This section presents examples of the supply chain impact of removing crude oil export restrictions under the Base and Potential Production cases on a congressional district level. A primary reason to assess the congressional district-level impact is to examine and quantify the geographic effects that can occur as the oil market and supply chain activity respond to the policy change.

The impact of moving from restricted trade to free trade is expected to be distributed across suppliers in multiple districts within and among states, regardless of whether crude oil resources are actually being extracted in any of these districts. IHS first identified and estimated the investment in all of the congressional districts that are either active or are expected to participate in producing legacy or new crude oil under the Base or Potential Production Cases. The reach of the industry's supply chain was then traced and quantified through other congressional districts that were impacted.

As with the national and state assessment, this section presents the economic contributions of the crude oil supplier industries as a result of a repeal of the US crude oil export ban. The impacts are summarized in this section for both the Base Production Case and Potential Production Case in terms of the benefits of free trade, compared with continuing under the current restricted trade. The following table shows only those congressional districts with crude oil production that can expect capital investments in the energy value chain under both Base and Potential Production cases.

Congressional districts by state with crude oil value chain activity

	Production	Upstream	Midstream Base	Midstream Potential	Downstream Base	Downstream Potential
Alabama	1, 2, 4, 7		1, 7			
Alaska	0	0				
Arizona	0			1, 3, 4		
Arkansas	4	1, 2, 4	1, 4	1		
California	3, 5, 6, 7, 8, 9, 13, 15, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 31, 35, 38, 39, 45, 47, 48	13, 15, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 3, 31, 35, 38, 39, 45, 47, 48, 5, 6, 7, 8, 9	21, 23, 44, 5, 51,	36, 42, 44, 45, 48, 5, 51		
Colorado	1, 2, 3, 4, 5, 6, 7	1, 2, 3, 4, 5, 6, 7	2, 4	4		
Delaware			0			
Florida	1, 17, 19, 20, 25		1			
Georgia			11			
Illinois	12, 13, 15, 18	12, 13, 15, 18	11, 12, 14, 15, 16, 17, 18, 3	11, 12, 14, 15, 16, 17, 18, 3		
Indiana	8	8	1, 2,	1, 2,		
Kansas	1, 2, 3, 4	1, 2, 3, 4	1, 3, 4	1, 3, 4		
Kentucky	1, 2,	1, 2	1	1		
Louisiana	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6		1, 2, 3, 4, 6
Michigan	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,	1, 10, 11, 12, 13, 14, 2, 3, 4, 5, 6, 7, 8, 9	10, 12, 3, 6, 7, 8	10, 3, 6, 7, 87, 8		
Minnesota			7, 83, 4, 5, 6, 8			
Mississippi	1, 2, 3, 4	3	2, 3	1, 2,		
Missouri				3, 4, 5, 6, 8		
Montana	0	0	0	0		
Nebraska	3		1, 3	1, 3		
Nevada	2, 4,					
New Jersey			1, 10, 6			
New Mexico	1, 2, 3	1, 2, 3	2	2		
New York	23, 27		20, 26			
North Dakota	0	0	0	0		
Ohio	2, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15, 16	13, 15, 16, 6, 7	10, 13, 6			
Oklahoma	1, 2, 3, 4, 5,	1, 2, 3, 4, 5	1, 2, 3, 4, 5,	1, 2, 3, 4, 5,		
Pennsylvania	3, 5, 9, 10, 11, 12, 14, 18	12, 14, 18, 3, 5, 9	1, 12, 5	1		
South Dakota	0		0	0		
Tennessee	7, 8,		8	8		
Texas	1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 34, 35, 36	1, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 34, 35, 36, 4, 5, 6, 8, 9	1, 10, 11, 12, 13, 14, 15, 17, 18, 19, 2, 21, 22, 23, 25, 27, 28, 29, 30, 31, 33, 34, 35, 36, 4, 5, 6, 7, 8, 9	1, 10, 11, 12, 13, 14, 15, 17, 18, 19, 2, 21, 22, 23, 25, 27, 28, 29, 30, 31, 34, 35, 36, 4, 5, 6, 7, 8, 9	13, 14, 16, 27, 29, 35, 36	1, 10, 11, 13, 14, 15, 16, 19, 23, 25, 27, 28, 29, 34, 35, 36
Utah	1, 2, 3, 4	1, 2, 3, 4	1, 2, 31	1, 2		
Virginia						
Washington			1, 2, 3, 6	2		
West Virginia	1, 2, 3, 7	1, 2, 3				
Wisconsin			2, 3, 7	2, 3, 7		
Wyoming	0	0	0	0		

Source: IHS Energy

Methodology

State-level results were linked to congressional districts using two internal IHS sources. First, the IHS Energy team provided assumptions at the district-level for drilling, production, and other exploration activities. Second, the IHS Economics team provided detailed sector-level economic activity, by congressional district, found in the proprietary IHS Business Market Insights dataset. As described below, types of impacts from the supply chain model—direct, indirect, and induced economic impacts—were linked and integrated from states to congressional districts separately.

Direct impacts at the congressional district level are a function of both the economic activity's location, as provided by IHS Energy, and the baseline economic activity in IHS Business Market Insights data. This process assigns the share of the impact to the district where the direct activity occurred, while crediting the residual shares to other districts within the state as a function of the location of the baseline activity. This logic allows for intrastate sourcing of direct activity but assumes a higher probability that supply chain activity (if available) will occur at the location of the direct activity.

Indirect and induced impacts are distributed to congressional districts as a function of baseline economic activity for each congressional district from IHS Business Market Insights. This logic allows for intrastate sourcing of indirect and induced activity based on the statewide distribution of supplier industries and income induced.

Finally, once all direct, indirect, and induced economic impacts were distributed to congressional districts, a final validation process was applied to ensure that economic activity in a given sector is not assigned to a district where that sector does not exist in the baseline. This logic was implemented to ensure that constraints in the location of skilled labor and capital were enforced.

Economic contribution results

The findings of the IHS study indicate that the impact on congressional districts' supply chains of removing the crude oil export ban will be similar to the national and state impacts. Congressional district impacts will be strong during the initial five years of the forecast period as investment and production ramps up, followed by a slower and flatter impact toward the end of the forecast horizon. Although growth moderates after the initial five years, the supply chain industries will continue to generate modest positive economic and employment impacts for all relevant congressional districts.

We present a summary of the supply chain economic impacts on congressional districts for two key dimensions: employment and value added contributions to GDP. The results are presented for states with the most impacted districts and for the top-ranked districts in each of the most heavily impacted states.

Employment

Removing the US crude oil export ban not only impacts the supply chain industries in congressional districts with crude oil activity through investment and production. It also affects adjacent districts that support this crude oil activity, including the related supply chain. Congressional districts with high levels of crude oil activity and concentrations of diversified supplier industries will benefit substantially. Examples include California's 23rd congressional district north of Los Angeles (which includes Kern County), Texas' 11th district around Midland, Texas' 18th district around Houston, and Oklahoma's 3rd district in the western part of the state—all of which will experience increases in employment of more than 800 workers per year during the 2016-30 period.

States with fewer congressional districts have a tendency to funnel the economic impact on one or two districts with a relatively large presence in the diversified supply chain industries. For example, much of the benefits flowing to Nevada (which has four districts) and Oregon (which has five districts) are

expected to primarily impact Nevada's 2nd district and Oregon's 3rd district where the supply chain sectors dominate.

Employment by congressional district: US crude oil export supply chain – Base Production*
(number of workers, difference free trade vs. restricted trade)

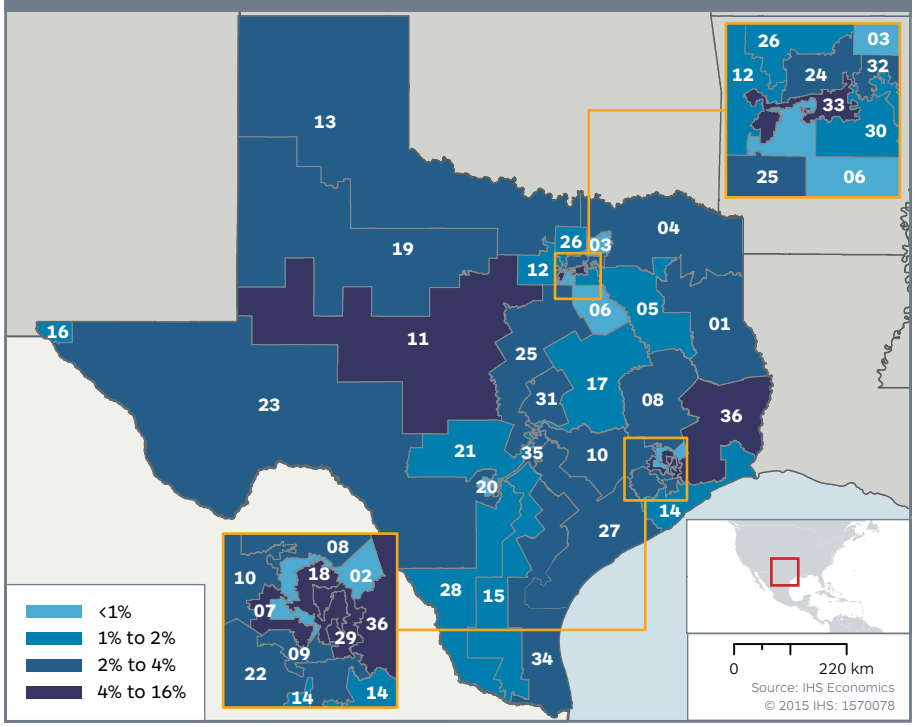
State	Congressional district	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
California	23	1,803	5,182	6,527	5,311	4,430	1,658	2,655
Illinois	8	1,322	2,746	2,959	2,595	2,106	690	1,242
Nevada	2	720	2,468	3,490	3,435	2,991	1,026	1,558
Oklahoma	3	1,006	2,283	2,589	2,250	1,774	489	986
New York	25	840	2,105	2,547	2,356	1,980	748	1,154
Texas	18	765	2,038	2,476	2,197	1,826	585	1,010
Illinois	16	980	2,015	2,170	1,906	1,504	476	889
Texas	11	661	1,782	2,170	1,941	1,594	507	881
Illinois	15	873	1,778	1,862	1,572	1,265	432	778
Oregon	3	740	1,767	2,121	1,934	1,567	511	882
Illinois	13	857	1,765	1,838	1,540	1,239	423	764
Oklahoma	5	784	1,749	1,967	1,702	1,338	365	746
Utah	1	715	1,744	2,043	1,756	1,422	460	819
North Carolina	12	773	1,653	1,934	1,769	1,488	496	839
Minnesota	7	680	1,593	1,904	1,828	1,515	570	881
US Total		**105,748**	**250,201**	**293,140**	**258,227**	**212,508**	**73,384**	**123,577**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

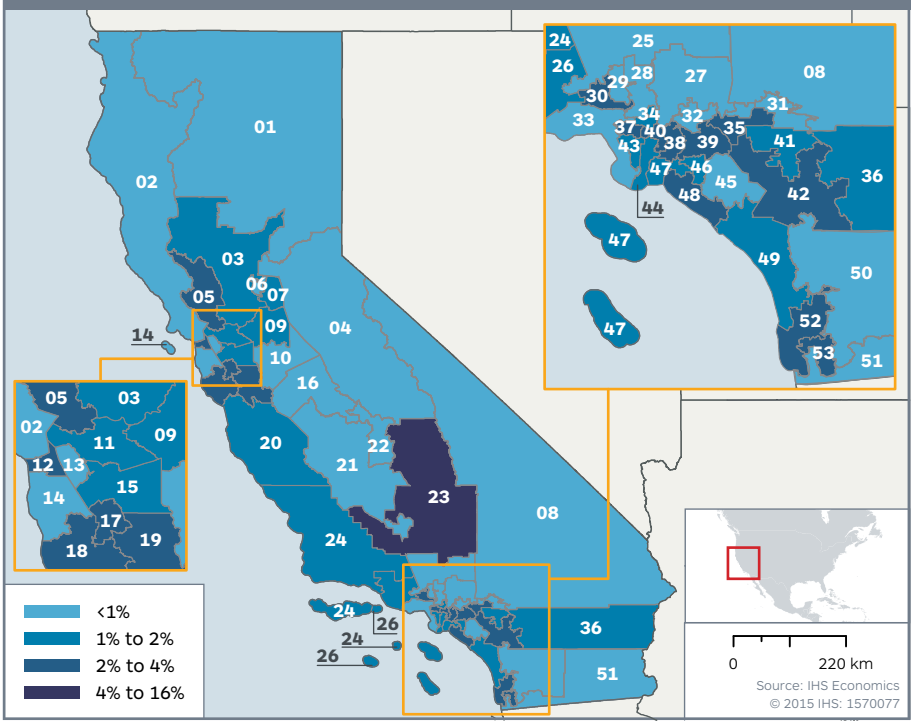
Some congressional districts will show only minimal effects of moving from restricted trade to free trade since there is no nearby direct activity. This tendency can be seen even in some districts in the two major oil-producing states of Texas and California.

Texas employment distribution by congressional district – Base Production
(2017 percent, difference free trade vs. restricted trade)



Another way to rank congressional districts is to examine the top four or five congressional districts in each of the 15 selected states for their job contribution. The tables below demonstrate the employment benefits to each of these district's supply chains under a free trade crude oil export policy. The largest impacts will be felt by companies operating in congressional districts in California, Texas, and Illinois. However, clusters of districts in Florida, New York, and Massachusetts will also experience noticeable effects.

California employment distribution by congressional district – Base Production (2017 percent, difference free trade vs. restricted trade)



Employment for top-5 congressional districts: US crude oil export supply chain -- Base Production* (number of workers, difference free trade vs. restricted trade)

State	Congressional district	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
Arkansas	4	474	1,154	1,395	1,288	1,008	290	548
Arkansas	2	403	971	1,153	1,000	783	223	436
Arkansas	1	282	707	853	794	627	176	335
Arkansas	3	178	421	495	430	338	94	187
California	23	1,803	5,182	6,527	5,311	4,430	1,658	2,655
California	42	474	1,367	1,820	1,569	1,328	483	759
California	38	433	1,219	1,599	1,362	1,131	408	655
California	39	399	1,209	1,555	1,285	1,050	355	603
California	40	374	1,088	1,456	1,252	1,058	392	610
Colorado	6	384	1,077	1,282	1,114	879	297	514
Colorado	7	374	1,051	1,358	1,199	983	365	574
Colorado	4	296	849	1,064	941	772	300	461
Colorado	3	276	792	978	856	695	265	416
Colorado	2	213	656	760	700	567	223	342
Florida	23	614	1,188	1,455	1,916	1,694	680	911
Florida	22	339	1,178	1,416	909	790	323	524
Florida	13	440	1,082	1,331	1,346	1,207	493	689
Florida	14	420	994	1,221	1,230	1,091	461	637
Florida	8	283	715	871	885	801	359	476
Illinois	8	1,322	2,746	2,959	2,595	2,106	690	1,242
Illinois	16	980	2,015	2,170	1,906	1,504	476	889
Illinois	15	873	1,778	1,862	1,572	1,265	432	778
Illinois	13	857	1,765	1,838	1,540	1,239	423	764
Illinois	18	791	1,548	1,631	1,378	1,101	358	669
Louisiana	6	393	1,210	1,491	1,396	1,150	320	589
Louisiana	3	353	1,099	1,345	1,255	1,047	304	543
Louisiana	1	152	469	581	544	452	132	234
Louisiana	2	134	401	487	444	363	102	190
Louisiana	4	125	383	463	426	351	99	182
New York	25	840	2,105	2,547	2,356	1,980	748	1,154
New York	22	644	1,482	1,626	1,322	1,058	370	655
New York	24	563	1,292	1,417	1,146	908	310	562
New York	27	522	1,280	1,549	1,420	1,197	463	706
New York	12	336	773	943	876	710	261	417
Ohio	16	750	1,489	1,494	1,221	1,017	353	633
Ohio	12	605	1,195	1,189	954	792	270	496
Ohio	15	561	1,111	1,122	915	761	265	475
Ohio	7	427	828	801	631	527	179	334
Ohio	6	413	822	810	650	546	187	341
Massachusetts	6	828	2,177	2,735	2,510	2,057	973	1,336
Massachusetts	5	447	1,143	1,470	1,330	1,138	513	711
Massachusetts	8	306	796	1,002	919	757	368	497
Massachusetts	3	212	575	718	659	547	249	347
Massachusetts	4	190	496	625	571	473	217	302

*The rank for all years is based on the 2017 ranking. All congressional districts displayed for states with less than 5 districts.

Source: IHS Economics

Employment for top-5 congressional districts: US crude oil export supply chain -- Base Production* (number of workers, difference free trade vs. restricted trade)

State	Congressional district	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
North Carolina	12	773	1,653	1,934	1,769	1,488	496	839
North Carolina	11	618	1,324	1,565	1,435	1,225	406	682
North Carolina	9	425	922	1,071	982	825	273	464
North Carolina	1	202	434	507	458	388	129	219
North Carolina	13	165	352	413	377	316	105	178
Oklahoma	3	1,006	2,283	2,589	2,250	1,774	489	986
Oklahoma	5	784	1,749	1,967	1,702	1,338	365	746
Oklahoma	1	475	1,045	1,173	999	778	204	434
Oklahoma	4	411	918	1,040	903	719	199	398
Oklahoma	2	341	764	860	741	584	159	326
Pennsylvania	18	398	845	853	704	564	170	338
Pennsylvania	5	315	655	620	486	381	109	237
Pennsylvania	14	283	594	615	517	414	127	246
Pennsylvania	13	258	556	594	507	411	127	240
Pennsylvania	9	226	478	468	375	298	89	182
Texas	18	765	2,038	2,476	2,197	1,826	585	1,010
Texas	11	661	1,782	2,170	1,941	1,594	507	881
Texas	7	581	1,524	1,851	1,669	1,406	452	770
Texas	29	545	1,466	1,791	1,612	1,342	434	740
Texas	36	551	1,437	1,734	1,546	1,275	405	706
Utah	1	715	1,744	2,043	1,756	1,422	460	819
Utah	2	490	1,213	1,433	1,261	1,035	346	593
Utah	4	455	1,094	1,278	1,098	886	283	509
Utah	3	164	393	460	397	319	102	183
Washington	7	549	1,345	384	360	287	111	269
Washington	2	522	1,293	1,570	1,395	1,160	441	690
Washington	9	530	1,273	1,242	1,128	942	349	573
Washington	1	403	986	2,861	2,519	2,077	780	1,109
Washington	3	294	716	865	769	636	245	382
Wisconsin	3	535	1,024	1,064	950	754	233	444
Wisconsin	4	465	967	1,054	984	812	274	468
Wisconsin	5	475	893	901	769	625	188	369
Wisconsin	6	461	887	924	815	658	211	390
Wisconsin	7	416	792	818	707	574	172	335
US Total		**105,748**	**250,201**	**293,140**	**258,227**	**212,508**	**73,384**	**123,577**

*The rank for all years is based on the 2017 ranking. All congressional districts displayed for states with less than 5 districts.

Source: IHS Economics

Value added

A free trade crude export policy will have a measurable impact on the nation's GDP, and this will be felt throughout the crude oil supply chain at the state and congressional district level. Congressional districts in California and Texas, two states with significant oil production and expected investment, are well-represented in the table below, which shows the US congressional districts that would experience the greatest value added boost under free trade.

Surprisingly, even though Illinois ranks as only the 14th highest state in terms of oil production, five of its' congressional districts rank in the top 20 in terms of their supply chain value added contribution. Together, these five districts account for 5% of the US supply chain impact, representing the single largest effect from free trade in crude oil—surpassing even California and Texas.

Value added by congressional district: US crude oil export supply chain – Base Production*
($million, real 2009, difference free trade vs. restricted trade)

State	Congressional district	2016	2017	2018	2019	2020	2021-30 average	2016-30 average
California	23	370	853	911	655	623	407	499
Nevada	2	258	602	708	683	653	545	557
Illinois	8	285	523	507	447	410	298	343
Illinois	18	270	451	426	362	326	237	280
Illinois	16	233	426	414	368	330	231	272
New York	25	213	404	397	360	354	360	356
Oregon	3	198	381	393	359	342	342	340
Illinois	13	203	370	346	291	265	209	238
Texas	18	177	370	384	330	290	174	220
North Carolina	12	178	319	317	283	262	145	187
New York	22	167	291	260	207	194	181	195
Washington	9	156	291	256	228	219	177	194
Texas	11	133	278	288	249	217	127	162
New York	24	157	274	245	194	180	165	180
Texas	29	123	260	270	235	207	125	156
US Total		**21,234**	**40,606**	**40,480**	**34,494**	**31,701**	**21,754**	**25,737**

*The rank for all years is based on the 2017 ranking.

Source: IHS Economics

In summary, the magnitude of the impact of removing the crude oil export on supply chain sectors within a congressional district will depend on two major factors—first, the degree of drilling and extraction activity, and second, the network of supply chains in the congressional district. In both the Base Production Case and the Potential Production Case, the initial ramp up of investment will make a strong impact in congressional districts. In the later years, the growth in investment and production moderates, and removing the ban will have modest—yet still positive—economic and employment impacts on congressional districts.

The network of companies that supply the US oil and gas industry reaches far beyond Texas, North Dakota, California and other states where oil is being extracted. This supply chain can be found in an engine manufacturing plant in Illinois, in Minnesota construction firms building on-site projects for producers next door in North Dakota, and in the Massachusetts and New York companies that provide sophisticated technology and financing to crude oil producers and their suppliers.

In this report, IHS analyzed the impact of lifting the current ban on oil exports and finds that a substantial share of the economic benefits would flow through to the supply chain. These benefits to the supply chain would have a positive impact on every US state and virtually every congressional district.