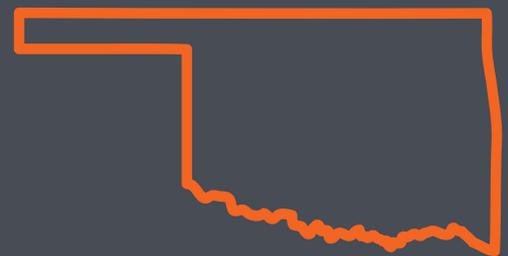


# TRADING UP: A GLOBAL ANALYSIS OF OKLAHOMA TRADE



WES WATKINS CENTER FOR  
**INTERNATIONAL  
TRADE DEVELOPMENT**  
School of Global Studies and Partnerships





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## ACRONYMS

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**CITD** – Wes Watkins Center for International Trade Development at Oklahoma State University

**FDI** – Foreign Direct Investment

**FTA** – Foreign Trade Agreement

**GDP** – Gross Domestic Product

**HS Code** – Harmonized System, a standardized numerical method of classifying traded products.

**NAFSA** – formerly National Association of Foreign Student Advisors, now the Association of International Educators, but still referred to as NAFSA

**NAICS** – North American Industry Classification System

**NTB** – Non Tariff Barrier

**RCA** – Revealed Comparative Advantage

**USEIA** – United States Energy Information Agency

## HS CODES AND INDUSTRIES\*:

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### 2 DIGIT LEVEL\*

- 01-05** Animal & Animal Products
- 06-15** Vegetable Products
- 16-24** Foodstuffs
- 25-27** Mineral Products
- 28-38** Chemicals & Allied Industries
- 39-40** Plastics/ Rubbers
- 41-43** Raw Hides, Skins, Leather, & Furs
- 44-49** Wood & Wood Products
- 50-63** Textiles
- 64-67** Footwear/ Headgear
- 68-71** Stone/ Glass
- 72-83** Metals
- 84-85** Machinery/ Electrical
- 86-89** Transportation
- 90-97** Miscellaneous

\* Harmonized System Codes . (n.d.). Retrieved from <https://www.foreign-trade.com/reference/hscod.htm>

# EXECUTIVE SUMMARY

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While the research on this project has spanned a number of months, this report is being finalized at a time when most of the world is still sequestered at home during the COVID-19 pandemic. It is a time of profound economic uncertainty, where the importance of global supply chains has become part of the public narrative. It is a time where everything from the character of day to day human interactions to the shape of global engagement are being questioned and reconsidered. Some level of restructuring appears inevitable. In fact, it is widely expected that permanent changes to supply chains and trade flows will be one outcome. This scenario will provide Oklahoma's citizens, firms, and institutions with both challenges and opportunities, and we hope analyses like this one can help aid the ways we navigate these shifts.

Our analysis approaches Oklahoma trade at a variety of altitudes and applies several different lenses. It is expressed in plain language but with enough depth to uncover general market inefficiencies, potential opportunities for Oklahoma businesses, and possible directions for deeper exploration, all with a view toward improving Oklahoma's global competitiveness.

We start with an overview of Oklahoma's role in global trade. Next we apply a broad industry lens. A section on methodology explains how we determined specific, more detailed areas of focus and why we believe that approach to be relevant. Finally, we conduct commodity level studies (using the 4-digit harmonized code) and apply supply chain network and relative comparative advantage analysis to a handful of selected commodities. Our purpose is to demonstrate the insight this type of research can produce, and to provide a framework and direction for future study.

We have worked hard to make this report logical, purposeful, and accessible to a broad audience. Our main focus is on business leaders and those who influence policy decisions as we believe these actors will play a primary role in how Oklahoma becomes more competitive in the global economy. We have also included a brief summary at the end to highlight the Oklahoma State University faculty whose research ties to each of the areas we studied, and we are grateful for their ongoing contributions to their fields and to our students.

When Congressman Wes Watkins founded the CITD in the late 1980s, he had a vision to grow Oklahoma's global trade presence. Watkins' biographer Kim D. Parrish captured the Congressman's dream about a place "where students would be trained in the discipline of doing business with the world, opening up international markets in Asia, Africa, South America and Europe to products born and bred in Oklahoma by Oklahomans."\* At the Wes Watkins Center for International Trade Development at Oklahoma State University, through efforts like this one, we continue striving to fulfill Wes Watkins' vision as we bring the knowledge, network, and resources of OSU together to make Oklahoma more globally competitive, increase trade, and create jobs to keep Oklahoma companies and students in the state to build their futures.

We hope you will join us in this quest and would welcome input, feedback, or inquiries that would lead to meaningful future efforts.



Andrew Ranson, CITD Director

\* Kim D. Parrish, Making Things Better: Wes Watkins' Legacy of Leadership, Oklahoma Heritage Association Publishing, Oklahoma City, 2016, p.322.

# WHY DOES GLOBAL TRADE MATTER?

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## It's How We Get What We Need

Without engaging in international trade, the United States would lack many of the products and services to which its citizens have become so accustomed. As a simple example, bananas are an important staple in the American diet, and while the U.S. does produce bananas in Hawaii, Florida, and California; these states simply do not have the production capacity to meet the demand for U.S. American banana consumption. Therefore, the U.S. imports around 94 percent of all bananas consumed in the U.S., primarily from Latin American countries.<sup>1</sup> The U.S. imports bananas because the opportunity cost of producing its own bananas instead of focusing on other products and services is too high. The U.S. in turn exports products and services in which it has a relative advantage in producing, such as machinery, technology, meats, and grain products, as well as services, its largest export industry.

## It's How We Support Better Jobs in Our Communities

In addition to increasing sales, businesses that export also support a higher number of quality jobs than if they were just servicing domestic markets. This in turn feeds local economies. Furthermore, importing products creates the benefits of expanding the product selection and services available to local economies. It is also important to acknowledge that trade does bring the risk of job losses locally, particularly in the manufacturing sector. For example, the U.S. Bureau of Labor Statistics reported that in Oklahoma between September and December 2018, the effect of trade on jobs totaled 83,749 jobs created and 77,698 jobs lost.<sup>2</sup> The net effect of trade on job creation was positive, but the losses do require policy makers be aware of shifts in the labor pool to ensure retraining is available if needed and that competition is fair.

## It's How We Make Our Economy More Efficient

It is important to note that trade is not a zero-sum game and instead can offer outcomes where both the sellers and buyers benefit. In its most basic form, international trade provides countries with markets to sell their products and the ability to buy products they cannot efficiently produce themselves. These two opportunities stimulate economic growth and make economies more efficient by directing economic inputs towards goods and services for which a country has the greatest relative advantage in producing. They also provide growth via greater economies of scale, valuable cross-cultural communication, and knowledge sharing.

# GLOBAL TRADE IN OK

Typically, when people think about Oklahoma, they do not think about it in terms of global trade. Instead, they may think of ranches, wide-open spaces, Native American history, The Grapes of Wrath, oil, and country music. However, in 2018\* Oklahoma goods export were \$6.1 billion (USD), making it the 38<sup>th</sup> largest state exporter.<sup>3</sup> This trade has a direct effect on Oklahoma's economy. For example, based on the most current available data, the exports of goods supported around 28,000 thousand jobs in 2016<sup>4</sup> and these jobs pay on average 16 percent more than non-export oriented jobs.<sup>5</sup>

## Small and Medium Businesses Trade Too

While the total volume of trade in Oklahoma is dominated by large corporations, small to medium enterprises (SMEs) do make up a sizable portion. In fact, in 2016, 26 percent of global exports from Oklahoma came from small to medium sized firms.<sup>6</sup> This demonstrates that firms need not be large multinational enterprises to engage in international trade. This is further supported by a new trade theory that explains why the most productive corporations are engaged in international trade. The previous school of thought was that only large multinational corporations participated effectively in trade activities. However, evidence shows that not all "large" firms are "productive" enough to be competitive for trade. In other words, only firms that are more efficient and perform well enough financially to compete in the global market space and cover the often-high fixed costs of exporting are engaged in trade. The hierarchy is further deepened when considering that only the most productive firms engage in foreign direct investment in addition to trade.<sup>7</sup>

## Room to Grow

International trade in Oklahoma has grown roughly \$1.0 billion (USD) between 2008 and 2018. This growth has mostly been on pace with GDP growth, although in 2018 trade contributions to Oklahoma's GDP increased by 0.21 percent.<sup>8</sup> This growth means there are more opportunities now than ever before for Oklahomans to engage in international trade<sup>9</sup> and the road for growth in the export of goods for Oklahoma includes commodities beyond those that the state is known for, such as wheat, cotton, and oil.

When considering the volume of trade in goods (that is, both the export and import of merchandise), trade represented a substantial 8.7 percent share of Oklahoma's GDP in 2018. Even though international trade has registered substantial growth rates in Oklahoma during the past 10 years, the state's international trade to GDP ratio is in the bottom quintile nationally, right after Virginia (8.9 percent), and before New Mexico (6.3 percent), Wyoming (6.1 percent), Colorado (5.9 percent), Hawaii (5.7 percent), South Dakota (4.8 percent) and the District of Columbia (2.5 percent).

“There are **MORE OPPORTUNITIES** for Oklahomans to engage in international trade **THAN EVER BEFORE.**”

\* Throughout this report we use 2018 data as it is the most up to date and reliable. However, when 2018 data is not available, we use older data.

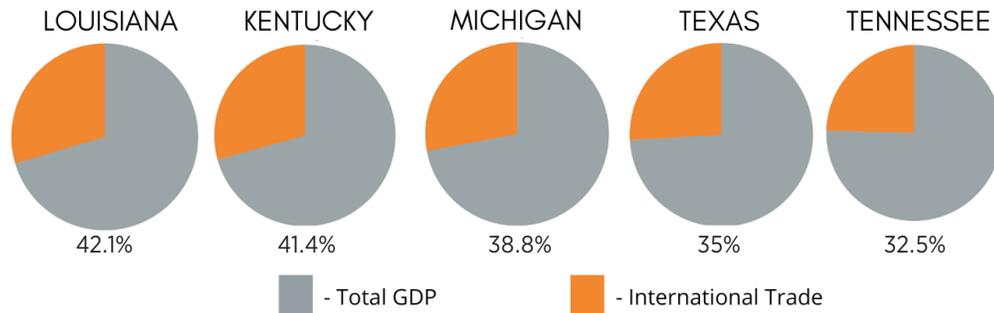


Figure 1: International trade as a share of state GDP (Highest Performing States). Source: CITD Analysis.

States ranking highest in the international trade to GDP ratio are Louisiana (42.1 percent), Kentucky (41.4 percent), Michigan (38.8 percent), Texas (34.9 percent) and Tennessee (32.5 percent). All these states are strong actors in the automotive industry and, in the case of Louisiana, the oil & gas sector.<sup>10</sup> Figure 1 and 2 display the differences between the highest and lowest performing states in terms of the international trade to GDP ratio.

Final authority for trade regulation is a matter of national sovereignty and is governed at the federal level. Therefore, when studying trade at the state level, it makes sense in most cases to take the regulatory environment as a given. Trade is regulated to protect firms, workers, and society as a whole from national security risks, unfair competition and/or unsafe products. To limit trade, governments use tariffs, which is a tax on imported products, or non-tariff barriers (NTB). NTBs restrict trade through the use of many mechanisms that include, but are not limited to, quotas, subsidies, pre-approval and registration, licensing requirements, and other technical requirements. While countries can reduce trade barriers unilaterally, most use international trade agreements to negotiate reciprocal trade liberalization that increases market access opportunities for its national firms. It is important to be aware of trade agreements when considering destinations for growing international trade in Oklahoma.

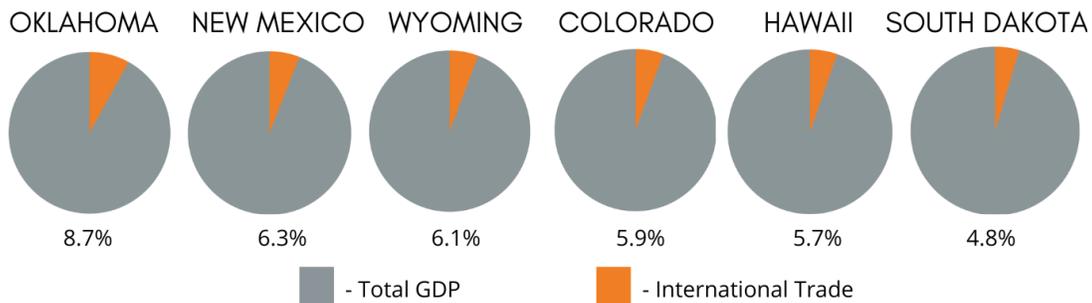


Figure 2: International trade as a share of state GDP (Lowest Performing States). Source: CITD Analysis.

## Other Countries Want to Invest in OK

Another important component of global commerce is the attraction of foreign direct investment (FDI). FDI patterns tend to mirror the direction of trade, as firms try to cut down transport costs and bring production closer to consumers or where intermediate inputs are sourced. In 2016, foreign-owned enterprises employed over 50,000 workers in OK, with Mexican investments generating the largest number of jobs in the state.<sup>11</sup> FDI was originally thought of as a substitute for trade, since investing to manufacture within a country would “jump” tariffs. However, due to modern global supply chains, FDI more often acts as a complement to trade. Therefore, attracting FDI can be an important contribution to a country’s long-term economic development.<sup>12</sup>

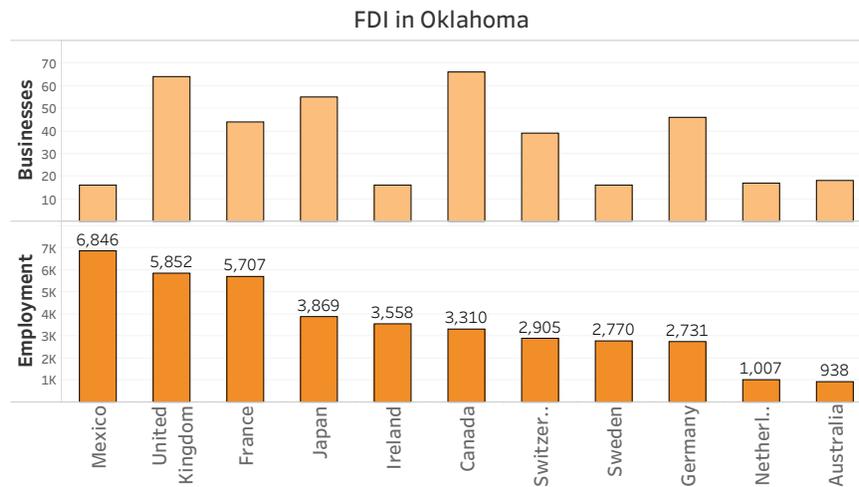


Figure 3: Top foreign investors creating jobs in Oklahoma.

As shown in **Figure 3** the foreign direct investments into Oklahoma from Mexico, the UK, and France alone create nearly 20,000 jobs. Foreign global champions like France’s Michelin (tire and pneumatic maker), Mexico’s Bimbo (bread and bakery), Germany’s Siemens (electronics and engineering), Belgium’s Inbev (beer), the U.K.’s BAE Systems (aeronautics and defense), and Spain’s Acciona (wind turbines and renewable energy) are all actors in the Oklahoma economy and examples of Foreign Direct Investment in the state.<sup>13</sup> The investments these countries make in Oklahoma further stimulate the local economy, contributing to the skills of the local workforce and the competitiveness of the local business environment.

In the following sections, we first provide an overview of the status of Oklahoma’s international trade across industries, identifying any potential for trade growth. Next, we detail the research methodology used for in-depth commodity level network analysis and then apply this methodology to seven different commodities to explore how network connections impact the market and changes in comparative advantages. Finally, we conclude with a discussion of future research opportunities.

# OKLAHOMA TRADE BY SECTOR

## Trade in Services

Trade reports often combine goods and services or focus only on goods. And yet, services make up the majority of economic activity in developed economies. Unlike physical goods, because services are intangible, it can be challenging to understand the concept of services being exported. Common services are in the financial, maintenance, insurance, transportation, travel, education, communication, and IT industries. While regulation and trade agreements are far less developed for services trade, this is a fast growing and increasingly important area of international trade focus.

Despite its importance, trade in services is more difficult to research because it is harder to track. For goods, there are Harmonized Tariff Schedules (or HS codes), comprising a detailed and complex labeling system for all products based on agreed upon international standards. However, service trade does not have a similar classification system and services are delivered to the end-user in different ways, which makes them harder to identify and separate.<sup>14</sup> For example, many traded services are exchanged electronically or, in the case of education and healthcare, while they may be delivered in the U.S., they still count as exports when they are provided to foreign customers. Others are also hard to track because many companies combine goods and services within their products. Reporting on the modes of service trade is improving and there are indications that this is a high growth component of the overall trade picture.

As a sector, the value of service exports from Oklahoma between 2006 and 2016 grew five times faster than the export of goods: a rate of 58 percent, compared to an 11 percent growth in the export of goods. And this higher percentage rate is not just a reflection of a much smaller value: in 2016, service exports reached \$4 billion (USD), only \$1.2 billion (USD) less than the value of goods exported during that year. In 2018, the service sector alone was responsible for about 72 percent of Oklahoma's GDP.<sup>15</sup>



Services with the greatest export growth potential in the state of Oklahoma include business and financial services, e-commerce, travel services, engineering, architecture/design, technology troubleshooting, and telecommunications. These are fields which have registered some of the highest job creation numbers in the United States during the last 20 years and are especially attractive when considering the fact that more traditional sectors of the economy, like agriculture and manufacturing, have registered substantial net job losses during this period. Besides having a lot of room for growth in the future, the wages for these sectors are among the highest overall.

Latin America in particular is an attractive market for increasing Oklahoma service exports. According to the Bureau of Economic Analysis, the United States service exports to the region as a whole grew from \$106 billion (USD) in 2010 to \$157 billion (USD) in 2018, an increase of 45 percent.<sup>16</sup> As the presence of U.S. firms continues to grow in the region, so does the market for Oklahoma service providers. Additionally, a growing number of multinational Latin American firms with a presence in the United States offer an array of opportunities for Oklahoma services in fields as diverse as mining, food and beverages, banking, telecommunications, retail, transportation, and e-commerce. Proximity and similar time zones are two additional factors that make Latin American markets for services an attractive option.

## Trade by Sector: Services

Another reason to develop the service sector in Oklahoma is that in the current global context of automation and the growing use of technology, creating new, quality service sector jobs and improving existing ones can be a safeguard from these future threats to Oklahoma jobs. This could in turn become a strategy of crucial importance



for the state, considering that Oklahoma is currently a state that loses talent and skills through a so-called “brain-drain”. According to the latest study by the Kansas City Federal Reserve, Oklahoma has had a negative net domestic migration between 2016 and 2018, and residents with bachelor’s degrees or higher, primarily recent graduates, have accounted for virtually all net outflow. On average, the state has had a net loss of 5,300 college graduates every year since 2013. In other words, more than half a percent of the entire population with college degrees in the state has left Oklahoma every year during the last 6 years, mainly due to the lack of quality jobs.<sup>17</sup> This is why further developing the education sector, explored more below, is so important.

## Education: A Service Sector with Potential for Growth

A great example of how beneficial services can be to a state’s economy is the economic value generated by incoming international students. A 2019 study by the Association of International Educators (also known as NAFSA) found that “for every seven international students enrolled, three U.S. jobs are created and supported by spending occurring in the higher education, accommodation, dining, retail, transportation, telecommunications and health insurance sectors.”<sup>18</sup>

Globally, roughly 5 million students sought higher education abroad in 2016, generating an impact of \$300 billion (USD).<sup>19</sup> The United States’ share was 22 percent in this growing market (followed by the United Kingdom with 11 percent, Australia with 11 percent, and China with 9 percent),<sup>20</sup> which is expected to continue expanding and reach 6.9 million students in 2030.<sup>21</sup> Sixty percent of all current international students globally come from a handful of countries: China, India, South Korea, Saudi Arabia, Canada, Mexico, and Brazil,<sup>22</sup> but growth is also strong among smaller countries in Latin America, Africa, and Southeast Asia.

According to NAFSA, a total of 1,094,792 international students were enrolled in American higher education institutions during the 2017-2018 academic year. That means more than 1 of every 20 students enrolled in U.S. colleges and universities that year came from abroad. These students generated an income of \$39 billion (USD) and were responsible for supporting 455,622 jobs in the United States. States like California (161,942 international students, income of \$6.6 billion (USD)), New York (121,260 international students, income of \$5.0 billion (USD)), Texas (84,348 international students, income of \$2.2 billion (USD)), and Massachusetts (68,192 international students, income of \$3.0 billion (USD)) benefited the most from this growing market. Although growth in the number of international students in the United States has slowed

“During the 2017-2018 academic year, **8,948 INTERNATIONAL STUDENTS** were enrolled in higher education institutions in the state, generating **\$285.7 MILLION (USD)** in revenue and supporting **8,945 JOBS.**”

down during the last 2 years (3.3 percent in 2016-17, and only 1.5 percent in 2017-18), the trend for the last 10 years has been of rapid expansion, going from 623,805 international students in 2007 to 1,094,792 in 2017. That represents a 75.5 percent growth over 10 years.<sup>23</sup>

Although relatively small in comparison to the more established higher education centers in other parts of the United States, Oklahoma is also an attractive destination for international university students. However, more could be done to attract international students. In spite of overall market growth, total international enrollment in Oklahoma higher ed has been nearly flat since 2007. During the 2017-2018 academic year, for example 8,948 international students were enrolled in higher education institutions in the state compared with 8,345 in 2007. Nevertheless, the revenue was significant. Those 8,948 international students generated \$285.7 million (USD) in revenue and supported 8,945 jobs. The institutions with the highest international enrollment numbers in the state during the 2017-2018 academic year were the University of Oklahoma, Oklahoma State University, the University of Tulsa, and the University of Central Oklahoma.<sup>24</sup>



There is still a lot of room for growth in Oklahoma's service export market. Evaluating how Oklahoma can develop in this area is an opportunity for future research and exploration.



## Heavy Industry

What we're calling "Heavy Industry" refers broadly to capital-intensive industries that require a large proportion of machinery and equipment to produce their output. An enduring example of an Oklahoma heavy industry producer is Ditch Witch, which makes earth-moving construction equipment.<sup>25</sup> Heavy industry manufacturing has been a staple of the Oklahoma economy since shortly after achieving statehood in 1907, and the state has since remained a desirable and competitive location for these industries.<sup>26</sup> Heavy industry producers also supply goods to other industries, such as oil-related businesses, trucking and logistics companies, manufacturing plants, farming and agriculture, and aerospace, each of which is vital to Oklahoma's economy. Relationships with these industries combined with Oklahoma's access to inputs imperative to manufacturing make this state an important hub for heavy industry. These inputs include important transportation networks, a quality labor pool, access to raw materials, and statewide organizational support.

Oklahoma's central location has made it an important transportation hub, and it is accessible by three intersecting interstates, an inland port, railways, and both private and commercial airports. Additionally, Oklahoma's CareerTech vocational education system has excellent trade and technical schools to support a high quality and dynamic workforce for different types of manufacturing needs. Organizations like the Oklahoma Department of Commerce and the Oklahoma Manufacturing Alliance also act as important resources to support the needs of the state's manufacturing firms.<sup>27</sup>

All these features create a hospitable environment for manufacturing plants and many U.S. firms have chosen to put down roots here in Oklahoma including Ditch Witch, Hem Saw, and Acme. Companies headquartered elsewhere, such as Boeing, Lufthansa, Siemens, and Michelin have also been vitally important to the success of our state. Additionally, manufacturing companies geared towards heavy industry are also a major source of foreign direct investment.<sup>28</sup>

## Light Industry

Light industries, while also not formally defined, are usually less capital-intensive than heavy industries and tend to produce relatively light-weight, high-value products. This includes end-use consumer products such as household appliances, furniture, and textiles. These industries cover a large variety of HS codes, and Oklahoma firms both export and import these types of goods in significant numbers. For example, Oklahoma imported roughly \$500 million (USD) of wood and wood products and \$419 million (USD) of textiles annually between 2016 and 2018. Additionally, Oklahoma imported \$100 million (USD) a year just in artificial flowers alone. Oklahoma firms involved in importing and exporting light industry goods include large firms such as Hobby Lobby as well as numerous small and medium businesses.

For most of the United States, large sections of light industry manufacturing have been sent offshore over the past 50 years. However, Oklahoma has increased its exports in a variety of light industry products, even if the volumes and values are not as large as other sectors. For example, a fast-growing Oklahoma light industry export

### HEAVY INDUSTRIES

refer to capital-intensive industries that require a large proportion of machinery and equipment to produce.

### LIGHT INDUSTRIES

are usually less capital-intensive and tend to produce relatively light-weight, high-value products.

## Trade by Sector: Goods

is soaps, cleaning agents and toiletries, with annual growth of 29 percent since 2006,<sup>29</sup> and reaching a value of \$72 million (USD) in 2018.<sup>30</sup> And while it is only a fraction of imported textiles, Oklahoma also exported over \$31 million (USD) in textiles and other clothing articles in 2018.

### Agriculture

Agriculture is an important part of Oklahoma's economy. The sector is responsible for over 300,000 jobs<sup>31</sup> and is an important driver of exports. While free trade agreements (FTAs) have opened some foreign markets and present numerous opportunities, Oklahoma producers also face challenges to marketing their agricultural products abroad.



While traditionally known for cattle ranching, the Oklahoma agriculture sector also produces a number of other export goods that are important for the state. These include wheat and meslin, corn, pork meat, beef and dairy products, cotton, and even edible offal. International markets for these products are often found close to home. For example, Mexico is one of the state's largest buyers of corn, wheat, and pork meat. However, distant countries are also important clients for Oklahoma agricultural products. Morocco and Nigeria purchased large volumes of cereals from the state in 2018; cotton and cotton products were sold to Vietnam, Indonesia and Pakistan; and Japan, South Korea and China are some of the most important international markets for Oklahoma pork meat (an industry responsible for thousands of jobs in the state). Other markets offer untapped potential. For example, the United Arab Emirates purchases large amounts of beef, dairy products and cereals from the United States, but very little from Oklahoma.

Small-scale producers in the state often participate in international trade through vertically-integrated supply chains within large corporations. Most of these, like Tyson Food, Cargill and Seaboard Foods, are based outside the state. Besides the challenges of tapping into the potential offered by new markets and capturing more value from its agricultural products, sustainability is an important trend currently challenging the way agriculture is done in Oklahoma. The state's important cotton-growing industry, for example, is seeing its market impacted directly by consumer demands for more sustainable production techniques and guarantees of environmental responsibility.

### Natural Resources

Natural resources play an important role in the Oklahoma economy. Endowed with both fuel and non-fuel minerals, Oklahoma has been a leading producer of oil, natural gas, lead, and industrial minerals like limestone, iodine and gypsum for over a century.<sup>32</sup> In the 21<sup>st</sup> century, the Oklahoma's energy sector (which includes oil and natural gas) plays the most prominent role in the state's natural resource economy.

By some estimates, the state's energy industry is responsible for roughly one quarter of all jobs in the state.<sup>33</sup> The surge in shale oil production during the last 10 years, favorable oil prices, and changes in the legal framework opening the door for the U.S. to export oil (lifting of the U.S. oil export ban in 2016) have allowed Oklahoma companies specialized in the field of exploration and production to expand during this period. Some of these firms are Chesapeake

Energy, Continental Resources, Devon Energy, Enable Midstream Partners, Helmerich & Payne, Laredo Petroleum, Mammoth Energy Services, Panhandle Oil & Gas, Sand Ridge Energy, Williams Companies, and WPX Energy.

Besides these large players, many smaller firms are also active in the sector, providing jobs and income across the state. A key trend related to oil production is the increase in natural gas production as a by-product of shale oil wells. As a result of their activities in oil, Oklahoma energy firms are also active in the natural gas sector, a sector of growing importance and future potential both in the American energy industry and in international markets. Dry natural gas production in the state, home to the nation's third largest reserves of natural gas, has gone from 1.5 million cubic feet in 2000 to 2.7 million cubic feet in 2018.<sup>34</sup>

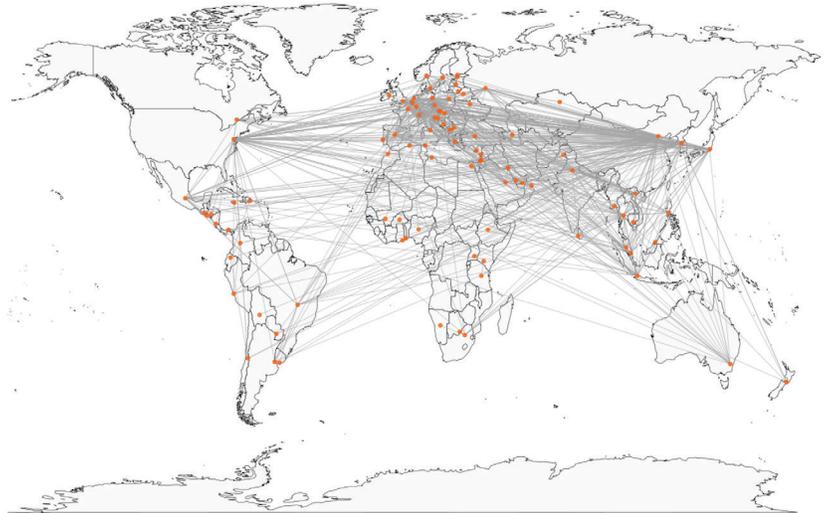
Despite the sector's relevance for the state's economy, Oklahoma firms are not relevant actors in oil and gas exports. Most of the state's energy firms concentrate their activities in the upstream and midstream sectors. Upstream activities refer to the exploration of oil and gas sources, drilling of wells and their operation for production. Midstream activities refer to the transportation, storage and wholesale marketing of oil and gas. By contrast, the state's midstream infrastructure does afford Oklahoma firms a role in imports. Pipelines that run through the state linking the Gulf Coast and the Midwest/Northeast, together with the oil storage facilities at Cushing and the refining complex in the Tulsa area represent assets that make the state an important transit point for Canadian oil produced in the tar sands region of Alberta.

**“OKLAHOMA** has been a **LEADING PRODUCER** of oil, natural gas, lead, and industrial minerals like limestone, iodine and gypsum **FOR OVER A CENTURY.**”

# RESEARCH METHODOLOGY

## Single Commodity Network Analysis

To understand individual transactions, it is vital to understand the context in which they take place. For trade, this context is a complex network, as shown in **Figure 6**. This network includes trade in finished goods but is dominated by trade of intermediate goods within global supply chains, which make up around 70 percent of total trade.<sup>35</sup> Global supply chains create complex network connections that lead to high-order interdependence. Market shocks such as those resulting from the COVID-19 pandemic reveal this supply chain interconnectivity. Better understanding of this interdependence can lead to both novel insights and more accurate predictive models.<sup>36</sup> Therefore, to gain greater understanding of the state of trade for Oklahoma we examine several specific commodities and map out their connections in global supply chains. This approach is excellent to uncover what advantages and challenges firms face in trading in these sectors, and can also provide insights to help Oklahoma policy makers and firms increase Oklahoma's competitiveness and ultimately its market performance.



**Figure 6:** 2016 International trade flows for all commodities. Orange points are country capitals

The tree maps in the previous section (**Figures 4 and 5**) identify major exports and imports but do not determine a sector's comparative advantage. A commonly used metric to determine comparative advantage is the revealed comparative advantage (RCA). For state by state comparisons in the U.S., this metric measures the ratio of a state's exports of a commodity to that state's total exports over the ratio of all states' exports of that same commodity to all exports of all states. Therefore, if the RCA is a value greater than one for any given commodity, an advantage is 'revealed.' Furthermore, if the year over year RCA is increasing for an economy, this represents

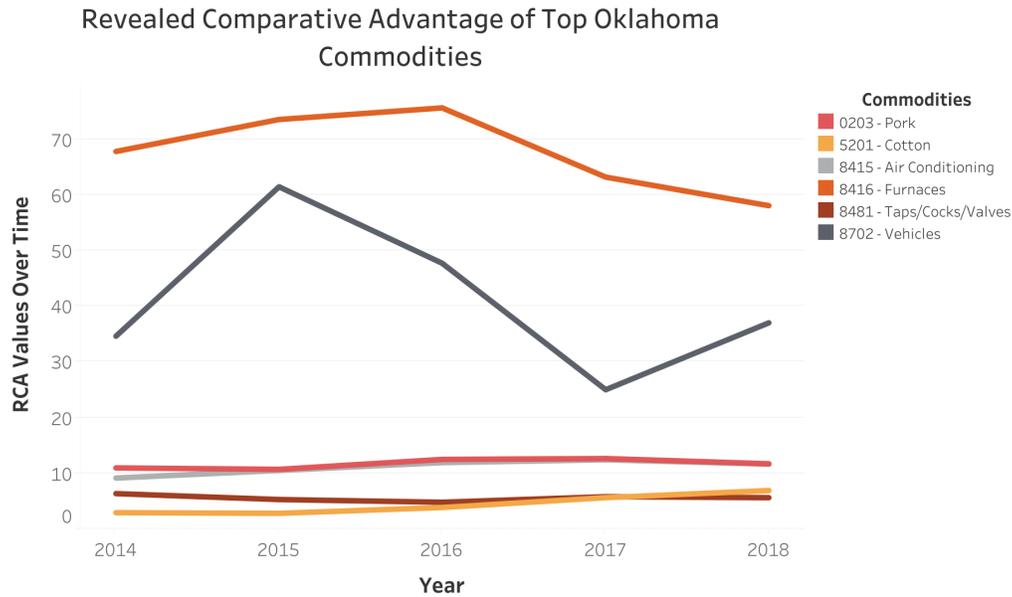
### REVEALED COMPARATIVE ADVANTAGE (RCA)

measures the ratio of a state's exports of a commodity to that state's total exports over the ratio of all states' exports of that same commodity to all exports of all states.

a strengthening of that economy's ability to export the good. RCA calculations are typically utilized for examining country-level data. However, to better pinpoint the strengths and advantages Oklahoma holds as an exporter and producer of goods, we decided to apply it at the state level.

For the commodity level analysis in this report, we wanted to better understand Oklahoma's strengths in the context of our neighboring states as well as states that are similar to Oklahoma in both median household income and GDP. Relating Oklahoma's RCA numbers to both of these comparison groups highlighted different narratives for each commodity, which will be expounded upon throughout this report.

We chose to focus on commodities from different sectors that have been integral to Oklahoma’s economy and for which Oklahoma has both increased and decreased its RCA to best identify opportunities for Oklahoma firms and avenues for policy makers to focus their efforts to assist firms in overcoming challenges. As shown below in **Figure 7**, this includes industries involving mineral products, animal and animal products, textiles, machinery and electrical, and transportation.



**Figure 7:** RCAs of Top OK Commodities. Source: CITD Analysis.

One important caveat to consider is data quality. While we use the best data available, trade data is imperfect in that activity is often both under and over counted for several reasons. For example, the “rules of origin” for a product determines the duties and restrictions different countries place on that product. While much work has been done attempting to harmonize the rules of origin and trade data in general, these measures are not consistent around the globe, and all these variables have the potential to affect import and export data differently.<sup>37</sup> Additionally, it is difficult to correct inconsistencies in some datasets, particularly industry level datasets, due to the fact that data must be anonymized to protect the confidentiality of individual companies. State level export data can also be affected if a company has locations in multiple states, but only counts exports in the state in which they are headquartered.

# COMMODITY LEVEL ANALYSIS

## HS 2709: Petroleum Oils and Oils Obtained from Bituminous Minerals, Crude

If a layperson were asked what they would expect to be one of Oklahoma's main exports, they may guess, oil; but if you asked them about imports, it is unlikely they'd say the same. And yet, despite Oklahoma producing 575,000 barrels of crude oil per day,\* crude oil represented 26 percent of Oklahoma's imported goods in 2018 according to official statistics of the United States Census Bureau.<sup>38</sup> This amounted to a value of \$3.095 billion (USD) in imports that year. Furthermore, this high volume of crude oil imports takes place in the context of rising domestic oil production. A decade of rising U.S. oil production has seen the nation produce record amounts of oil, growing from 7.78 million barrels per day in 2008 to double that amount, 14.61 million barrels per day only 10 years later. The surge in American oil production has prompted some to declare U.S. oil independence, to the point where some of the locally produced oil is now being exported. This change happened in 2016, when under President Obama, the ban on oil exports was lifted. The results following that change are evident: crude oil exports from the United States surged from \$10 billion (USD) in 2016 to over \$60 billion (USD) in 2019. This American crude is exported to a variety of destinations, including Canada, South Korea, the Netherlands, India, the U.K., Taiwan, and China.<sup>39</sup> The seemingly baffling import of oil by Oklahoma makes oil a great example to show how supply chain network analysis can explain trade relationships and reveal actionable policy insights for improving Oklahoma's terms of trade.

The first step in understanding the counterintuitive import of crude oil is the determining where the oil comes from and what is being done with the oil after it is imported. The changing geopolitical context over the last 10 years have seen the U.S. gradually shift from purchasing crude oil from the countries of Saudi Arabia, Venezuela, Iraq, Russia, Nigeria, Brazil, and Colombia to sourcing it exclusively from the tar sand oil deposits in Alberta, Canada. For Oklahoma, this is a particularly important change, because oil coming from the tar sands is shipped not just to Oklahoma, but to the Gulf Coast petrochemical complexes in Texas and Louisiana. Besides using some of the imported oil in its refining industry, Oklahoma lies en route to the existing Gulf Coast petrochemical infrastructure, which concentrates more than 50 percent of the United States' refining capacity. This affords Oklahoman infrastructure an important role, as well as a relative advantage over other petrochemical facilities in the nation. In fact, the role is not limited to refining, since a large amount of the crude oil imported from Canada is shipped by rail, representing a boon for the rail and transport industry in Oklahoma, as well as the storage and pipeline infrastructure out of Cushing.

After locating the source of the oil and determining that it is then refined for later export, we can then answer why this is the case. The answer has to do with something called the crude slate. The crude slate can be defined as the crude diet, or the mix of different crude grades that refineries use in their production process. This takes us to concepts that are perhaps well-known within the oil industry, but not very well-understood outside of the industry. According to the American Petroleum Institute, crude oil can be classified as sweet or sour, depending on its sulfur content, as well as heavy or light, depending on its density and specific gravity. Sweet crudes are crudes that have low sulfur content (which is a very corrosive element), and heavy crudes are crudes that are rich in sulfur. Heavy crudes, as the term implies, have a higher density and gravity, whereas light crudes have a lower density and lighter gravity.

\* As of December 2019, according to the United States Energy Information Agency.

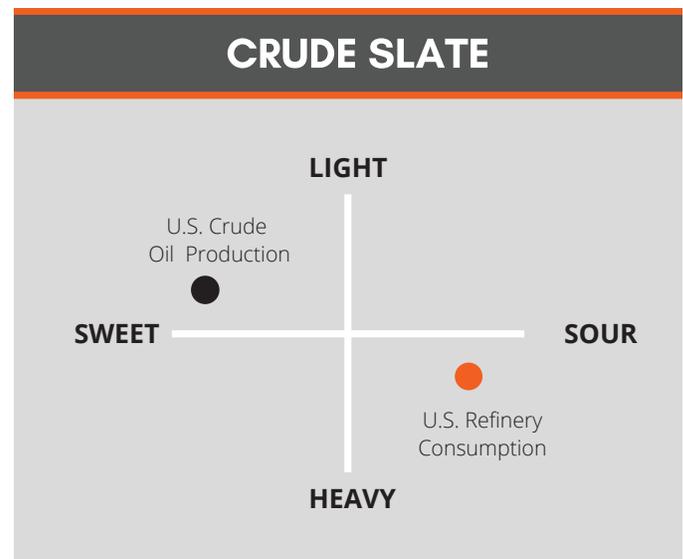
To make things more interesting, different parts of the world produce different types of crude oil within this sweet-sour and heavy-light scale. Saudi Arabia, for example, has both sweet light and heavy sour crudes, whereas Russia produces mid-sour and heavy sour in the Ural region, and extra light and sweet oil in its Far Eastern island of Sakhalin. Venezuela and Canada produce heavy sour crudes. In the United States, around three-fourths of the crude currently being pumped is sweet and light. This includes shale oil obtained through fracking, which has seen the production levels in states like North Dakota, Oklahoma, Texas and New Mexico surge in the last ten years.

But the trade in oil is not just determined by the types of oil being produced; oil deposit type is only half of the story. The other half has to do with refineries. Oil refineries require billions of dollars in investment, and they are planned for with the mid- and long-term in mind. One of the key aspects of refineries is the crude slate they are designed to process. Refineries must invest billions of dollars in specific equipment (like crackers, cokers, and hydrotreaters) to process their defined crude slate. In the United States, which for decades imported the majority of its oil, refineries are geared to process a crude slate that corresponds to those sources that supplied them with crude oil. In other words, most American refineries are geared for the heavy sour crudes that they have been importing for decades from Saudi Arabia, Venezuela, Kuwait, Iraq, and Russia, to name a few. More importantly, the mismatch between the oil produced domestically in the U.S., which is sweet and light, and the oil consumed by refineries, which is heavy and sour, means that the U.S. must both import crude oil to feed its refineries and find a market for the oil it is currently producing.

Refineries whose feedstock is light sweet oil have what is in the industry called a “sweet tooth”. The presence of sweet tooth refineries in East Asia (China, Taiwan, Japan, South Korea), Western Europe (the U.K., the Netherlands) and in Canadian cities of Montréal and Toronto mean that American sweet light has a market; at least for the time being. Refineries often do change their crude slate, but this is a costly transition that is guided by market conditions, oil availability, and does not happen overnight.

In Oklahoma, the existing refining capacity is operating at full capacity. According to the United States Energy Information Agency (USEIA), Oklahoma refineries have a combined capacity to process 525,300 million barrels per day.<sup>40</sup> Some of these refineries, like the Ardmore and Tulsa East and Tulsa West refineries, were built as early as 1913. The other two larger refineries, Ponca City and Wynnewood, were built in the 1920s. Only the smallest refinery, the Thomas Refinery, was built in the last 40 years. The existing infrastructure has been updated and refitted through the years, but as mentioned previously, the feedstock or crude slate they are designed for cannot be adapted overnight. This means that Oklahoman refineries have a need for imported heavy sour crude, explaining the \$3 billion (USD) in imports of crude oil from Canada.

Interestingly, it can also be noted that the four largest refineries, making up 97 percent of the state’s refining capacity, are owned by corporations headquartered in Texas (for example Valero Energy Corporation, from San Antonio, Phillips 66 Co. from Houston, and HollyFrontier Corporation from Dallas). Only the smaller Thomas Oil Refinery, with a 14,000 barrels per day refining capacity, is owned by a firm headquartered in Oklahoma. This firm is Ventura Refining & Transmission LLC, from Oklahoma City. For the state of Oklahoma, this begs for some questions to be asked. Is there a clear mid- to long-term strategy in place for the state’s economy and local actors



**Figure 8:** Crude grades and their uses within the U.S. market. Source: CITD Analysis.

in regard to the petrochemical industry? Concentration of refining capacity and ownership of refineries in firms headquartered in Texas reveals a clustering around existing and growing installed capacity, capital markets, and a business ecosystem that becomes more favorable and competitive for this sector as it grows further. Will Oklahoma continue to participate in this market? Furthermore, is capturing value a priority for Oklahoma firms and the state's policy for the oil sector? Although the state produces a considerable amount of oil (570,000 barrels per day), much of which is not currently being processed in Oklahoma refineries, no crude oil exports are being registered from the state. This means that when exported, this crude oil is being shipped and credited to firms in other parts of the country, most likely Texas or Louisiana.



Although many of the factors that define the crude oil market are not within the state's control (types of crude produced, location of production, crude oil prices, refining, pipeline and storage infrastructure, etc.), monitoring of certain indicators can be crucial for the state's oil producers and existing refiners. For example, monitoring the "sweet tooth" of refineries in East Asia, Québec and Western Europe, is crucial as they are the markets for sweet light crude produced in the United States. If refineries in these areas begin a transition towards heavy sour crude, American oil would be out of a market, since American refineries themselves are currently not geared to process sweet light crude, meaning the domestic market would not be an option. Along the same lines, a transition in local refining capacity would require billions of dollars in investments but would guarantee a local market for locally produced oil.

Besides the fact that imports are currently necessary for the U.S. petrochemical industry and refineries are critical determinants of crude oil flows, the international trade in crude oil has other implications for the state of Oklahoma. For example, although the state purchased substantial amounts of Canadian crude, Canada's purchases from Oklahoma are much lower. Seen from the state level, Oklahoma had a \$3.4 billion (USD) trade deficit with Canada in 2019. Canada purchased only \$1.57 billion (USD) worth of goods from Oklahoma and exported \$4.96 billion (USD) (including crude oil) to the state. Surely, this allows for some negotiations for Canada to step up purchases and correspond to Oklahoma's investment in Canadian goods. Additionally, the transit route for Canadian crude towards the Gulf Coast petrochemical complex affords the storage and pipeline infrastructure at Cushing a crucial role. What would happen if those flows were to change or be disrupted? Jobs dependent on the crude oil transport in Cushing and throughout the state, for example in the rail freight sector, would be affected. These make for compelling reasons for the state to closely monitor and understand the dynamics of its international trade in crude oil.

# COMMODITY LEVEL ANALYSIS

## HS 0203: Meat of Swine; Fresh, Chilled or Frozen

### Overview

Meat of swine is one of the most important agricultural products exported by Oklahoma. According to the Oklahoma Pork Council, the pork sector is the second largest agricultural enterprise in the state.<sup>41</sup> There are more than 1,900 farms in Oklahoma that produce swine meat, and these farms are responsible for generating more than 12,100 jobs. In 2018, pork meat exports from the state amounted to \$197.2 million (USD), a small share (3.3 percent) of the entire U.S. pork meat exports for that year. The value for American pork exports that year was \$5.87 billion (USD). The largest client for pork meat from Oklahoma was Japan, followed by neighboring Mexico, China (the largest pork meat consumer on the planet), and South Korea.

### Competitiveness

In the national context, Oklahoma is also a heavyweight. The United States exports more pork meat than any other country, and about 6 percent of those hogs come from Oklahoma. The state is the ninth largest pork meat producer in the U.S., with 1.6 billion pounds of live weight produced in 2017, for a total value of \$819.3 million (USD). To put this in context, the state with the largest production, Iowa, produced 12.7 billion pounds of live weight in 2017, worth \$5.67 billion (USD). Other leading producers include North Carolina, Minnesota, and Illinois.<sup>42</sup>

Additionally, Oklahoma enjoys a strong revealed comparative advantage in the pork sector. When compared to surrounding states, Oklahoma's comparative advantage is almost twice that of North Carolina's, a leading pork meat producer, and almost 60 percent higher than Missouri. Even Texas, a state that typically dwarfs Oklahoma in any type of industry, has a much lower RCA, as seen in **Figure 9**. While having a strong revealed competitive advantage does mean that Oklahoma is well-suited for producing and exporting pork, that advantage does not always correlate to higher amounts of exports. In fact, in 2018, Oklahoma only contributed about half as much as Texas to the nation's exports of pork. While there are many other factors involved in making a successful exporter, with such a high RCA, Oklahoma should be capturing more of the value within this market.

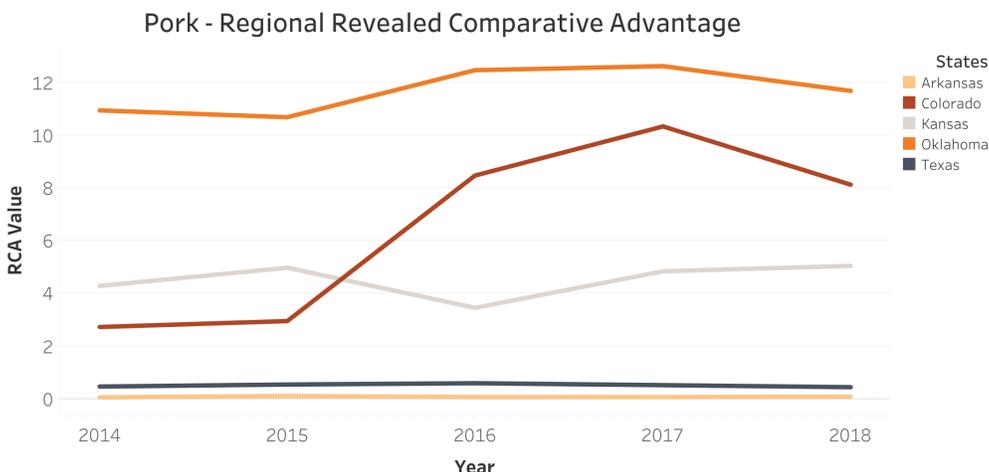


Figure 9: Pork RCA Graph. Source: CITD Analysis.

### Supply Chain Network

A very important factor for the pork meat export sector is the need for vertical integration in the supply chain. Most of the value added in the pork sector is later in the chain and many Oklahoma pork meat producers lack the capacity to reach clients in far-away international markets and participate as suppliers for larger corporate actors due to high overhead costs related to logistical, legal, and financial capacity. Due to these high overhead costs and regulatory requirements, the market is dominated by large and very large meat and food processing corporations. Many of these operate in Oklahoma, purchasing live hogs and pork meat from local producers and further processing and marketing that meat in international markets. Some of these firms include names like JBS USA (property of Brazilian meat-processing giant JBS, the largest meat-processor in the world), as well as Tyson Foods, from Springdale, Arkansas, Cargill Meat Solutions, from Wichita, Kansas, Smithfield Foods, from Smithfield, Virginia, and Seaboard Foods, from Shawnee Mission, Kansas. Seaboard Foods operates the largest pork slaughter and packing plant in the state, which is located in Guymon, Oklahoma.



Remarkably, although Oklahoma is a large pork meat producer in the national context, Oklahoma firms do not appear in the short-list of dominant actors in the sector. One Oklahoma firm Lopez Foods, registers 48<sup>th</sup> in the National Provisioner's 2018 Top 100 Meat & Poultry Processors.<sup>43</sup> Headquartered and operating out of Oklahoma City, López Foods employs more than 1,000 persons and markets processed pork meat products both nationally and internationally. Working with local firms to create the capacity and infrastructure to engage in international trade could prove an important area for state policy. Having such firms will allow Oklahoma actors to capture an increasing share of value within this value chain as well as generate high-skill, high-paying quality jobs associated with business management, planning, marketing and operations. As it stands now, most of these jobs in the Oklahoma pork meat export sector, with the exception of Lopez Foods, are located outside the state.

### Insights and Observations

When analyzing pork production and export statistics, an interesting fact stands out. Although Iowa's pork production is almost eight times larger than Oklahoma's, Iowa's pork industry is less dependent on exports. In 2018, according to data from the U.S. Census Bureau, 24.1 percent of Oklahoma's pork production was destined for international markets, compared with a more moderate 14.8 percent for the Iowan pork industry. That means that a quarter of every dollar Oklahoma earns through the sale of pork meat came from abroad, an important takeaway from our analysis.

Another important insight arises when we look at Oklahoma's most important export markets: Japan, Mexico, and South Korea. Interestingly, these markets exhibit different pork consumption preferences. The Japanese market, a very affluent market with a preference for lean meats, is a large (and growing) buyer of high-value pork cuts. Another growing market, albeit for a different type of meat cuts, is Mexico. Mexican consumers prefer the fattier cuts traditionally used in Mexican cuisine, making this an excellent market for lower value, higher volume pork meat exports. This knowledge can be used when developing an export strategy.

Other markets to which Oklahoma currently exports pork meat also offer opportunities. For example, China, the world's largest pork meat consumer, is seeing its local production devastated by African swine flu. Estimates range between 30 and 50 percent of lost production, which could create a boon for countries with available pork meat to sell to the Chinese market.<sup>44</sup> While the tariffs associated with the U.S.-China trade war have been a stumbling block for Oklahoma pork exporters, if the supply drops enough, then prices could allow for greater exports even with the tariffs. Other exporters, such as Brazil, the European Union and Canada have all capitalized on this opportunity without retaliatory tariffs in place and have increased their shipments to the Chinese market. South Korea, on the other hand, is a growing consumer of high-value pork cuts and has an FTA in place with the United States. The growing South Korean economy and evolving consumption trends mean that this niche can prove an interesting market for Oklahoma pork producers to explore further.

The time for Oklahoma pork producers to seek new opportunities in trade is now. Although the value of U.S. pork exports has grown by 26.2 percent between 2008 and 2018 (when it reached \$5.87 billion (USD)), Oklahoma's pork exports have remained relatively stagnant. The value of pork exports from Oklahoma has gone from \$185.2 million (USD) in 2008 to \$197.3 million (USD) in 2018, a 6.5 percent growth rate. This means that for some reason, Oklahoma pork producers are not getting a fair share of this export growth. Markets like South Korea have seen the value of their U.S. pork imports double between 2008 and 2018 (going from \$229.48 million (USD) to \$595.28 million (USD) in 2018), and Oklahoma pork producers could benefit more from this surge in pork imports.<sup>45</sup> Next steps the industry might consider pursuing include further research into the market conditions that act as barriers to entry for smaller actors and the dynamics behind the development of local firms to be able to scale to engage in international trade, capture more value and generate quality jobs locally.

# COMMODITY LEVEL ANALYSIS

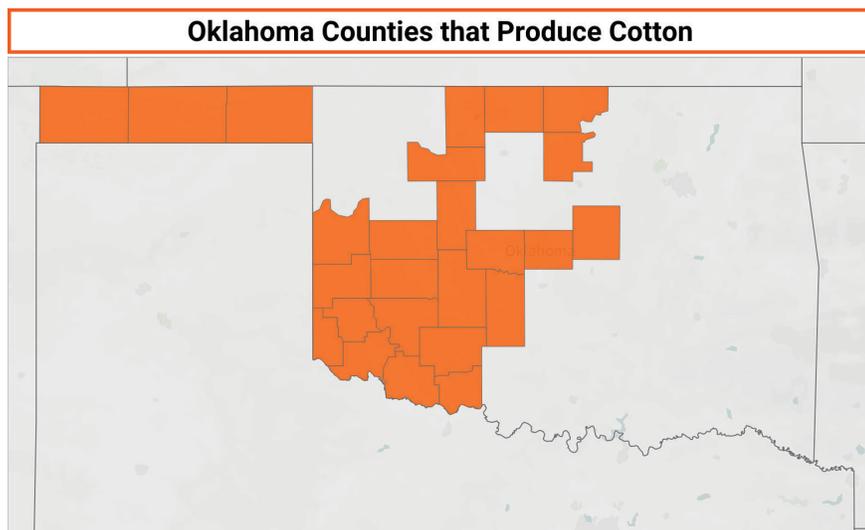
## HS 5201: Cotton; Not Carded or Combed

### Overview

Historically, cotton has been integral to Oklahoma's economy. It was the predominant agricultural commodity in the state from 1910 to the late 1930s. Today, it remains an important crop for local farmers.<sup>46</sup> In 2017, 25 counties in Oklahoma were involved in the production of cotton (**Figure 10**).<sup>47</sup> In 2018, the state exported cotton to 17 countries. The total dollar value of Oklahoma cotton exports reported by the United States Census Bureau was \$165 million (USD).<sup>48</sup>



For what seems to be a simple agricultural product, the global path of cotton is quite a storied one. For instance, the U.S. is the largest exporter of the raw material of cotton, providing 41 percent of the world's cotton in 2018. Countries that import U.S. cotton convert those raw materials into apparel and other finished goods. Many of these clothing and apparel items are then imported by the U.S.



**Figure 10:** Cotton-Producing Counties in Oklahoma.  
Source: CITD Analysis.

Vietnam with 6.86 percent and South Korea with 2.81 percent. In order to determine which items to include in this analysis, we turned to article 61, from the harmonized tariff schedule, which contains 25 commodities at the six-digit code level ranging from briefs to bathrobes to blazers. Any type of apparel and clothing accessories, knitted or crocheted which included "Cotton" in their description, were included in the analysis.

By analyzing data from the U.S. Census Bureau, we witness this phenomenon at the state level. The cycle begins with raw material cotton exported from Oklahoma to locations around the globe. In 2018, over a third of Oklahoma exports went to Vietnam, followed by China, South Korea, and Indonesia. The destination and density of exports for 2018 numbers are visually shown in **Figure 11**.

According to the values reported by the United States Census Bureau, Oklahoma imported over \$27 million (USD) worth of cotton apparel. China is the main origin with 45.28 percent of the imports, followed by Bangladesh with 22.15 percent,

Largest Buyers of Oklahoma Cotton



Figure 11: Countries to which OK exports the raw material of cotton. Source: CITD Analysis.

In 2018, there were 12 countries importing cotton from Oklahoma and then re-exporting cotton apparel to Oklahoma. In total, 82.18 percent of the apparel analyzed in this report comes from countries to which Oklahoma also exported raw cotton, showing the path cotton takes around the world can be a full circle (Figures 11 and 12).<sup>49</sup>

Texas, a cotton giant, was responsible for half of U.S. cotton exports in 2018. Although Oklahoma cotton exports only accounted for 2.5 percent of the national cotton exports that same year, Oklahoma was still ranked as the sixth largest cotton export state. Not only is Oklahoma integral to the cotton trade for the U.S., the U.S. cotton trade is integral to Oklahoma's economy.

Oklahoma Suppliers of Finished Cotton Goods

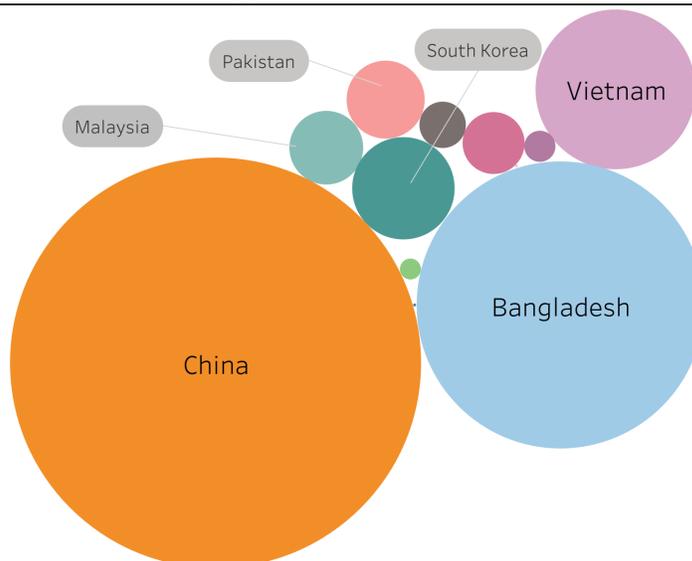
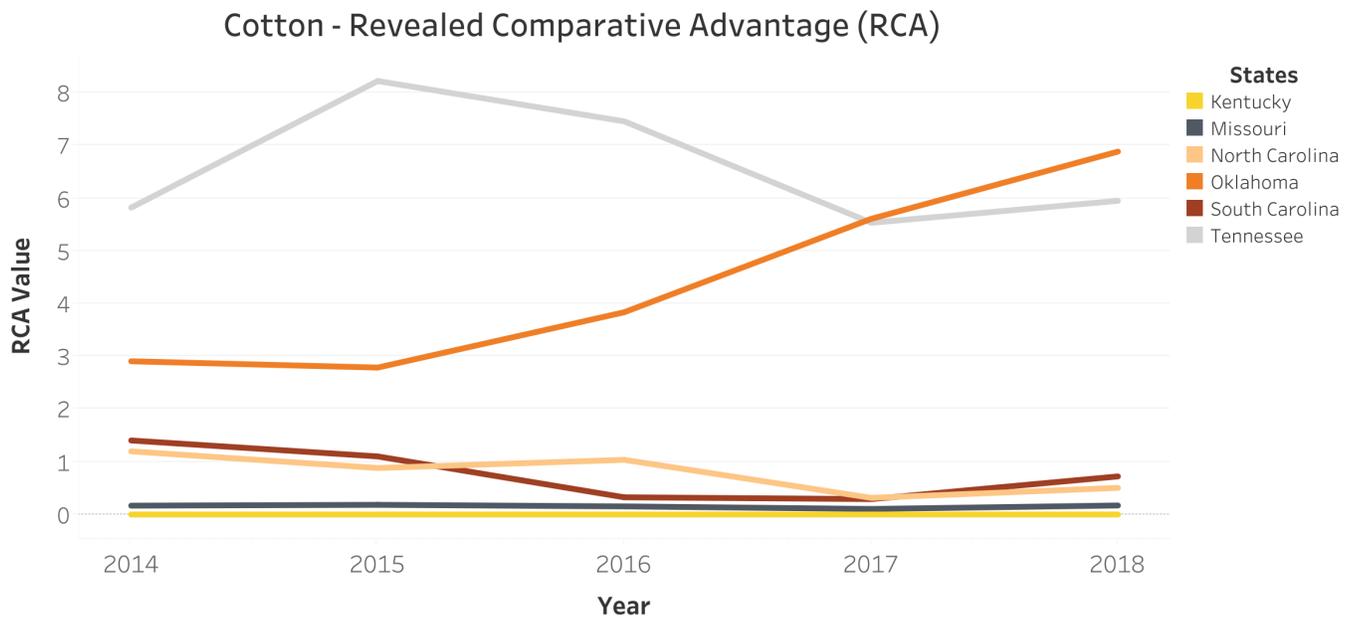


Figure 12: Countries from which OK imports cotton goods. Source: CITD Analysis.

## Competitiveness

In 2018, OK cotton exports were valued at \$165.21 million (USD), accounting for 2.7 percent of the total exports from Oklahoma that same year. Clearly, cotton production is one of Oklahoma’s strengths. This is further demonstrated by analyzing how the revealed comparative advantage of cotton production in Oklahoma stacks up alongside other states that have similar median household incomes (**Figure 13**). While Oklahoma has maintained and increased its revealed comparative advantage for this raw material, Tennessee is a strong performer as well, and in 2018, had a much larger overall market-share for U.S. cotton exports than Oklahoma at 11.68 percent.



**Figure 13:** Cotton RCA Graph. Source: CITD Analysis.

## Supply Chain Network

Raw cotton consists of cotton fibers and seeds which are separated from the plant when harvested. Cotton fibers are used mostly in the apparel industry. The seeds, divided into linter or cottonseed, are utilized for different purposes. The linter is used to produce paper, polymers, and industrial products. Cottonseed is a material used in the production of oil, cattle feed, cooking fat, and fertilizers. According to the National Cotton Council of America, 57 percent of all cotton is utilized in the apparel industry, another 30 percent goes to the production of home furnishings, and the remainder is used for industrial products.<sup>50</sup>

Liu et.al. describe the complete supply chain: “The supply chain starts with picking the cotton boll and ginning to separate cotton lint and seed. Merchants or traders then buy cotton in bales which are sold to mills in the global markets. Spinners and yarn mills use a mixture of cotton and other fibers to produce yarn and fabric. A textile factory then converts the fabric into the final products sold to the apparel and other industries. The retail industry distributes and sells the final products to consumers.”<sup>51</sup> This process is shown in **Figure 14**.

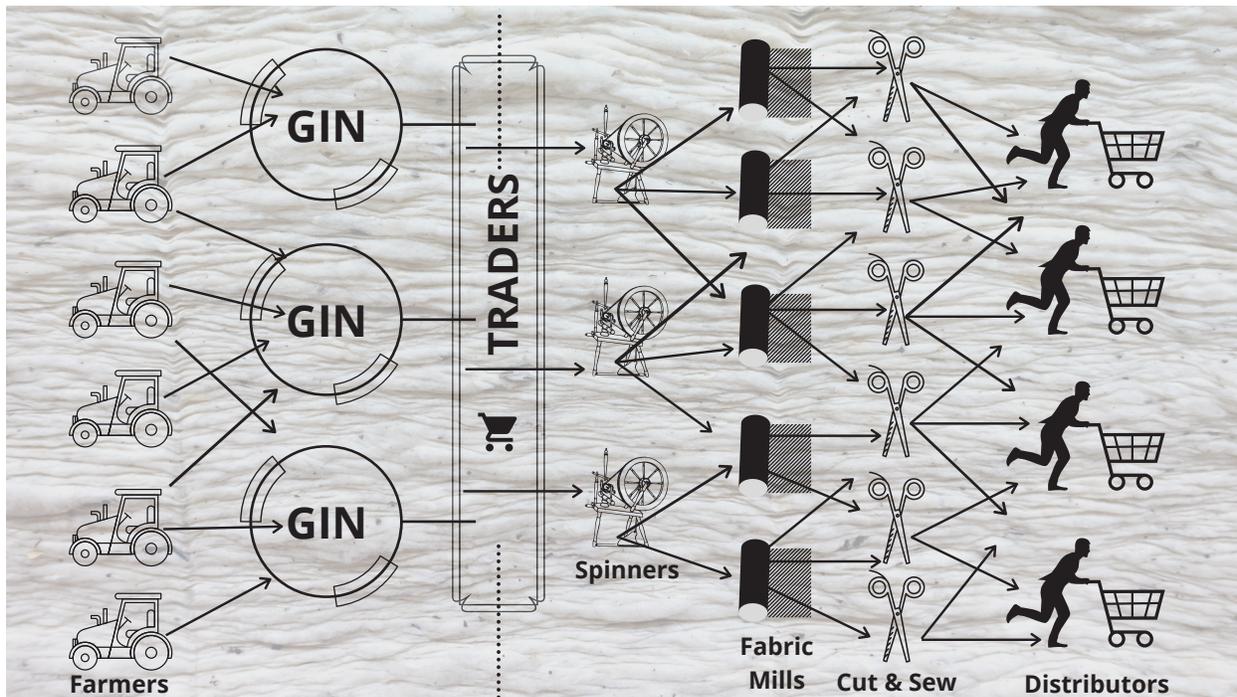


Figure 14: Textile supply chain. Source: CITD Analysis.

## Insights & Observations

Over the past few decades, the media has shined a light on issues within the cotton supply chain regarding both labor rights and pollution. Additionally, consumers have become more concerned with the societal and environmental impacts of the products they buy, which has led to dramatic changes in the clothing industry overall. It is now quite common for fashion industry firms to integrate sustainable initiatives on a firm-wide level.<sup>52</sup> For the apparel industry, that means large companies like Wrangler, Levi's and Nike are determined to obtain sustainably sourced cotton in order to reach their new, more environmentally-friendly standards.<sup>53</sup>

As a response to these changes in demand, cotton producers have created sustainable goals for cotton production. The U.S. Cotton Protocol is expected to be the world's leading resource on sustainable cotton production. The protocol includes mandates which will boost soil carbon by 30 percent, and increase land-use efficiency by 13 percent. This protocol also aims to decrease greenhouse gas emissions by 39 percent, cut down soil loss per acre by 50 percent, slash water use by 18 percent, and reduce energy consumption by 15 percent.<sup>54</sup>

# COMMODITY LEVEL ANALYSIS

## HS 8415: Air Conditioning Machines; Comprising A Motor Driven Fan And Elements For Changing The Temperature And Humidity, Including Those Machines In Which The Humidity Cannot Be Separately Regulated

### Overview

Air conditioning (AC), a much-loved machine in the U.S., regulates the air in a car, room, or building to a set temperature in order to provide comfort. In the U.S., approximately 75 percent of all homes have an air conditioner. Combined, these machines use 6 percent of all the electricity generated in the country. Additionally, they generate 117 million metric tons of carbon dioxide emissions and are therefore subject to environmental regulations.<sup>55</sup>

At the four-digit level, HS 8415, Oklahoma exported commodities to 48 countries with a total export value of \$114 million (USD) in 2018. The bulk of these exports, 81.14 percent, went to Canada, followed by Mexico with 5.38 percent, and the remaining 13.48 percent went to 46 different countries. Furthermore, the analysis of this commodity at a six-digit level revealed that 62.66 percent of exports correspond to HS 841582,\* or rather, the actual end-product of an air conditioner. Many of the parts used in the manufacturing of these air conditioners are imported by Oklahoma. In fact, in 2018, Oklahoma imported around \$20 million (USD) worth of commodities at the four-digit level (HS 8415), the bulk of which came from Mexico (38.6 percent) and China (20.83 percent), and a breakdown of these imports at the six-digit level (HS 841590) demonstrates that the majority of Oklahoma's imports in this category are "parts of air conditioning machines."

This indicates that Oklahoma is adding the bulk of the value to these machines by utilizing the imports of air conditioning machine parts and converting them into their final form to then sell to end consumers. This part of the supply chain is where most of the benefit within the industry lies, making it a profitable endeavor for Oklahoma firms.

### Competitiveness

In 2018, Texas was the leading producer of air conditioners in the nation and exported 20.1 percent of the national total for this commodity. By comparison, Oklahoma was ranked seventh in the nation for exports of the HS 8416 commodity (see HS 8416 section for more analysis of that commodity). Regionally, both Texas and Oklahoma outperform their neighbors, Arkansas, Iowa, Kansas and Missouri, which have a smaller share of national exports.

However, Ohio, a state with a similar median income, but a much lower RCA (seen in **Figure 15**), is responsible for more export market share at the four-digit level for this commodity. The revealed comparative advantage estimated for the other states with similar household incomes show that Oklahoma has a strong and growing comparative advantage from 2014 through 2017, but it appears to have tapered off in 2018.

\* Air conditioning machines comprising of a motor-driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be separately regulated; incorporating a refrigerating unit.

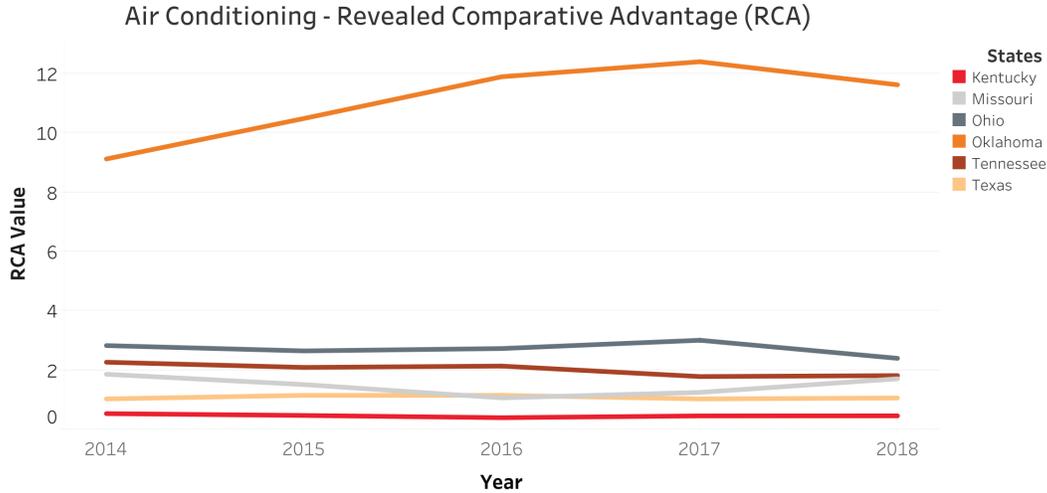


Figure 15: Air Conditioning RCA. Source: CITD Analysis.

### Supply Chain Network

Air conditioner manufacturing consists of a truly global and complex supply chain. One key component in the AC manufacturing process is the compressor, which consists of several parts and substances from different HS Codes. Compressors are then combined with both small and complex parts in order to assemble an air conditioning machine. Finally, finished air conditioners are shipped to customers via dealers, directly to clients with large project contracts, or exported to foreign markets. **Figure 16** illustrates the supply chain.<sup>56</sup>

## 8415 Supply Chain

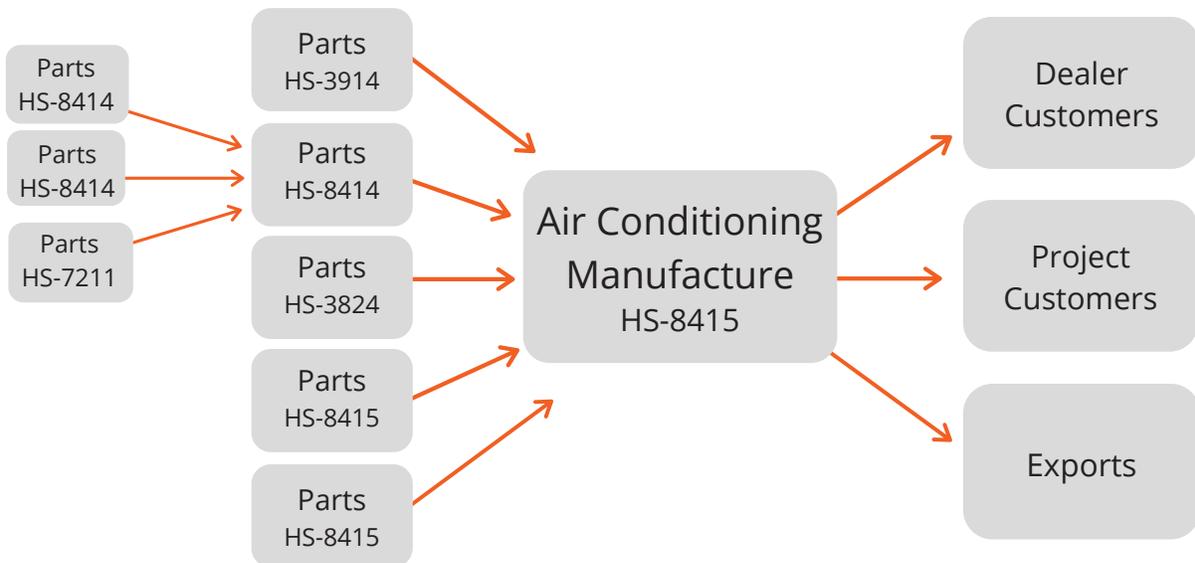
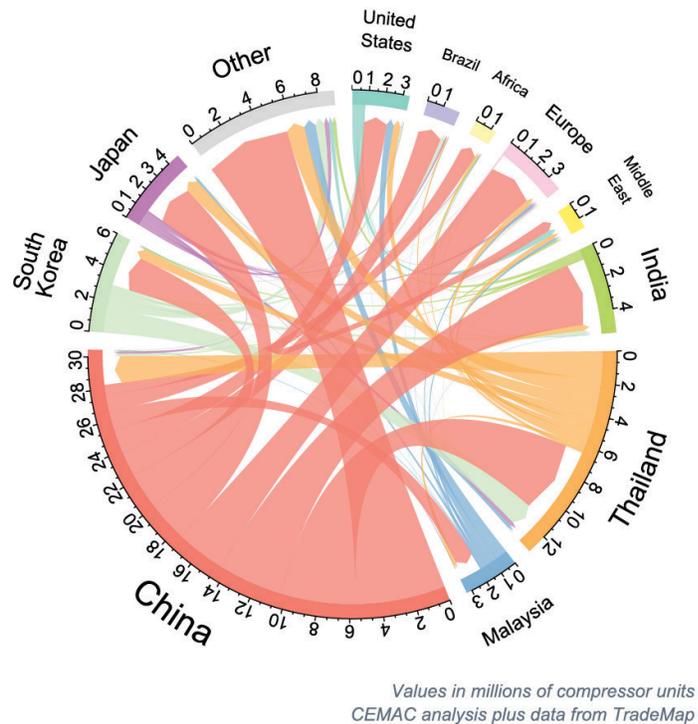


Figure 16: Air conditioning supply chain representation. Source: CITD Analysis.

## Commodity Level Analysis: HS 8415

Economies of scale are important for complex supply chains such as the one involved in air conditioning manufacturing, especially for those processes which count on the production of small parts. Therefore, it is not surprising that the major players involved in AC manufacturing (the U.S., China, Japan, and South Korea) already have the infrastructure necessary to achieve economies of scale. As discussed, compressors are a key component within the AC supply chain, and China produces most of the world's compressors, as seen in **Figure 17**.<sup>57</sup> However, the manufacturing of these compressors also requires parts from several countries. Compressors made in China are typically produced with machine parts from the U.S. and South Korea, and lubricants from Japan.<sup>58</sup> Although China produces nearly a third of the world's compressors, the amount they export only represents 17 percent of the compressors produced by the country. The remainder are utilized to supply local manufacturing demands. The second largest compressor exporter is Thailand, followed by South Korea.



**Figure 17:** Trade flows in 2017 of room air conditioning compressors. The arrow's origin shows the origin of the compressor, the arrowhead points to the destination. Shares are calculated based on values in millions of compressor units.

## Insights & Observations

Two major threats within the air conditioning industry include growing tensions due to fierce competitiveness, and the rising need for research and development in order to keep up with the recent trend of stronger environmental regulations.

Intellectual property is crucial in this complex supply chain network due to the intense research and development efforts required to successfully gain competitive advantage. Patents and patent protection are important tools utilized by companies to secure their competitive edge. Toward the end of 2019 and early in 2020, turf wars on many manufactured products emerged, especially for those protected by patents. Additionally, the AC industry has not been spared in the trade war between the U.S. and China as some products within this supply chain have been affected by retaliatory tariffs by both countries.<sup>59</sup> Overall, these dynamics in the trade environment disrupt the supply chain and create more costs for the end consumer. Since Oklahoma firms are a part of this supply chain at multiple levels, the state will be especially susceptible to fluctuations within this market.

Many of the current research and development goals within the industry aim to create higher energy efficiency through the improvement of lubricants and oils as well as technologies for rotaries, inverters, controls, etc. If real progress is to be seen on the environmental front while companies fiercely protect their patents, cooperation will be required to phase out substances that deplete the ozone layer such as the hydrofluorocarbons (HFCs) used in refrigerants.\*

\* The Montreal Protocol is an agreement created in 1987 to regulate the production and consumption of ozone-depleting substances. As part of the protocol, in 1991 the Multilateral Fund was created to help developing countries with financial and technical assistance for the implementation of the Montreal Protocol. There are ongoing projects in China, Thailand, Vietnam, and Indonesia, among others, to transitioning from the ozone-depleting refrigerant to ozone-friendly refrigerants ones. United Nations. (n.d.). The Montreal Protocol. Retrieved from <https://www.unenvironment.org/ozonaction/who-we-are/about-montreal-protocol>

# COMMODITY LEVEL ANALYSIS

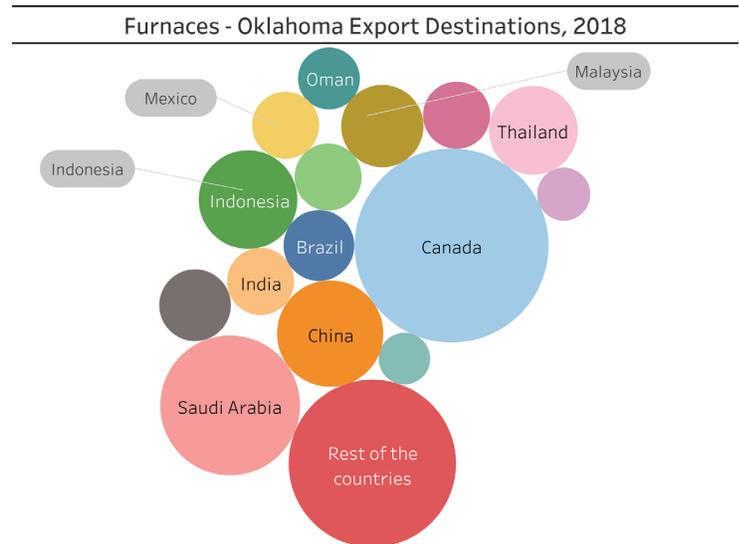
## HS 8416: Furnace Burners For Liquid Fuel, For Pulverized Solid Fuel Or For Gas; Mechanical Grates, Mechanical Ash Dischargers And Similar Appliances

### Overview

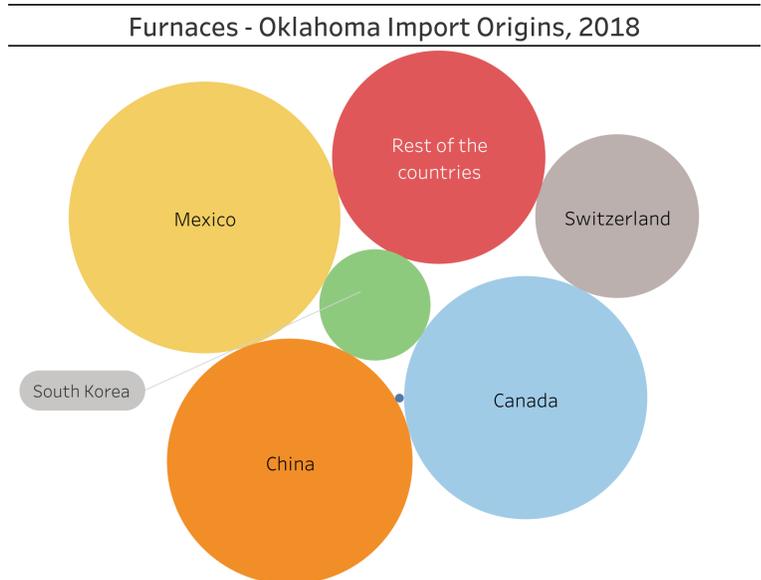
A furnace burner is a component of machinery designed to use the chemical energy stored inside fuel to create heat. This heat can be used for heating buildings or for power applications. For instance, furnace burners are an integral part of a boiler intended to heat water or to create steam for industrial, commercial or institutional processes. The common fuels used in burners are oil, coal, and natural gas. Gases are created as a reaction of the combustion, and controls on those emissions are required. Furnace burners are manufactured in different sizes and types according to the use and type of fuel they burn. Specifically, at the four-digit level, furnaces are categorized by the type of fuel they use and the parts they need to operate, as well as the parts used to assemble or repair them.

Oklahoma exported \$57 million (USD) and imported \$12 million (USD) in 2018. In 2018, Canada was the main destination with 23.74 percent of total exports. The second destination was Saudi Arabia with 12.33 percent followed by China (7.13 percent), Indonesia (6.14 percent), and Thailand (4.97 percent). On the import side, almost a third of the value, or 29.39 percent, came from Mexico, followed by China with 24.02 percent, Canada with 23.54 percent, and Switzerland with 10.67 percent. The export and import relationships for OK and HS 8416 are shown in **Figure 18 and 19**.

Several companies in Oklahoma manufacture furnace burners or parts. Activities include in-house design capabilities for industries, boilers, services for design and maintenance, and equipment manufacturing to measure the performance of the burners. Most are located in Tulsa and its surrounding areas.



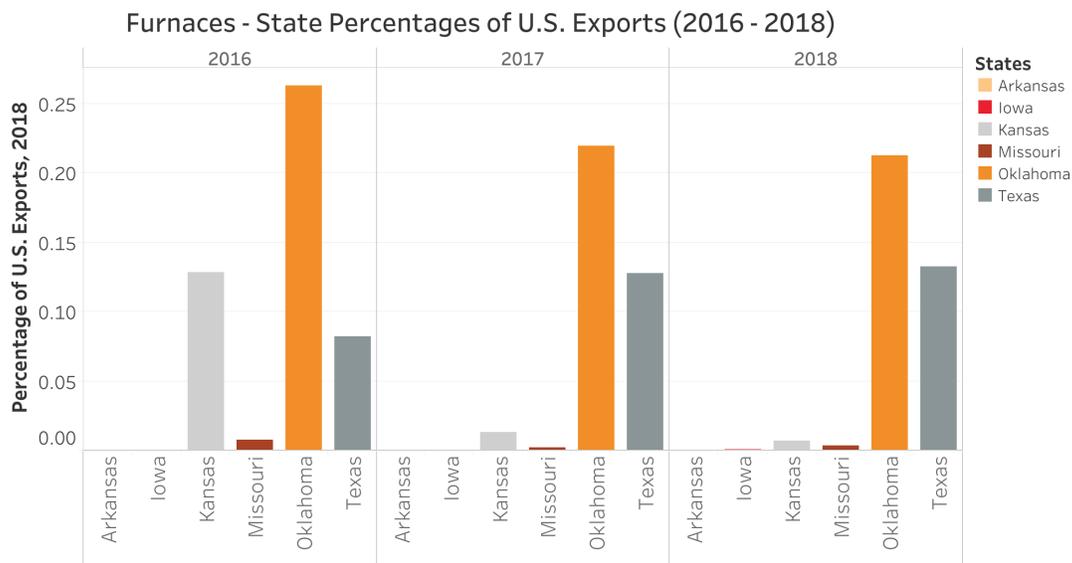
**Figure 18:** Countries to which OK exports furnaces. Source: CITD Analysis.



**Figure 19:** Countries from which OK imports furnaces. Source: CITD Analysis. Source: CITD Analysis.

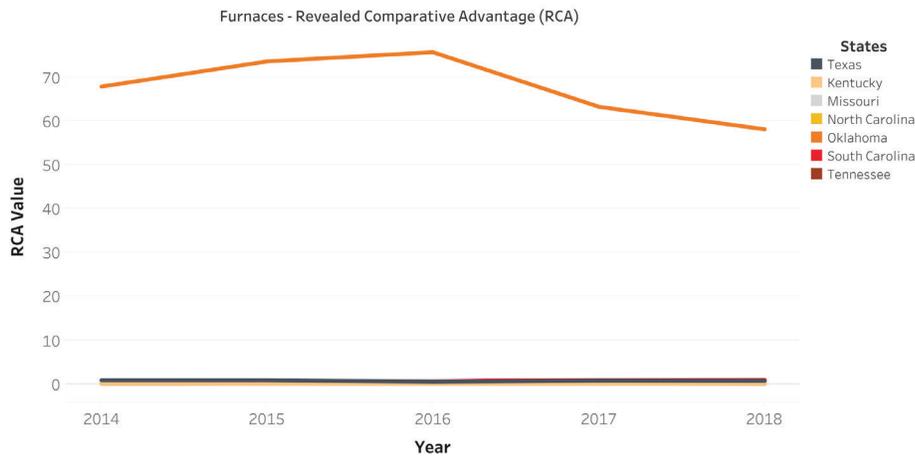
## Competitiveness

Oklahoma is the number one state exporting this commodity, with 21.29 percent of the country value exported in 2018. In general, the U.S. experienced a decline in exports for this commodity from 2016 to 2018 going from \$316 million (USD) to \$267 million (USD), or 15.51 percent. However, the relative reduction of exports from Oklahoma was double that, going from \$83 million (USD) in 2016 to \$57 million (USD) in 2018, a 31.33 percent decline. When combined, the exports for Arkansas, Iowa, Kansas, and Missouri account for only 1.11 percent of 2018 U.S. exports. Yet, during this same period, Texas, the second-largest exporter with 13.27 percent of the country value, experienced a 34.62 percent increase in the value of exports from \$26 million (USD) in 2016 to \$35 million (USD) in 2018. While Oklahoma continues to lead in the exporting of this commodity, the decrease in export value indicates a need for firms, in cooperation with the state and federal policymakers, to examine the root cause and address the decline to prevent further market share erosion. The values are shown in **Figure 20**.



**Figure 20:** State share of U.S. exports for 8416.  
Source: CITD Analysis.

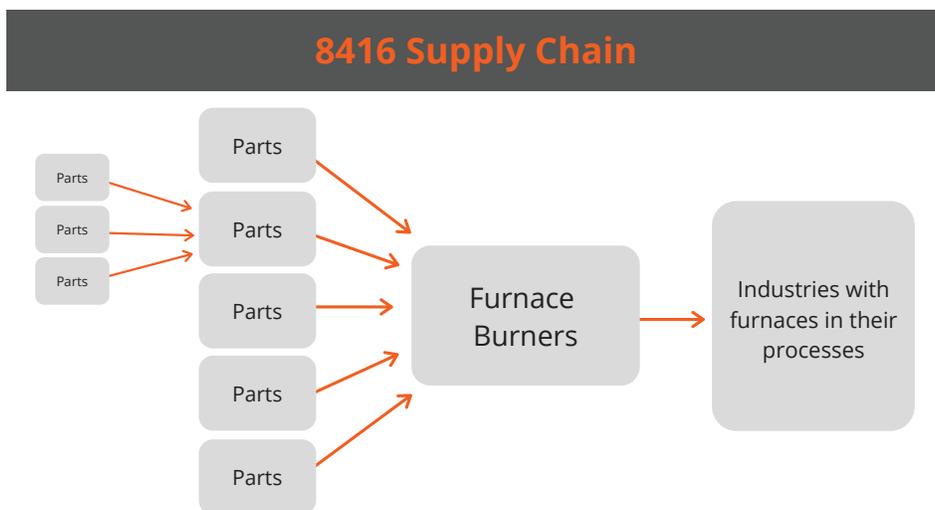
As noted above, Oklahoma is the leading state exporting this commodity. It also maintains a relative comparative advantage, but this advantage was receding between 2016 and 2018. The rest of the comparison states in **Figure 21** showed no comparative advantage exporting the commodities that fall under the HS 8416 classification. Although Oklahoma is the biggest exporter of this commodity, a deeper analysis should be conducted to determine what factors are affecting the state's performance. Especially considering that studies are concluding that the trade policy in 2018 and 2019 affected manufacturing industries; and this industry (NAICS code 3339) is listed as number nine in the top ten domestic industries that are most affected by increased costs as a result of the new import tariffs.<sup>60</sup>



**Figure 21:** Furnace RCA Graph  
Source: CITD Analysis.

### Supply Chain Network

Within the commodity HS 8416, there are four subdivisions at the six-digit level: A) for liquid fuel and pulverized solid fuel/gas; B) others, including combination burners; C) for appliances such as stokers and ash dischargers, and D) parts of furnace burners. For Oklahoma, roughly 98% of the value of the goods Oklahoma exports within HS 8416 are from subdivisions A and D. The supply chain for HS 8416 is not as complex as other commodities, as the parts which make up the finished product are all within the same HS Code. A key component within the supply chain for HS 8416 is parts of furnace burners, which are a significant portion of the value of goods Oklahoma exports of commodity HS 8416. The supply chain works as follows; the small parts are completed so they can be combined with the more complex parts. From there, the small and complex parts are assembled to form the furnace burners. Finally, these furnace burners are integrated into an industrial process. On the next page, **Figure 22** illustrates the supply chain.



**Figure 22:** Furnace supply chain  
Source: CITD Analysis.

### Insights & Observations

This industry is impacted by trade and environmental policies in particular. We see this in Oklahoma's trade patterns for HS 8416, but the impact appears to be reflected nationally as well in the decrease of overall U.S. exports of HS 8416 from \$378.98 million (USD) in 2014 to \$267.94 million (USD) in 2018, a drop of 29.30 percent. Also notable is the fact that most of the change occurred after 2016. From the trade policy standpoint, production currently relies on imports for inputs, particularly from Mexico, China, and Canada and may be negatively impacted by high tariffs, which ultimately make Oklahoma's end-product less competitive globally. On the environmental policy side of the equation, there are countries that have been given time to decrease emissions of atmospheric pollutants that in the U.S. are restricted by regulations such as the 1970 Clean Air Act. Because the restrictions in the U.S. are stronger than in some other countries with whom U.S. firms compete for exports, and complying with those regulations adds cost, U.S. prices for these goods may become less competitive. One way to overcome these challenges may be through research and development which could lead to less expensive production of final goods that still meet regulatory requirements, as well as increased efficiency as a product attribute. At the same time, R&D could also lead to identifying sources for inputs from regions where exposure to high tariffs may be reduced. Further research is needed to validate these hypotheses.

# COMMODITY LEVEL ANALYSIS

## HS 8481: Taps, Cocks, Valves And Similar Appliances For Pipes, Boiler Shells, Tanks, Vats Or The Like, Including Pressure-Reducing Valves And Thermostatically Controlled Valves

### Overview

While the full title ascribed to the four-digit heading of HS 8481 is quite challenging for those outside of the fields of machinery or engineering to penetrate, it can be broken down to three types of products (taps, cocks, and valves) with the primary use of all three being the transmission of fluid power. When examined at the six-digit level, the two most important categories of Oklahoma exports are HS 848140 – “Safety or Relief Valves”, which are rated for lower pressures such as those in sink and shower faucets, and HS 848180 – “Valves for Other Appliances”, which is for higher pressures such as those in aircrafts.<sup>61</sup> These items, manufactured here in Oklahoma, are the small pieces of equipment that support the integrity and extend the life of everyday appliances such as bath faucets as well as machining equipment used in many different industries i.e. transportation, engineering labs, oil pipelines, aerospace etc.

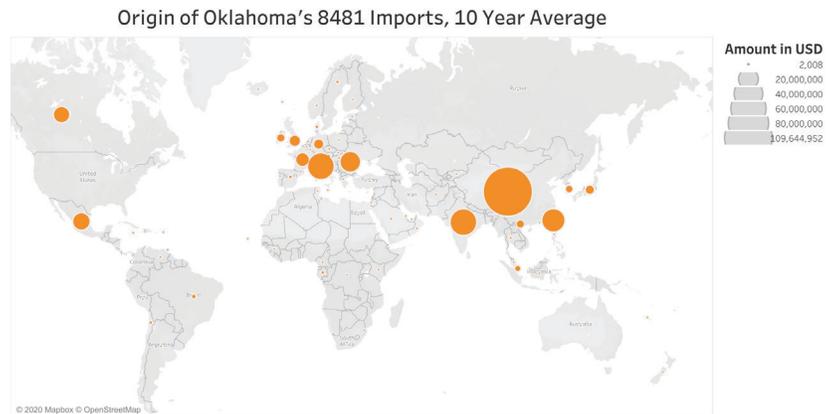


Figure 23: Import Trade Flows, 8481. Source: CITD Analysis.

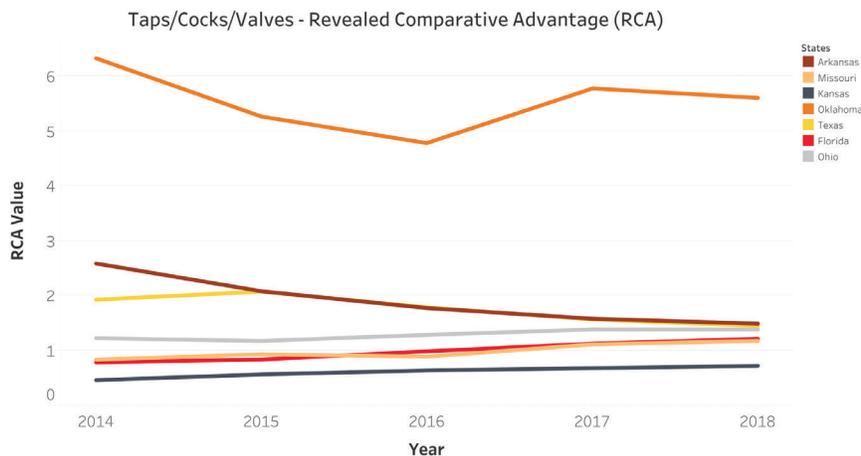


Figure 24: Export Trade Flows, 8481. Source: CITD Analysis.

At the four-digit level, HS 8481 is both a top import and export of Oklahoma. Additionally, the 10-year trends for HS 8481 exports and imports are quite similar. At first glance, this points towards a possible market inefficiency. However, as shown in **Figure 23**, the bulk of Oklahoma imports of HS 8481 are coming from China, and the bulk of exports are going to Canada (**Figure 24**). This indicates that either an important value-added process is taking place here in Oklahoma, or that Oklahoma’s imports in the HS 8481 category fill different needs within the state than those products that are exported. More research will need to be done to determine the total significance behind these trade flows.

## Competitiveness

Oklahoma has a noticeable revealed comparative advantage (RCA) for commodities under the HS 8481 heading, which means Oklahoma has a distinct edge at producing and exporting these items even when compared against other regional producers and producers with similar median income, as shown in **Figure 25**. However, it is also necessary to point out that even with a high RCA, Oklahoma does have a lower market share for exporting goods in the HS 8481 when compared to states with larger GDPs, like Ohio and Florida. A high RCA does put Oklahoma in an ideal position for market expansion for trade in goods under the HS 8481 heading, but it will take concerted efforts to differentiate Oklahoma producers in order to capitalize on this position.



**Figure 25:** Taps/Cocks/Valves RCA, Surrounding States.  
Source: CITD Analysis.

We also examined trade flows at the HS 8481 heading level over the last 10 years, and observed a sharp drop in both imports and exports from 2014 through 2016. This trend seemed to follow a similar pattern seen within the oil industry during the same time period,<sup>62</sup> suggesting that Oklahoma’s export and import of items under the HS 8481 category are tied to the oil industry. This was later supported by industry sources.<sup>63</sup> A specific observation of the 10 year-trend for the six-digit level code HS 848180 showed Oklahoma exports dropped from 2014-2016, while other nearby states, like Kansas, saw an increase – although they export this commodity at a much lower volume.

The exploration of export trends in other states and revealed comparative advantage in production led to further examination of the total market for HS 848180. All 50 states, the District of Columbia, and two territories (Puerto Rico and the U.S. Virgin Islands) have had some hand in the export market in this six-digit commodity over the last ten years. Though this is one of the most important commodities for Oklahoma, the state does not even crack the top 10 exporters of this commodity in the country at the four-digit or six-digit levels. Meanwhile, other states, like Illinois, Arizona, Florida, New York, and Wisconsin had very noticeable increases and were able to expand their reach over the last decade (**Figure 26**).

This is especially concerning considering the total market for this six-digit commodity is growing. Total U.S. exports of HS 848180 grew from \$4.2 billion (USD) in 2010 to \$6.4 billion (USD) in 2019, representing a 50 percent increase in the past 10 years. However, Oklahoma is losing market share. Even Texas, our fellow oil state and a state that produces and exports the lion’s share of this commodity, underwent a 4.3 percent market share loss in the past 10 years. This relationship is shown in Figure 26.<sup>64</sup>

848180 Market Share Wins and Losses from 2010 to 2019

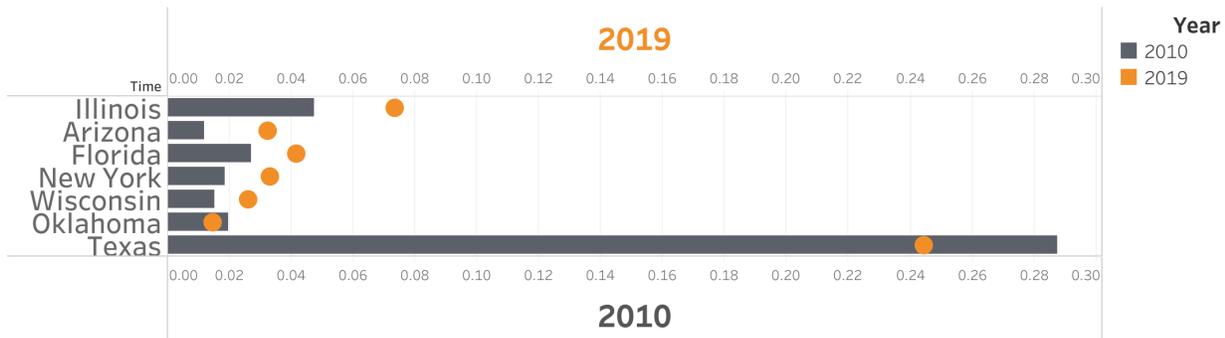


Figure 26: 848180 Major market share wins and losses from 2010 - 2019. Source: CITD Analysis.

### Supply Chain Network

Oklahoma’s source for its revealed comparative advantage in producing products under the HS 8481 heading is readily identifiable. While most of the raw materials needed for these products such as steel, iron, and tin are not produced in-state, Oklahoma does have access to one necessary raw material, copper,<sup>65</sup> as well as high-end manufacturing equipment, skilled technical workers and engineers, and proximity to transportation networks. Additionally, since these products are merely components of larger machinery, they are utilized in a myriad of industries including those that have historically been tied to the fabric of Oklahoma business. The largest of these being oil production and pipelines as well as the aerospace industry. However, while these connections have proven advantageous in the past, it is imperative that manufacturing in Oklahoma diversifies its markets to be less reliant on the oil industry in the future.

### Insights & Observations

Industry sources have shared with us that they are not always informed of the exact end-use of their products, so it is difficult to know exactly what needs may arise within the supply chain, or what potentially untapped markets lie in wait.<sup>66</sup> If a large portion of exports of HS 848180 are tied to the oil industry then manufacturers should look to expand into other oil extraction markets or explore market diversification as Oklahoma’s revealed comparative advantage in producing and exporting items in the HS 8481 category support the notion that there may be market share out there waiting to be captured by Oklahoma producers.

# COMMODITY LEVEL ANALYSIS

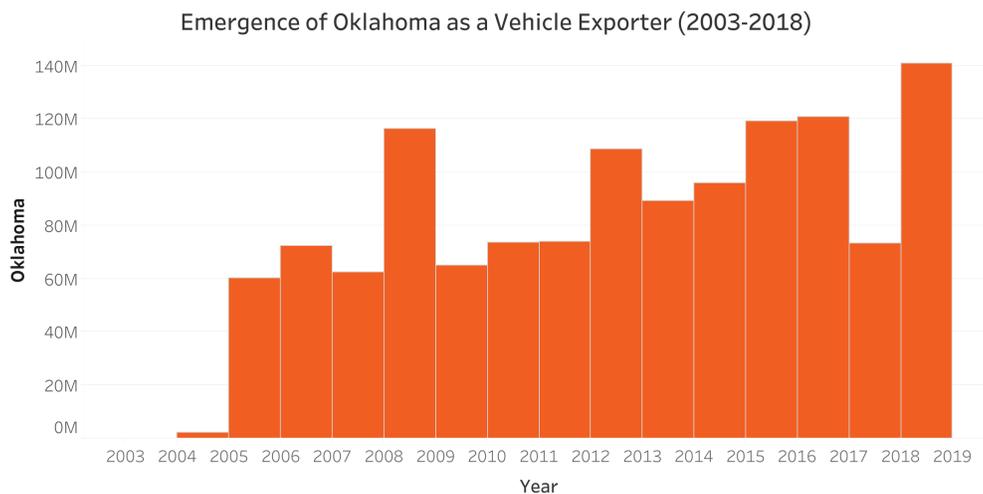
## HS 8702: Vehicles; Public Transport Passenger Type

### Overview

HS code 8702 refers to transportation buses. The size of the buses varies, but as explained by the code's specification, it includes only those vehicles for the transport of 10 or more persons, including the driver. This eliminates large SUVs from the category. The subcategories within HS 8702 include variants with different engine types and sizes, fuel types, and used and new.

In 2018, Oklahoma exported \$140.8 million (USD) worth of public transport vehicles. The export value for this category started from nearly nothing in 2003 but grew steadily to reach a value of \$116 million (USD) in 2008. From then on, export values have fluctuated, going from \$119 million (USD) in 2015 to \$73 million (USD) in 2017, but averaging roughly \$100 million (USD) a year. The rapid emergence and growth of this industry in Oklahoma, shown in **Figure 27**, is likely related to the 1999 opening of the IC Bus of Oklahoma plant in Tulsa. After some years spent getting production running, exports from that plant began in earnest in 2004. Trade facilitation (in the form of changes to or implementation of NAFTA terms) with Canada might have also played a role in IC Bus's decision to pursue international expansion.

Oklahoma has quickly made a name for itself within this industry and in 2018 was the third largest U.S. exporter of this commodity. For comparison, New York, the largest U.S. exporter, has a market share only 6% greater than Oklahoma's.



**Figure 27:** Oklahoma's growth in the vehicle export market from 2003 to 2018.  
Source: CITD Analysis.

IC Bus of Oklahoma is the largest manufacturer for HS 8702 in Oklahoma with a revenue of \$10.25 billion (USD). The company is a subsidiary of Navistar International Company, headquartered in Lisle, Illinois. In 1999, IC Bus opened a production facility at the old Air Force Plant 3 near Tulsa International Airport. All the company's buses are assembled in its Tulsa facility, which employs over 1,200 persons and has been gradually expanded during the last 20 years. In 2018, IC Bus had a nearly 50 percent market share in the school bus segment and it is investing heavily in innovation and new technologies to keep up with a changing market.<sup>67</sup>

From 2013 to 2018, over 90 percent of HS 8702's exports went to Canada and primarily consisted of school and shuttle buses. As with other vehicles produced in the United States, factors like fuel consumption, spacious design, engine size, similar road size and specifications make Canada a natural (and one of the few) export markets for American-made vehicles. Other factors such as purchasing power, school infrastructure, and cultural acceptance of this mode of transportation also make Canada one of very few good markets for U.S.-made buses.

Oklahoma accounts for 15.57 percent of the United States' exports of HS 8702. Besides Canada, which purchased \$948 million (USD) in 2018, the next largest market was Mexico, with \$40 million (USD), followed by Venezuela, with \$4.4 million (USD). In addition to international exports, in 2018, Oklahoma provided \$1.037 billion (USD) of domestic shipments of this commodity throughout the United States.

As mentioned previously, HS 8702 includes several types of buses. One of the most practical distinctions is used versus new. Low export values before 2003 most probably correspond to used buses being shipped by immigrants or businessmen to Mexico and Central America and being registered as "exports". After that year, a market began to develop in Mexico and Latin America for new, locally manufactured buses. Nevertheless, the overall value for HS 8702 over the past ten years has included a small percentage of used buses exported to Mexico, Central America, Armenia and Aruba, among other countries.

"From 2013 to 2018, **OVER 90 PERCENT** of HS 8702's exports **WENT TO CANADA** and primarily consisted of school and shuttle buses."

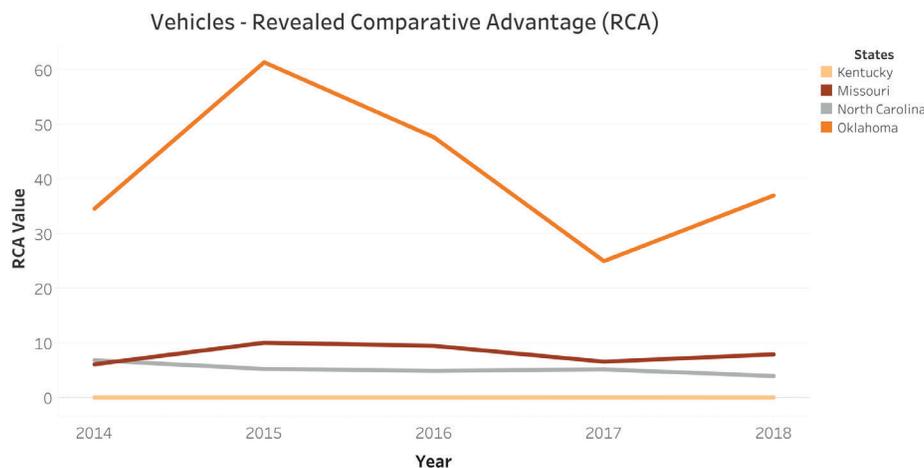
Based on product diversity demand, the U.S. also imported \$1.2 billion (USD) worth of buses in 2018. Half of these came from Canada (\$654 million (USD)), but a considerable amount came from other countries. Macedonia, site of Belgian coach-bus firm Van Hool production facilities, was the second source, with \$217.5 million (USD). Mexico (\$91 million (USD)) and Germany (\$81 million (USD)) were next, followed closely by Belgium (\$52.9 million (USD)), probably again related to buses of the Van Hool brand. It is important to note that imports of the Van Hool brand are not direct substitutes for the buses produced by IC Bus. Their market segments are different, with Van Hool

## Commodity Level Analysis: HS 8702

specializing in coach buses (the type used to haul teams or tourists around), whereas IC Bus's segments are school and shuttle buses.

### Competitiveness

Oklahoma has a decisive advantage over neighboring states in the export of buses. Oklahoma exported more than \$140 million (USD), which is more than Texas, Iowa, Kansas, Missouri and Arkansas combined (~\$83 million (USD)). As shown in **Figure 28**, Oklahoma's RCA for HS 8702 is volatile, but remains substantially higher than other states. The Tulsa production facility is a key asset that drives this sector's export activity. Competing facilities or brands are apparently not present in neighboring states, except for Missouri. This means there is a degree of advantage in this industry in Oklahoma and at a regional level.



**Figure 28:** Vehicles (8702) RCA.  
Source: CITD Analysis.

Imports of this commodity are very low, reaching only \$2.4 million (USD) in Oklahoma in 2018. Neighboring states (AR, MS, IA, KS) remain in a similar \$1 to \$7 million (USD) range. The exception is Texas, whose imports of buses in 2018 had a value of \$121.3 million (USD).

### Supply Chain Network

As discussed previously, IC Bus of Oklahoma is the largest producer and exporter of buses under the four-digit code 8702. Its parent company, Navistar, is a diversified, vertically integrated conglomerate. Assembly (and sale) of buses takes place in IC Bus's Tulsa facility making use of parts shipped in from Navistar's Conway, Arkansas factory, which is dedicated to parts production. However, Navistar sold the Conway, AR plant in 2017 to DBG, a Canadian metal product supplier. Parts produced in Conway are still being used in the Tulsa plant, but it is possible that imports from Mexico, China, or Western Europe also make their way into buses assembled at Tulsa.

Determining whether Navistar is responsible for a share of Oklahoma's imports in vehicle parts (HS 8708) requires further analysis, considering that the import might also be registered by plants dedicated to this activity in other states. A network analysis or mapping of Navistar's operational strategies would be required to answer these questions. Complicating this further is that the HS code for auto parts includes vehicle parts for all headings from 8701 to 8705, which include sedans, SUVs, tractors, and transportation and freight vehicles.

### Insights & Observations

While expanding the research to include the entire supply chain network was beyond the scope of this initial report there are several key takeaways. First, Navistar's IC Bus Corporation is the key actor in Oklahoma. The conglomerate also has strong investments in China, Canada, Mexico, and Brazil, which can open the door to increased foreign trade flows with those countries within this corporate network. Second, an important point in the international trade of HS 8702 is that it is strongly impacted by market peculiarities and regulations that require specific vehicle adaptations, according to Belgian coach manufacturer Van Hool. The same applies for American buses going abroad.

The market with most similar characteristics is limited to Canada, and eventually (after adaptations like right-hand wheel) Australia or New Zealand. **The export market for U.S. buses is thus extremely limited.** International market potential is concentrated in Canada (emphasis added).<sup>68</sup> Third, the development of alternative fuels and hybrid electric-diesel engines is a sector where Navistar is currently investing large amounts of money. Development of these new technologies can potentially transform and afford great advantages to actors in this market. Creating clusters that link these sectors with future implementers of these technologies as well as firms for whom they will be a core asset could be a strategy to help the sector in the state and stay ahead of the curve.

## CONCLUSIONS AND FUTURE RESEARCH

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In this report we have given a brief overview of why trade is good for Oklahoma, the overall state of trade for Oklahoma in each major sector, and a more detailed analysis of several commodities that Oklahoma exports. As we see it, the main value this report contributes to the discussion about trade in Oklahoma is the supply chain mapping for the specific commodities. We aimed to highlight the complexity of trade and a research methodology for how to best identify the challenges and opportunities facing Oklahoma in trade.

As shown in our analysis, the usefulness of supply chain mapping cannot be overstated. It can be used to identify new markets as well as determine if there are any missed opportunities in the value chain. For example, the analysis of the pork supply chain revealed that Japan may represent a good market for pork products that don't have an export market in Latin America; the analysis of oil imports showed that installed refinery capacity limit's Oklahoma's ability to process the oil extracted inside Oklahoma. Furthermore, as a global pandemic threatens to upend current supply chains, mapping those supply chains is increasingly important to prepare firms and policy makers to deal with future disruptions.<sup>69</sup>

Moving forward, the CITD has identified several potential paths forward for research in addition to firm-specific research needs we are considering. The first is a larger supply chain network analysis that will allow us to conduct predictive network analysis. Such analysis will better inform relevant actors for responding to market shocks, infrastructure needs, and limitations, as well as help identify new markets for exports. In addition to network analysis, we are also pursuing an effort to measure the depth of non-tariff trade barriers that Oklahoma exporters face in different markets by making use of latent space analysis using current non-tariff barrier measurements. Of course, we always welcome suggestions, or if you have specific research needs please reach out to the CITD.

# APPENDIX

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## Research Conducted at OSU

Oklahoma State University conducts copious amounts of research not only for the benefit of the growth within the academic fields but also to benefit Oklahoma as a state. OSU collaborates with farmers in order to research at least two areas concerning the production of cotton. The first has the goal of increasing land-use efficiency and is being performed by the Cotton Section of the Department of Plant and Soil Sciences. Dr. Seth Byrd, Assistant Professor, and Cotton Extension Specialist is involved with the ongoing research at OSU. The second cotton-related research project seeks to decrease water use. This research is possible due to the partnership between the Oklahoma Water Resources Research Institute and the Division of Agricultural Sciences and Natural Resources.

Furthermore, as a leading education institution in an agriculturally relevant state, OSU, conducts some important research related to the pork meat export sector. Dr. Phil Kenkel, Regents Professor and the Bill Fitzwater Cooperative Chair of the Department of Agricultural Economics, conducts some of the research on the livestock sector at OSU. In addition to veterinary and meat quality research, relevant research includes the sector's actors and the management of cooperatives, an important group of actors in this state's pork industry. The challenges facing these actors are essential for the market and can offer an opportunity for targeted efforts, which lead to an impact in international trade flows in this state's pork sector. Recently, alongside two academics, Dr. Gregory McKee, Professor of the Department of Agricultural Economics for the University of Nebraska-Lincoln, and Dr. Jay Parsons, Associate Professor of the Department of Agricultural Economics for the University of Nebraska-Lincoln; they published a paper covering market cooperatives within the livestock sector and the benefits that have emerged from their formation.<sup>70</sup>

While there are strong ties to agriculture, research at OSU also goes beyond that of agriculture. Research about the manufacturing sector, processes, market shares, and biofuels, etc. is also conducted. The School of Materials Science and the School of Engineering Mechanical and Aerospace Engineering, both from the College of Engineering, Architecture, and Technology (CEAT), has conducted research on how recent tariffs have affected the competitiveness of Oklahoma firms globally. OSU has the Institute of Technology, which offers the only Air Conditioning & Refrigeration (ACR) degree in Oklahoma, as well as the Building & Environmental Thermal Systems Research Group (BETSRG), part of the College of Engineering Architecture and Technology, which conducts research focusing on HVAC systems modeling, building energy simulation and refrigeration.

Dr. Raymond L. Huhnke, Professor Biosystems & Agricultural Engineering, is working on biofuel research in collaboration with Agricultural Sciences, Engineering, Architecture & Technology, University of Oklahoma, and Brigham Young University. The goal is to provide solutions for energy needs and long-term sustainability.<sup>71</sup>

Dr. Dan Rickman and Hongbo Wang at the OSU Center for Applied Economic Research at the Spears School of Business produce a quarterly Oklahoma Economic Outlook report that analyses and forecasts our state's economic conditions. These reports provide valuable and timely insights.

The research conducted at OSU is an important contribution to helping Oklahoma companies export and import products. It helps with identifying hurdles and providing substitutes for companies to branch out and expand their products and market share. This is just a sample of some of the research conducted at OSU, which pertains to the commodities covered in the report.

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