4 The Freight Future

Freight transportation is strongly interconnected to changes and trends in the economy and goods movement patterns. Given this interconnection, freight transportation is continually evolving. This chapter describes the future trends that are likely to affect freight transportation in Oklahoma.

4.1 ENERGY TRENDS

Oklahoma is a major energy producing state, which has important implications for national and international freight movements. Oklahoma's energy production profile includes crude oil, refined petroleum products, natural gas, and wind. In 2021, the state ranked sixth in the nation for crude oil production and third in the amount of electricity generated from wind.[11]

4.1.1 Oil and Natural Gas

Oklahoma has leveraged its location and history of oil production to become a hub of oil movement and pricing in the U.S. Tank facilities—housing up to 15 percent of U.S. oil storage capacity, located in the town of Cushing and connected to a system of pipelines crisscrossing the country—primarily influence the movement of oil throughout Oklahoma. Cushing serves as the basis for the pricing of U.S. sweet crude oil and is integral to both the physical movement of oil and the movement of the oil commodity market. Oil comes by way of two key sources:

- Oil extracted locally in Oklahoma—comprising about 4 percent of the nation's oil reserves as well as 4 percent of U.S. annual oil production, totaling 143 million barrels in 2021
- Oil from the outside the state, including from the Bakken Formation (the Bakken) in North Dakota as well as Canada

Figure 4-1. Pipeline Landmark in Cushing, OK

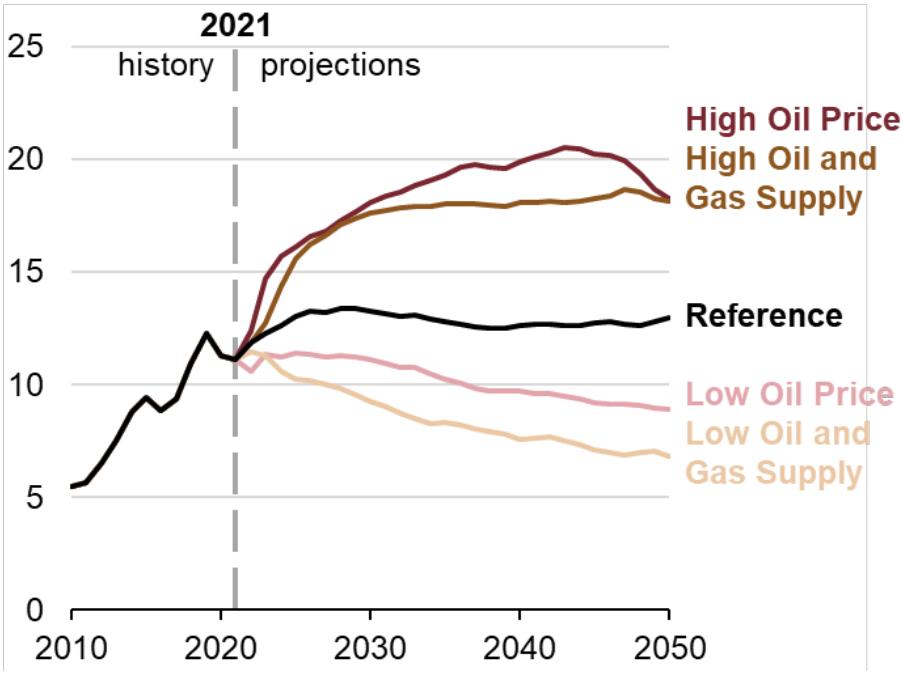
Source: StateImpact Oklahoma, 2022

[11] U.S. Energy Information Administration, Oklahoma State Energy Profile and Energy Estimates, 2021.

Oil and natural gas are crucial commodities to world energy usage, and trends affecting their extraction, storage, usage, and future are tied to international economic, social, and political factors that often change daily. At a high level, residual effects of the COVID-19 pandemic are likely to continue to affect energy commodities. In its 2021 energy forecast, the U.S. Energy Information Administration (EIA) notes that increasing demand for oil and gas for industrial uses and for export has incentivized production following a dip in demand during the early months of the COVID-19 pandemic. The EIA also forecasts that production will reach pre-pandemic levels by 2023 before stabilizing through 2050 (Figure 4-2). Figure 4-2 also illustrates U.S. oil production under differing price and supply scenarios, including a "Reference" (base) scenario. The Annual Energy Outlook Reference case includes the following assumptions:

- Petroleum and natural gas will remain the most-consumed sources of energy in the U.S. through 2050, but renewable energy will be the fastest growing.
- Wind and solar incentives, along with falling technology costs, will support robust competition with natural gas for electricity generation, while the shares of coal and nuclear power will decrease in the U.S. electricity mix.
- U.S. crude oil production will reach record highs, while natural gas exports will increasingly drive natural gas production.

Figure 4-2. U.S. Crude Oil Production under Five Scenarios (million barrels per day)

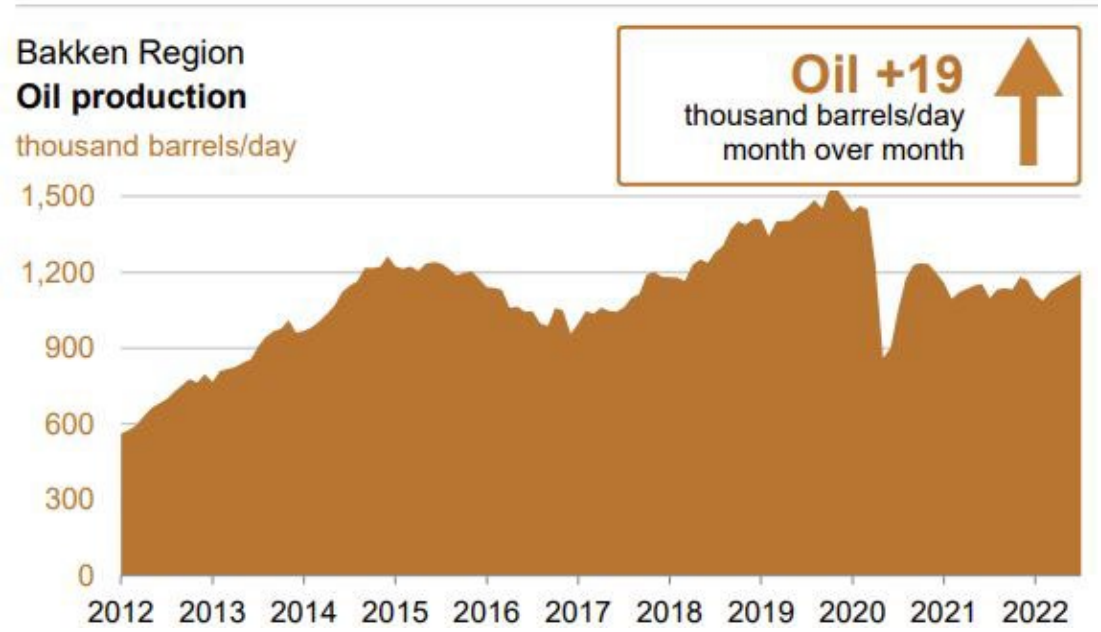


Source: U.S. Energy Information Administration, Annual Energy Outlook, 2022

Note that the EIA's forecast was conducted prior to the start of the Russian invasion of Ukraine. International sanctions on Russian oil have affected global oil prices and movements, and the long-term impacts of these changes remain to be seen.

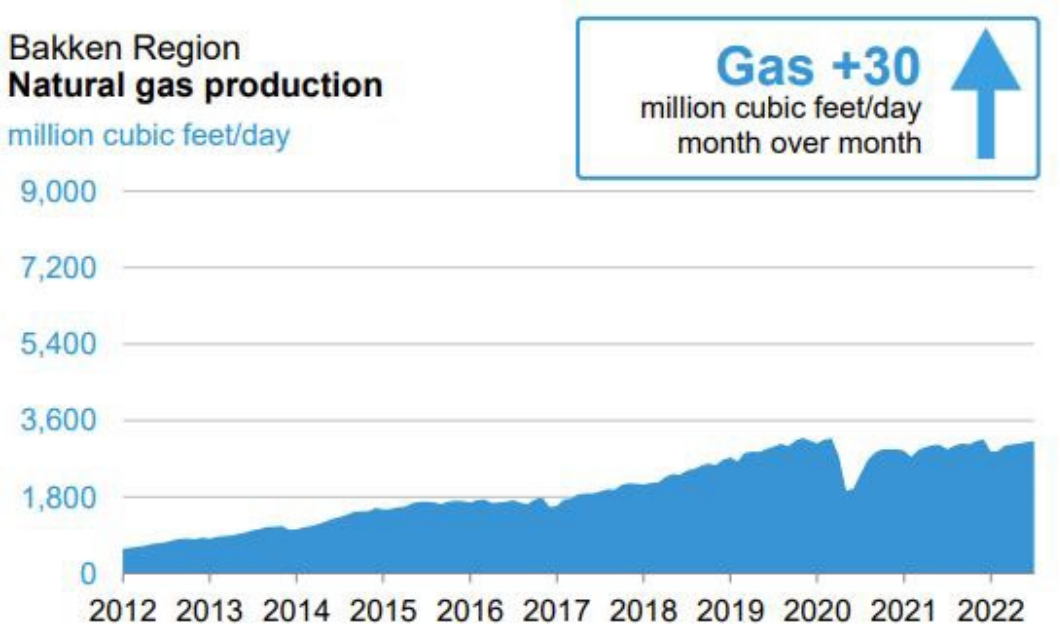
Oil and gas production originating from the Bakken Formation influences the amount of those commodities that flow into Oklahoma for storage and shipment to additional markets, including for international export through the Gulf of Mexico. While both oil and gas production dropped sharply in early 2020, production has generally followed the EIA's estimate of recovering to pre-COVID-19 pandemic levels (Figure 4-3 and Figure 4-4).

Figure 4-3. Historic Oil Production in the Bakken Region



Source: U.S. EIA Drilling Productivity Report, June 2022

Figure 4-4. Historic Natural Gas Production in the Bakken Region



Source: U.S. EIA Drilling Productivity Report, June 2022

Since 2013, pipeline capacity serving the Bakken Region has increased. Pipeline and refinery projects are planned that would more than double refining and pipeline takeaway capacity in the region. For the most part, rail transportation will be limited to shipping to markets not accessible by pipeline, particularly the East and West Coasts' refineries and ports. Consequently, crude oil moving by rail into Oklahoma from the Bakken Region is not expected to reach levels seen in past years.

Anadarko Basin: Oil and Gas

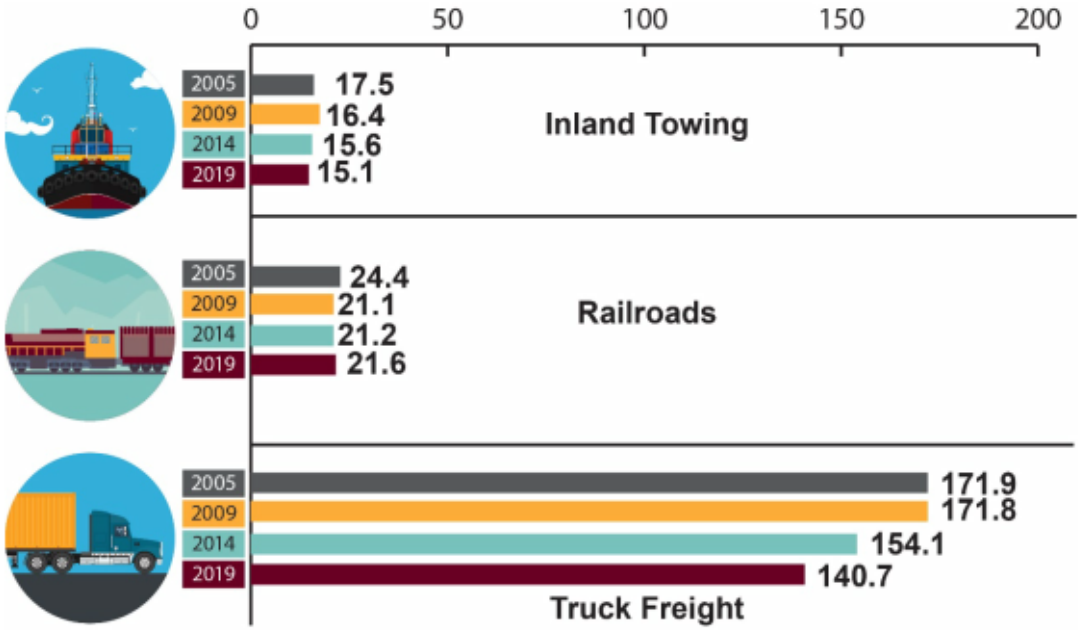
The Anadarko Basin located in the western part of the state is a major source of natural gas, and to a lesser extent, crude oil. While oil production is significantly diminished, natural gas production has increased and is expected to continue to grow. In 2021, Oklahoma was the nation's fifth-largest producer of natural gas, most of which flowed out of the state via pipeline. Although natural gas is shipped by pipeline, the sand, water, gravel, and heavy equipment that is required in the extraction process is moved primarily by rail and truck.

4.1.2 Environmental Issues and Clean Fuels

While Oklahoma maintains a favorable federal air quality standard, there remains a sharp focus on upholding this status. Transportation remains the largest source of greenhouse gas (GHG) emissions in the U.S., and the increasing number of vehicles on the transportation system presents opportunities to find innovative ways of sustaining environmental integrity in Oklahoma.

Oklahoma is poised to support industries producing clean energy and using clean energy technology as a means of meeting federally mandated air quality standards. Oklahoma continues to improve alternative fuel corridors, providing clean energy options to motorists—including charging stations and compressed natural gas stations on federally designated alternative fuel corridors. Other opportunities to improve sustainability of freight and reduce impacts on the environment lie with increasing utilization of rail and waterway services to transport goods due to their large carrying capacity and lower shipping costs. Both rail and inland maritime freight transport modes contribute far fewer emissions per million ton-miles of cargo moved than trucks, as they can move many more tons per trip than a tractor trailer and have better fuel efficiency. Figure 4-5, from the Texas Transportation Institute, illustrates the GHG emissions per ton-mile of freight moved by mode. Trucking contributed 140.7 metric tons of GHG emissions per million ton-miles in 2019, while inland towing contributed only 15.1 metric tons of GHG emissions in the same year.

Figure 4-5. Metric Tons of Greenhouse Gas per Million Ton-Miles (2005, 2009, 2014, and 2019)



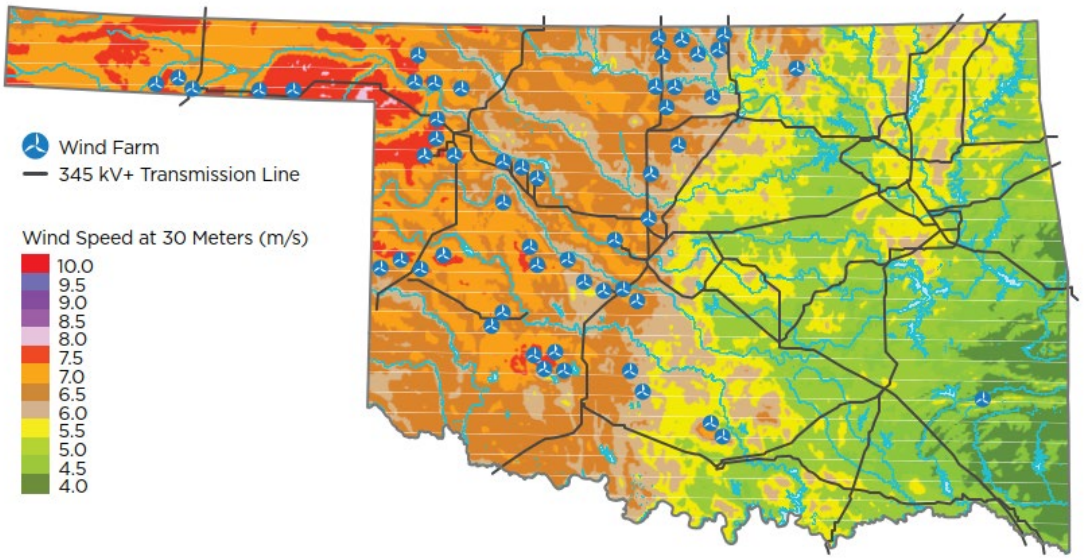
Source: Texas Transportation Institute, 'A Modal Comparison of Domestic Freight Transportation Effects on the General Public: 2001-2019," January 2022.

4.1.3 Wind Energy

According to the EIA, in 2021 Oklahoma ranked third in the nation in net electricity generation from wind, which provided over 41 percent of the state's electricity. Oklahoma's wind turbines account for 9 percent of the nation's total wind power generation, and new generation continues apace, as the 998-megawatt Traverse Wind Project came online in early 2022. Figure 4-6 shows the locations of wind farms and transmission lines within the state, highlighting Oklahoma's concerted effort to expand this sector.).

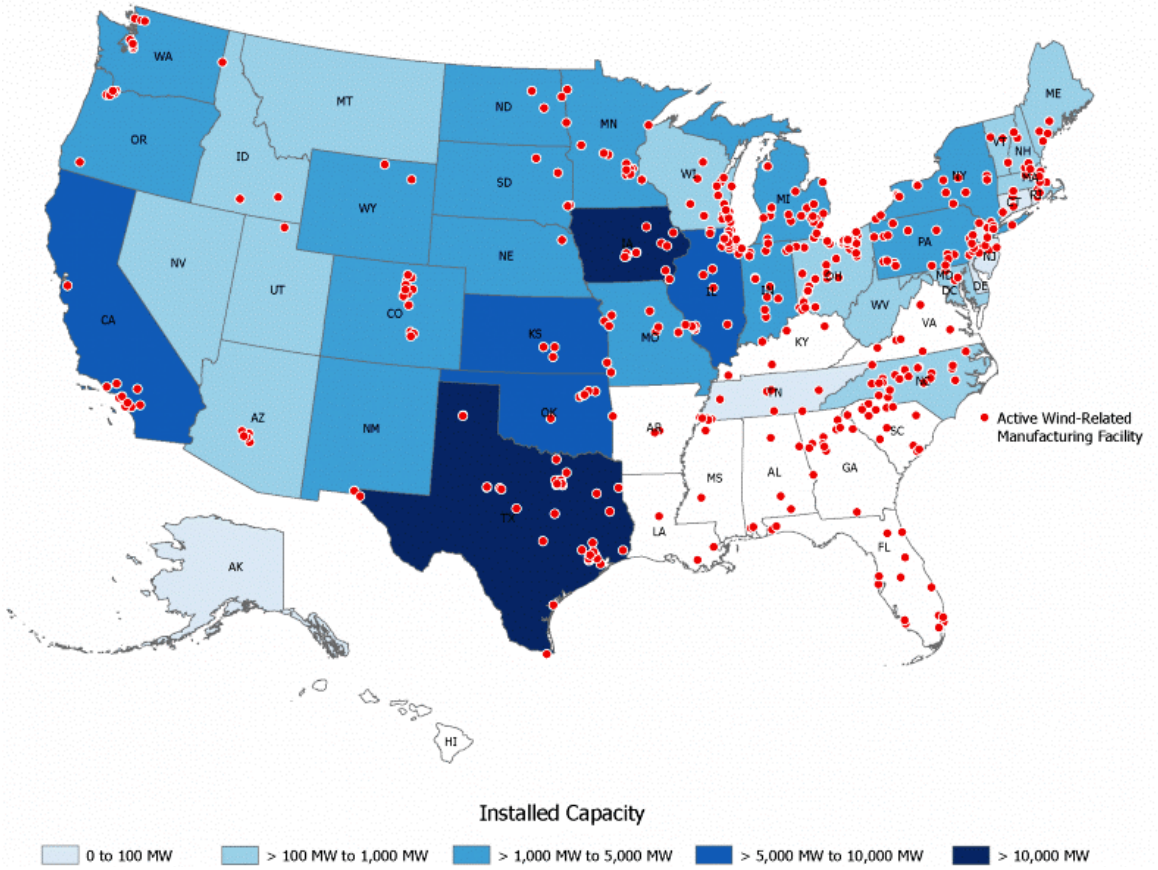
Wind farms generate significant freight movements during their construction, when many components, both large and small, are being brought in by truck, rail, or in some cases, ships. Wind farms are less freight intensive once operational. According to the U.S. Department of Energy, "the average utility-scale wind turbine contains roughly 8,000 parts, including blades averaging 116 feet in length and towers averaging around 80 meters (262 feet) high, roughly the height of the Statue of Liberty." These parts run from the very small, such as specialty parts used in the mechanics of the turbines, to the very large, i.e., blades and bases. The large pieces require special transport, often via rail. Oklahoma is home to about half a dozen wind turbine manufacturing outfits, with most of the nation's turbine manufacturing capacity located east of the Mississippi (Figure 4-7). Turbine manufacturing generates ongoing freight and care should be taken to ensure rail connections where needed and strength of roads and bridges for the shipment of larger components.

Figure 4-6. **Traverse Wind Farm**



Source: Oklahoma Commerce, 2022

Figure 4-7. ***Turbine Manufacturing Capacity***



Source: Office of Energy Efficiency & Renewable Energy, 2022 https://www.energy.gov/eere/wind/wind-manufacturing-and-supply-chain

4.1.4 Implications of Energy and Environmental Trends

Oklahoma has long been a leader in the energy sector and will continue to maintain that status. In addition to raw materials extraction, core components of Oklahoma's energy system include the manufacturing of natural gas products and its related machinery and distribution systems. The state is also proud of its ability to meet air quality standards, leveraged in part by proactive efforts in developing wind energy.

Energy freight movements are sensitive to national and global market forces; therefore, Oklahoma's freight transportation will need to position itself to be responsive to changes in the international scene. Oklahoma's rail, truck, and waterway systems provide ways to respond to the changing demand for this commodity. The volatile energy market poses a unique challenge to the transportation system due to the high volume of heavy loaded vehicles traveling through rural communities that are not equipped to handle the size and scale of these shipments.

4.2 DEMOGRAPHIC TRENDS

4.2.1 Population

Oklahoma is the 28th most populated state. July 2021 Census estimates the population of Oklahoma has grown to 4.0 million since April 2020, which represents a 0.7 percent increase, exceeding the national growth rate of 0.1 percent for the same period.

The state's population is anticipated to exceed 4.4 million people by 2040—a 10.9 percent increase over 2020—reflecting a tapering of growth from prior years. Growth is expected to be centered in the existing metropolitan areas.

4.2.2 Employment

As of May 2022, Oklahoma's unemployment rate is at its lowest in nearly 50 years (2.8 percent), which is nearly a percentage point below the national average of 3.6 percent. This indicates a strong labor market in Oklahoma with positive economic recovery efforts post-COVID-19 pandemic. Looking ahead, unemployment rates in the state are expected to be around 2.3 percent through 2023, as compared to U.S. forecast rates of 3.6 percent, suggesting continued growth of Oklahoma's labor market.

Industry employment projections are developed by the Oklahoma Employment Security Commission. Table 4-1 illustrates the importance of freight-related industry employment to Oklahoma. Roughly 53 percent of the state's employment depends on freight transportation. Table 4-1 highlights fourth-quarter 2021 employment across all sectors, totaling nearly 1.6 million employees. Freight-dependent industries—including Manufacturing, Goods Producing, and Trade, Transportation, and Utilities—employ a significant portion of the state's labor force, accounting for nearly 45 percent of total state employment. The increase in Oklahoma's labor force mirrors recent increases seen at the national level, which will likely influence an increase in freight-sector jobs as the economy continues to see growth in the period following the COVID-19 pandemic.

Table 4-1. Oklahoma Economic Sector Employment (Fourth Quarter, 2021)

Sector	Average Employment
Other Services	**410,777**
Government	**325,378**
Trade, Transportation, and Utilities*	**321,877**
Retail Trade	187,320
Transportation and Warehousing	69,962
Wholesale Trade	54,984
Utilities	9,610
Goods Producing	**245,621**
Manufacturing	**129,828**
Construction	**77,768**
Natural Resources and Mining	**38,025**
Agriculture, Forestry, Fishing, and Hunting	**10,065**
TOTAL	**1,559,339**

Source: Oklahoma Employment Security Commission and the U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW), 2022. https://www.bls.gov/eag/eag.ok.htm
* Note that the Trade, Transportation, and Utilities sector includes Retail Trade, Transportation and Warehousing, Wholesale. Trade, and Utilities

4.2.3 Implications of Demographic Trends

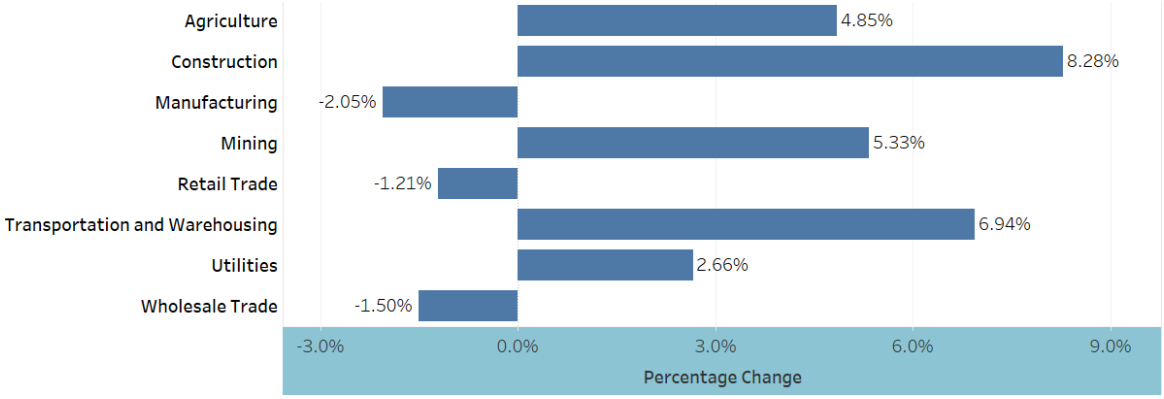
Oklahoma, like many other Midwestern and South Central states, is expecting modest growth in population and employment over the next decade. With growth concentrated in urban areas, freight flows, congestion, and conflicts are likely to increase. The expected future increase in population concentration in Oklahoma City and Tulsa will have a twofold impact on freight transportation in the state:

- The two major population centers will experience an increase in demand for goods, intensifying truck movements in the metropolitan areas due to increasing e-commerce purchases and shift toward increased urban warehousing and last-mile delivery strategies.
- Increased inbound truck activity combined with a growth in personal auto travel associated with the increase in population will contribute to additional congestion on the Oklahoma City and Tulsa road networks. Adding further to the congestion will be increased traffic passing through the two metropolitan areas.

As rural populations are more dispersed, other issues related to efficient freight transport will need to be addressed. In rural areas, increased home delivery and consolidation of commercial rail and intermodal services present challenges as further described later in this chapter.

Figure 4-8 shows the projected change in employment for Oklahoma freight-related industries between 2018 and 2028.

Figure 4-8. Projected Employment Growth (2018 through 2028)



Source: Oklahoma Employment Security Commission, August 2020.
https://www.ok.gov/oesc_web/Services/Find_Labor_Market_Statistics/Projections/

During this time period, construction and transportation and warehousing are expected to demonstrate the greatest employment growth. Air transportation is expected to increase nearly 18 percent, while warehousing and storage is expected to increase by roughly 15 percent, highlighting a continued shift in delivery strategies to account for heightened delivery volumes seen across the state as e-commerce sales continue to increase post-COVID-19 pandemic. As delivery strategies move toward a last-mile approach, warehousing and storage in both urban and rural areas have influenced a sizable increase in employment needs.

The manufacturing as well as retail and wholesale trade sectors are expected to have a decrease in employment. The decrease in manufacturing is expected to be driven largely by a reduction in apparel manufacturing as well as textile/textile product mills and printing manufacturing decline. A decrease in computer and electronics manufacturing will also add to the decline, likely for the foreseeable future as supply-chain issues fueled by the COVID-19 pandemic and geopolitical tensions have reduced availability of global superconductors, requiring domestic production to meet rising needs across multiple sectors. The decrease in retail-trade employment is expected to stem largely from a decline in employment at electronics and appliance stores, likely influenced by the semiconductor shortage that is reducing the supply of electronics globally. The decline in wholesale trade will be influenced by a decrease in both durable and nondurable goods.

4.3 ECONOMY AND TRADE

4.3.1 Economic Growth

Measured by annual real gross domestic product (GDP), U.S. economic growth declined sharply in 2020 due to the COVID-19 pandemic. In 2020, annual GDP fell 3.4 percent, following annual growth of 2.2 percent in 2019. A rebound in economic activity and job growth followed the pandemic's peak in 2021 as cases declined and vaccine rollout became widespread. GDP

increased 5.7 percent, the fastest growth seen since 1984.[12] As the economy shrunk in 2020 due to the impacts of the pandemic, so did freight traffic as the U.S. saw a decrease in both rail carload and intermodal volumes. Rail carloads had already been in decline between 2018 and 2019 (even with positive growth in GDP), falling 4.9 percent annually. In 2020, rail carloads decreased sharply by 12.9 percent, while intermodal containers and trailers fell by 1.8 percent.[13] By the end of 2020, higher grain and intermodal shipments, as well as reopening of auto assembly plants, influenced near pre-pandemic level rail volumes. In 2021, freight-rail traffic increased 5.7 percent, as grain saw its strongest year for freight-rail volumes since 2008, and coal carloads increased sizably due to significantly higher natural gas prices.[14]

Oklahoma's GDP began to slowly increase between 2017 and 2019, increasing 3.9 percent before the COVID-19 pandemic. In 2020, those gains were lost as gross state product fell 4.9 percent. While Oklahoma's GDP recovered by 2.7 percent in 2021, it did not reach pre-pandemic levels. Oklahoma experienced challenges with economic growth due to weakness in the state's energy sector leading into early 2020.[15] The U.S. GDP recovered to pre-pandemic levels by the second quarter of 2021 while Oklahoma's had not. While Oklahoma's labor market did not fall as steeply as the U.S. labor market during the height of the pandemic, Oklahoma's rebound was less pronounced, with fewer total nonfarm jobs by the end of 2021 than prior to the pandemic. Freight-related activity within the state shows truck vehicle-miles traveled (VMT) decreased 12.7 percent between 2019 and 2020, following pandemic-related declines in both U.S. and state GDP. Preliminary truck VMT data for 2021 signals considerable recovery (10.4 percent), within the state associated with increased economic activity and recovery from the COVID-19 pandemic.[16]

As captured by the Bureau of Economic Analysis, Oklahoma GDP growth in 2021 occurred across freight-dependent industries such as mining (including oil and gas), construction, manufacturing, retail trade, transportation and warehousing, and transportation and utilities. Construction saw its GDP share in the state increase by 1.8 percent above pre-pandemic levels, while nondurable goods manufacturing saw a 6.7 percent increase. Transportation and warehousing saw a 4.6 percent increase above pre-pandemic levels, while wholesale trade saw a near 1.5 percent increase. Retail trade saw the steepest increase in state GDP, increasing 21.7 percent above 2019 levels, accounting for 6.8 percent of the state's total GDP. Oklahoma's real GDP is projected to increase 5.6 percent in 2022, which would surpass pre-pandemic levels.[17] In comparison, U.S. GDP is expected to grow just 2 percent in 2022, while averaging 2.1 percent growth through 2026 and 1.8 percent through 2031.[18] Oklahoma's projected GDP

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12 https://www.washingtonpost.com/business/2022/01/27/gdp-2021-q4-economy/
13 https://www.logisticsmgmt.com/article/aar_reports_2020_u.s._rail_carload_and_intermodal_volumes_are_down_annually/railfreight
14 https://www.progressiverailroading.com/rail_industry_trends/news/AAR-North-American-freight-rail-traffic-rose-in-2021--65599
15 https://business.okstate.edu/site-files/archive/docs/economy/economic_outlook_2021_caer_update.pdf
16 ODOT, July 2022.
17 Economic_Forecast_2022.pdf (greateroklahomacity.com)
18 Global Economic Outlook (conference-board.org)

growth in 2023 is 3.3 percent, as compared to 0.6 percent forecast for the U.S., indicating Oklahoma's relative strength in recovery efforts compared to the national level.

4.3.2 Agriculture Products – Transmodal Transport

According to the U.S. Department of Agriculture, about 28 percent of U.S. agricultural shipments and about 10 percent of U.S. grains are shipped in containers. Containerized (intermodal) transport allows shippers to maintain the identity of bulk agricultural products and allows customers to buy in small lot sizes. Based on an average between 2017 and 2021, agriculture accounts for about 1.4 percent of Oklahoma's GDP and has been identified as a critical user of the transportation system. Intermodal transportation can benefit a wide range of shippers, including agriculture producers. In 2018, BNSF Railway opened a new intermodal logistics center in Oklahoma City.

Similar to the intermodal transportation, there is a growing demand for transload facilities so that noncontainerized freight can be transferred from one mode to another. In particular, there is an increasing demand for shipments that travel on Oklahoma rail or water systems and use truck for either "first mile" or "last-mile" transport. In Oklahoma, wheat production is a key agricultural product that uses transload facilities. Because wheat—among other agricultural products— are grown largely in low-density western areas of the state, farmers rely on trucks and short-line railroads to get product to barges and/or Class I railroads.

4.3.3 E-Commerce

Online sales of goods serve both businesses and consumers. However, business-to-consumer (B2C) e-commerce is the principal front of competition, pitting traditional storefront retailers against e-commerce merchants in pursuit of consumer spending. This segment is also forcing major changes in transportation patterns by replacing large, consolidated truck deliveries to stores with small, dispersed deliveries to residences, and therefore eliminating some consumer shopping trips and altering the origins of shipments. These changes, discussed further below, have significant impacts on goods movement in Oklahoma.

E-commerce has been growing rapidly for two decades; however, the COVID-19 pandemic rapidly accelerated this growth, particularly B2C. From 2002 to 2018, e-commerce sales grew at 7.1 percent per year for wholesale, 11.0 percent per year for manufacturing, and 16.6 percent per year for retail. The growth was especially dramatic for retail. In 2002, e-commerce retail sales were less than $45 million, and by 2018 they had grown more than tenfold to $520 million.[19]

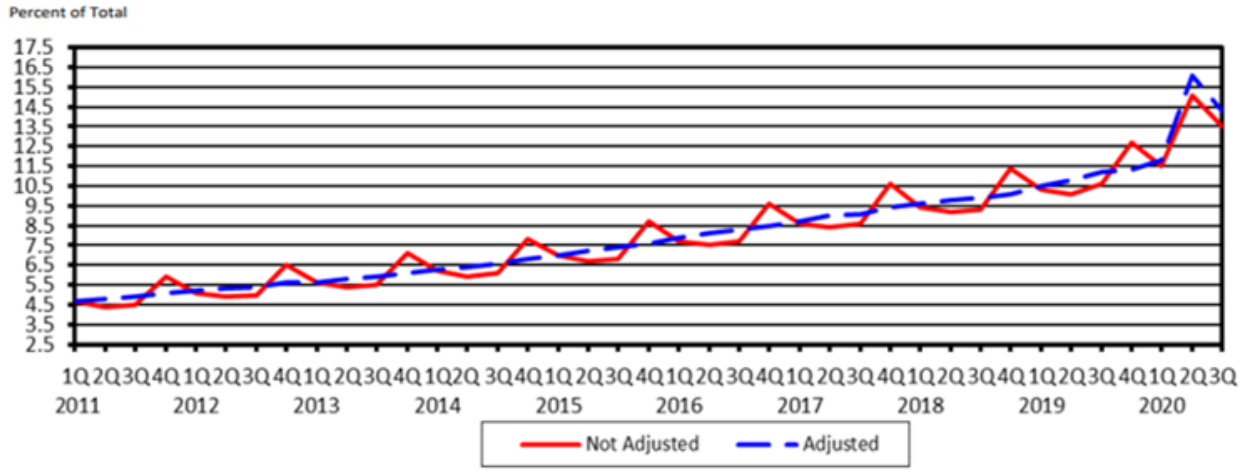
Technological advances support online sales growth by allowing consumers greater access to product information, quick and easy price comparisons, and faster, cheaper, personalized delivery options. Moreover, as same-day delivery and free shipping on returns become more commonplace, the traditional value of brick-and-mortar stores diminish further, and many

[19] https://www.mckinsey.com/industries/retail/our-insights/solving-the-paradox-of-growth-and-profitability-in-e-commerce

brick-and-mortar stores have begun accommodating the pickup of orders placed online, along with in-store e-commerce returns.

The start of the COVID-19 pandemic led to a dramatic increase in e-commerce from 11.8 percent in the first quarter of 2020 to 16.1 percent in the second quarter (Figure 4-9). In subsequent quarters, the seasonally adjusted share of e-commerce has decreased slightly and even stabilized at around 13 percent of retail sales.[20] This stabilization suggests that the pandemic had mostly a transitory effect on e-commerce sales, with the share of retail returning to levels only slightly higher than predicted by pre-pandemic forecasts. It is too early to assess with confidence the effect of the pandemic on the long-term prospects of the e-commerce sector. It is possible that the share of e-commerce will continue to increase at pre-pandemic rates until market absorption is maximized. Some analysts expect e-commerce growth to continue strongly, accelerated by changes in customer attitudes precipitated by the pandemic, reaching half of retail sales in the near future.

Figure 4-9. Estimated Quarterly U.S. Retail E-Commerce Sales as a Percentage of Total Quarterly Retail Sales



Source: U.S. Bureau of the Census, 2022

4.3.4 Warehouse Location and Automation

Distribution centers and warehouses have proliferated at an astounding pace, with annual development of new sites across the country more than tripling in the past 5 years. The increasing prominence of supply chains that emphasize faster times to market—combined with the pandemic-related growth in e-commerce—is leading to growing demand for warehouses, distribution centers, and fulfillment centers to support these activities.[21] Same- and next-day delivery requires more warehouses as well as warehouses closer to final market

[20] https://www.census.gov/data/tables/2018/econ/e-stats/2018-e-stats.html
[21] CBRE 2020 North America Industrial Big Box Review & Outlook https://www.cbre.com/-/media/project/cbre/shared-site/insights/local-responses/industrial-big-box-report-memphis/local-response-2020-ibb-memphis-overview.pdf

destinations (i.e., consumer homes and business). Some analysts estimate that e-commerce requires three times more warehousing space per product than traditional retail stores.[22]

Below are brief descriptions of the facilities that play a warehousing function in supply chains:

- Warehouses temporarily store product inventory and then send it on to end-points. Many retailers have evolved sophisticated inventory management systems to "pull" materials from warehouses on an as-needed basis, optimizing space usage. Supply chains will continue to seek to minimize inventory because it is expensive to own and hold. Inventory carrying costs typically total between 18 and 25 percent of the value of goods.
- Distribution centers also store products, although the duration of storage tends to be shorter than a warehouse, and distribution centers may also offer value-added services like cross-docking, product mixing, packaging, and order fulfillment.
- Fulfillment centers are a type of distribution center specializing in or offering order fulfillment. The term "warehouse" is often assumed to include both distribution centers and fulfillment centers (because the main function in each case is storage of goods).

4.3.5 Implications of Economic and Trade Trends

Innovations in transportation and e-commerce will affect the future for agriculture, retail, and warehouse operations.

As agriculture productivity and global demand for Oklahoma products such as wheat and soybeans increase, transportation efficiency will be of heightened importance. Oklahoma exports are likely to be transported by truck to rail or barge terminals. These transmodal (noncontainerized) operations present an opportunity to leverage the strengths of each mode to reduce agriculture transportation costs.

Multiple factors related to retail trade have the following implications for Oklahoma:

- Delivery vehicles in urban residential areas are likely to increase. As volumes grow, traffic and congestion can become an issue for residents and businesses.
- Delivery delays and their causes will be more visible to Oklahoma residents. This could lead to a higher incidence of complaints but could also make the challenges of freight delivery more tangible and meaningful to citizens.
- Concern for the safety and environmental qualities of delivery trucks is likely to continue. Adoption of different and new technology is apt to accelerate, including use of natural gas and hybrid electric trucks, and safety advances associated with connected and automated/autonomous vehicles. The ability for drivers to see—and vehicles to sense—

[22] Prologis (June 17, 2020), COVID-19 special report #6: "Accelerated Retail Evolution Could Bolster Demand for Well-Located Logistics Space." https://www.prologis.com/news-research/global-insights/covid-19-special-report-6-accelerated-retail-evolution-could-bolster

activity and obstacles all around them, promises substantial reductions in incidents and accidents, and makes trucks far more neighborhood friendly.

4.4 TECHNOLOGY AND INNOVATION

4.4.1 Connected and Automated/Autonomous Vehicles

Advanced vehicle technologies for trucking (including driver assistance) and autonomous and CVs are evolving quickly. Automation could substantially reduce fuel, labor, or equipment costs for trucking, thereby potentially reducing the cost of truck transportation for the region's freight customers. For example, predictive cruise control, which combines cruise control with GPS and topographical data, can optimize fuel performance across varying terrains, while platooning can also improve fuel efficiency. Drivers being able to fulfill their rest requirements while in their vehicles means hiring fewer truck drivers, completing more deliveries in each period, and purchasing fewer trucks by fleet operators. These savings would be offset by the technology costs, but even so, there is the potential for meaningful advantage to customers.

FedEx recently collaborated with Paccar and Aurora in a test to send packages on a 500-mile trip between Houston and Dallas on an autonomous truck.[23] Kodiak Robotics has partnered with third-party logistics firm Ceva Logistics to autonomously transport cargo between Texas and Oklahoma City on I-35 and completed the first pilot run of the service in 2022.[24] (Figure 4-10).

Figure 4-10. Ceva and Kodiak Automated Tractor Trailer

Source: Ceva Logistics, 2022

[23] https://www.bizjournals.com/pittsburgh/inno/stories/news/2021/09/24/fedex-paccar-aurora-partner-autonomous-trucks.html

[24] https://www.freightwaves.com/news/kodiak-hauling-autonomous-loads-for-ceva-from-texas-to-oklahoma-city

In 2022, the Oklahoma legislature passed a law allowing fully automated vehicles to operate on public roads. This law, known as SB 1541, authorizes the operation of fully autonomous vehicles without human drivers, so long as an automated driving system is engaged, and the vehicle meets certain standards. Persons or companies wishing to operate a fully autonomous vehicle without a driver must provide the state with a law enforcement interaction plan. Additionally, Oklahoma's law SB189, provides for truck platoons of up to two vehicles. This law allows trucks to follow more closely than non-platooned motor vehicles as long as their speeds are electronically coordinated.

Automation could provide meaningful transportation safety benefits by reducing truck crashes. Human error—typically a truck driver or other drivers—causes or worsens most commercial truck accidents. There is some evidence that technologies such as forward collision warnings, camera systems, and automatic emergency braking systems do enhance safety. However, higher levels of automation for trucks have not yet been proven in real-world applications.

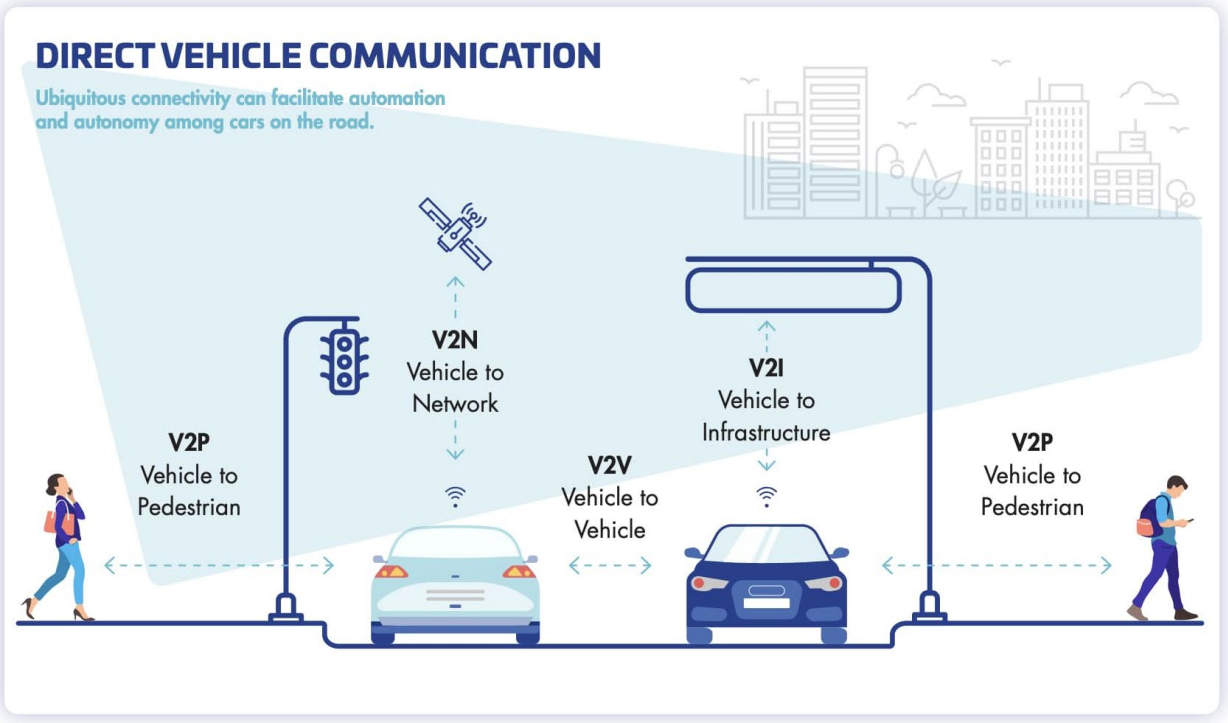
While there are many potential cost savings and societal advantages to deploying automation in trucking, widespread adoption of high levels of automation is unlikely in the medium term. Barriers remain for this technology to be commercially viable and to realize the benefits described above. These include challenges navigating roadway work zones, perceptual challenges during adverse weather, and operational requirements for staff to travel with the shipment even if they are not driving for loading/unloading, refueling, vehicle breakdowns, other emergencies, etc.

CV technologies allow vehicles to communicate with one another (vehicle-to-vehicle), with infrastructure (vehicle-to-infrastructure), and with other equipment, objects, or persons (vehicle-to-everything) (Figure 4-11). CV technologies are closely aligned with Automated Vehicle technologies, but the key difference is that CV is connecting the vehicle with external sources. CV technologies can offer benefits to safety, mobility, and operations. Transportation agencies have been investing in vehicle-to-infrastructure technologies for Transportation System Management Operations (TSMO) activities to communicate roadway conditions such as backups, truck parking availability, and intersection information directly to vehicles. These agencies have invested in roadside infrastructure, or roadside units which communicate with a vehicle's onboard unit. A key component of enabling agency-controlled CV technology is the presence of fiber and electric connections to provide power and communicate data back to agencies.

ODOT works closely with the University of Oklahoma ITS Laboratory. ODOT has also participated in Heartland region ITS and TSMO research, and the city of Tulsa maintains an Urban Mobility Innovation Team, aiming to "Develop a policy and technical action plan to lower barriers for emerging transportation technology adoption in Tulsa."[25]

[25] https://www.cityoftulsa.org/government/departments/finance/performance-strategy-and-innovation/urban-mobility-innovation-team/

Figure 4-11. Connected Vehicle Configurations



Source: Thales Group

4.4.2 Vehicle Electrification

Commercial-vehicle electrification has reached the point of being viable and cost effective in several applications. As the costs have decreased—and governments increase incentives for electrification and raise standards for diesel-powered trucks—the electrification of truck fleets has become more of a practical possibility than ever. Truck electrification includes a wide range of technologies, each with different advantages. Truck electrification using batteries is the most common type, encompassing battery-only electric, hybrid electric, and plug-in hybrid electric.

Americas Commercial Transportation Research Co. projects that battery-electric trucks will make up half of Classes 4 through 8 vehicles sold in the United States by 2035.[26] Their cost analysis found that battery-electric medium-duty trucks have cheaper total cost of ownership than comparable diesel trucks, and this advantage is expected to increase as battery technology continues to improve and new regulations are introduced to curtail diesel emissions. The highest adoption rates are forecast for Classes 6 through 7 trucks (60 percent in 10 years), while Classes 4 through 5 trucks are more likely to switch to gasoline engines. Class 8 trucks are likely to favor diesel engines until emission regulations are tightened.

In addition to traditional plug-in charging, electromagnetic induction, or wireless, charging technologies have been piloted for transit systems and show promise for freight use along

[26] https://www.truckinginfo.com/10161524/act-half-of-class-4-8-sales-to-be-bev-by-2035

local delivery routes. Induction charging involves in-pavement coils which transmit electricity to a vehicle outfitted with corresponding coils. The vehicles can park on top of the induction charging infrastructure for short intervals to receive partial charge. In 2021, Tesla partnered with WAVE, owned by Ideanomics, to pilot induction charging for its Semi electric truck. WAVE estimates charging power of 500 kilowatts to 1 megawatt.[27]

The following factors are driving growth in truck electrification:

- Lower total cost of ownership for some applications, including lower maintenance costs.
- Governmental incentives and regulations intended to reduce GHG emissions and nitrogen oxides emissions. These include both incentives that facilitate electrification and more stringent requirements for traditional diesel or gasoline trucks. Many analyses find that the cost competitiveness of the technology in the short term depends critically on these governmental actions.
- Continued improvements in truck electrification and battery technology.
- Further developments and testing of battery technology by truck manufacturers.
- Surge in e-commerce increasing demand for light-duty trucks for deliveries, which are more conducive to electrification.
- Significant interest from businesses to take advantage of cost savings and lead technology adoption.
- Some businesses see truck electrification as a way of showcasing environmental stewardship. Amazon ordered 100,000 electric delivery vans from Rivian with the intention of deploying them by 2030.[28] Ikea has plans to use electric trucks to perform all home deliveries in New York City and Los Angeles by 2025.[29] Walmart also has significant plans to roll out electric trucks in the coming year. FedEx has committed to replacing their entire fleet with electric trucks by 2040.[30]

The following barriers are slowing the electrification of the truck fleet:

- High capital costs relative to conventional trucks, though lifetime costs are quickly reaching parity with diesel vehicles
- Difficulties securing loans for more expensive electric trucks, especially without governmental support
- Slowness of recharging requires significant changes in how many trucks are operated today. However, Daimler unveiled a new battery composition that will charge a truck to 80

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27 https://www.vehiclesuggest.com/tesla-move-to-wireless-charging/
28 2 Lambert, Fred. "Closer Look at Rivian's Electric Delivery Van for Amazon." Electrek, 6 Feb. 2020, electrek.co/2020/02/06/ rivian-amazon-electric-delivery-van-closer-look/
29 Zero Emissions for Home Deliveries. https://about.ikea.com/en/sustainability/%20becoming-climate-positive/zero-emissions-for-home-deliveries
30 https://www.mjbradley.com/sites/default/files/EDF_EV_Market_Report_April_2021_Update.pdf

percent within 30 minutes, which could be a promising new technology to speed charging.[31]

- Lack of charging infrastructure
- Significantly less service support available for maintenance and repairs
- Concerns about longevity and depreciation, particularly with batteries

Given the characteristics of the technology, the following trucking applications are favorable to electrification, particularly for a state like Oklahoma with both urbanized cities and long distances between destinations:

- Urban delivery applications that require frequent braking and slow speeds, allowing benefits from regenerative braking
- Applications where the truck returns to home base—facilitating rapid charging—and operates within a range of 100 to 150 miles. In some cases, these can be strung together in relay routes of longer distance
- Long-haul routes where drivers have the opportunity to coincide their rest schedules with refueling

Oklahoma National Electric Vehicle Implementation Plan

The IIJA bill authorized a new formula funding program (National Electric Vehicle Infrastructure, or NEVI), which allocates money to states specifically for vehicle electrification projects. Oklahoma is set to receive approximately $66.3 million between 2022 and 2026 under this new program. To meet program requirements, each state must submit a NEVI plan. In 2022, FHWA approved Oklahoma's plan, which documents the existing conditions regarding to statewide vehicle electrification infrastructure and outlines planned infrastructure investments. Oklahoma's plan is ambitious, aiming to keep the state in the top 10 states for charging stations per capita. The state's leading status in wind energy generation provides a significant opportunity to decrease total emissions because renewable resource would produce the electricity used to power vehicles. Figure 4-12 illustrates the evident gaps in electric vehicle charging locations along Oklahoma's interstate highways. This map provides a potential path forward to building out the state's commercial-vehicle charging network.

[31] Freight Waves, September 2022

Figure 4-12. Oklahoma Electric Vehicle Charging Station Gaps Along Interstate Highways

Source: Oklahoma NEVI Plan, 2022

4.4.3 Commercial Vehicles Equipment and Other Technology

For some time, truckers have been employing technology in their operations and supporting public initiatives to add technologies on the highways. The products that have developed are important to safety, cost monitoring, and efficient operations.

Truck and Trailer Information Systems

Trucking equipment is continually evolving to include technologies to monitor the performance and operation of the vehicle, to improve communication with company personnel and for the safety and convenience of the operator. These technologies cover a wide range of capabilities from speed control, engine monitoring, communication, and driver comfort and convenience.

Highway Technology

Highway technologies are also evolving and being deployed with greater frequency. Current applications of electronic signage help drivers avoid problem areas and improve their trips by having access to current travel time and alternate route notification. Commercial-vehicle monitoring allows enforcement officials to monitor regulatory compliance of passing vehicles.

Load Access

Online load boards have been around for a considerable length of time. New technological capabilities have allowed the concept of real-time load access to grow. Brokers, logistics services, and trucking companies with excess freight are all developing some form of a cellphone application that gives drivers access to potential loads to capture detailed load information and report status.

Unmanned Aerial Vehicles

Unmanned aerial vehicles (or drones) are lightweight aircraft that operate remotely without a pilot physically onboard. However, drones must be operated by a pilot registered with the

Federal Aviation Administration. Over 850,000 drones have been registered through 2021, with nearly 260,000 remote pilots receiving their certification. While drones have not advanced so far as to replace entire tractor-trailers on the nation's roadways, they can offer an advantage for last-mile deliveries, especially in rural areas.

4.4.4 Three-Dimensional Printing

3D printing technology is advancing rapidly. Three-dimensional (3D) printing is a type of additive manufacturing where products are formed by layering materials, as opposed to subtractive (cutting away) or formative (molding) manufacturing techniques. 3D printers are operated from software containing the design specifications. The size of the additive manufacturing industry was $15.4 billion worldwide in 2020, growing 21 percent over 2019 and forecast to grow at a compound annual rate of 21.8 percent through 2027.[32]

An important consideration in understanding the potential impacts of additive manufacturing/3D printing is that it is not primarily about stand-alone machinery for fabricating entire products. Rather, it is a flexible and sometimes superior technique for improving production of components within existing manufacturing processes, reducing costs, and making manufacturing more competitive. Because of its benefits, many manufactured elements may be printed, including intermediate products, original and replacement parts, and sub-assemblies. To that end, GE Renewable Energy is piloting 3D printing to manufacture of turbine components, including concrete bases, to help reduce transportation costs—a development that could allow portions of wind turbine manufacture to be done in-state, rather than be transported by truck or rail.

4.4.5 Railroad Technology

As an example of next generation technology, drones are being used to inspect difficult locations like tunnels and bridges. The Positive Train Control (PTC) systems that railroads are implementing nationwide promise improvement in safety performance. Additionally, regulators at the FRA and the Pipeline and Hazardous Materials Safety Administration called for a new electronically controlled pneumatic braking system that would prevent—or lessen the severity of—crashes involving hazardous materials.

4.4.6 Waterways Innovation and Technology

The IIJA has awarded federal funds to the USACE – Tulsa District to deepen the Arkansas River navigation channel to 12 feet. The MKARNS is a 445-mile-long waterway containing 18 locks and dams (including five in Oklahoma) serving three primary Oklahoma ports (Tulsa Port of Catoosa, Muskogee, and Oakley's Port 33). Deepening the channels will allow barges to handle an additional 400 tons—a capacity increase of 40 percent—which will reduce the transportation cost per ton by water and increase its attractiveness and competitiveness versus other transportation modes.

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[32] https://www.businesswire.com/news/home/20210916005909/en/15.4-Billion-Worldwide-Additive-Manufacturing-Material-Industry-to-2027---Latest-Advancements-and-Innovations---ResearchAndMarkets.com

4.4.7 Implications of Transportation Technology Trends

The implications of automated vehicle technology for Oklahoma are many and uncertain. The safety benefits when a driver is present in an automated vehicle could be substantial and would accrue from the interaction with technology-enabled automobiles as well as from enabled trucks. Advancements in safety could reduce community concerns about truck traffic and would be especially helpful in the context of home deliveries. However, without a driver actively behind the wheel, the public perception is apt to be different and risk-averse, even if the safety profile is eventually proven to be equally strong. Other legal, technological, and market issues could slow or speed implementation. As a result, truck and automobile technologies are likely to evolve by degrees, and automated operations are likely to coexist with traditional ones for years.

ODOT will have a role in implementing new vehicle technology as it interacts with the transportation network. Information technology and ITS applications will need to continue to evolve and expand to address various levels of communication and automation.

The rail and waterways industries are using new and sustainable methods for their systems as well. Drone technology, new braking systems, and improved replacement or repair components for locks and dams will improve efficiency and safety for rail and waterways.

4.5 TRANSPORTATION INDUSTRY TRENDS

4.5.1 Supply Chains

Supply-chain sourcing relates to where retailers obtain products for sale, where manufacturers obtain materials and components, and relatedly, where manufacturers locate the production that supplies retailers. The concept of supply-chain management or logistics is about efficient management of business operations from initial input (sourcing) to final product delivery. An optimized transportation system plays an essential role. Oklahoma is involved in complex supply chains that require goods movement across the globe. Supply chains in the state could be conceived as twofold (though somewhat interrelated):

- Supply chains handling bulk energy and agricultural goods
- Supply chains moving finished goods to businesses and consumers

Whereas prior to 2020, “just-in-time” (JIT) delivery was the leading phrase in logistics, rolling shortages of various goods occurred in the 2020 through 2022 time period, businesses started focusing on a “just-in-case” (JIC) model. JIC is an inventory management strategy used to deal with uncertainty in the supply chain and/or the anticipation of emergencies or sudden increases in demand. The U.S. shipping industry spent the previous decades perfecting JIT, managing lean inventories based on insights from machine learning, artificial intelligence, and big data. But the COVID-19 pandemic spurred unforeseen surges in demand, compounded by shortages caused by worldwide closures of factories and ports as well as trade policies. Businesses had to pivot to JIC, building up inventories to prepare for potential future shortages of key goods, and ordering well ahead of seasonal demands due to delays across the supply chain.

Import distribution centers have been challenged to pull containers from marine terminals, contributing to significant and widespread port congestion and nationwide delays. While container volumes were on the increase before the COVID-19 pandemic, imports across all sectors have since skyrocketed, partially due to increased ordering to cover JIC inventory planning. Rail has been integral to moving containers off congested ports and toward inland ports or other distribution points. Following the early 2020 facility closures and the lean operations of Precision Scheduled Railroading (PSR), the railroad industry had to reconfigure its operations to move from JIT to JIC and accommodate the record cargo volumes. The reconfiguration took time and effort to implement, and rail's importance to the supply chain was evidenced by the container backlogs that occurred while the industry was ramping up capacity. However, PSR still informs Class I rail operations, and unreliable service, fewer trains, and longer timeframes remain key issues in utilizing rail service in the current market environment.

Regarding the movement of finished goods in particular, "last mile" (the final stage of delivery to a customer's home or business) performance is especially important for e-commerce. B2C delivery has forced many retailers to focus more on last-mile logistics, which is generally considered to be the most complex and costly portion of the delivery process. While many continue to outsource this service to one of the big three delivery companies (UPS, FedEx, and USPS), some are opting for their own delivery services and service networks. The result of these developments is that the rise in e-commerce has produced a significant number of new participants in the distribution network, as well as new vehicles on the road. At the same time, the customer may also be responsible for the last mile through "buy online pickup in store" transactions use of Amazon lockers, UPS access points, etc.

Multistage logistics and automation have driven rapid growth in the development of smaller distribution centers. The average size of distribution centers has dropped to 220,000 square feet (SF), a decline of 15 percent between 2013 and 2017. In fact, the growth in these centers has occurred at both the larger (1 million+ SF) and smaller (under 250,000 SF) ends of the size range, as one would expect from multistage distribution strategies. The growth is driven by the continuing demand for faster times to market, with e-commerce a significant driver. More distribution staging closer to end-markets is the result, emphasizing delivery more than storage.

Warehouse development means more truck trips on both the inbound and outbound sides. Distribution-center cluster development is significantly affecting truck-trip distribution and network assignment patterns. With goods being moved between warehouses to meet short delivery timeframes—rather than goods being moved directly from warehouses to retail or wholesale locations—truck-trip generation will grow. This trend will add more trucks to the roadway system, especially in clustered developments, where truck trips may be generated and destined for many unique locations, as opposed to a more limited and predictable number.

4.5.2 Railroad

Demand for freight-rail service is expected to continue in Oklahoma, enhanced by the state's geographic location. Twenty-one freight railroads, including three Class I carriers, operate in the state. Railroads are regularly implementing new technology to improve the safety and efficiency of rail operations.

One area of safety focus is PTC, which is a technologically based means of ensuring train separation and derailment avoidance. PTC is mandated and regulated by the FRA and required on lines where regularly scheduled passenger trains operate and where certain freight commodities are carried. This system, which is interconnected with a train's throttle and braking systems, monitors the track ahead for conditions that could affect the movement of a train (such as track occupancies, restricting signals, or misaligned switches). The system advises a train engineer of a condition requiring remedial action. If the train engineer does not take remedial action within the prescribed time period, the system will stop the train. PTC is an overlay on already existing signal systems and dispatch systems that control the movement of trains across North America.

Another area of safety focus is grade-crossing safety. Motor vehicles of all sorts enter into a rail-highway grade crossing too often, either without taking proper precautions to observe surrounding conditions or intentionally ignoring active warning devices. The railroads—in concert with the U.S. DOT and state departments of transportation—are working to make drivers more aware and are closing crossings where possible.

As for efficiency, railroads are improving their physical plants to allow larger capacity railcars to move throughout the system. This provides commercial benefits to shippers and receivers in Oklahoma and other states. Additionally, Class I railroads are running longer trains, both for unit trains and merchandise freight. To do this, the railroad companies are utilizing advanced computerized dispatching systems and a locomotive allocation system called "distributed power." With distributed power, a train can have locomotives (power) at the front of the train, mid-train, and (often) at the rear of the train. These locomotives are all controlled by the engineer in the front of the train. The distributed power allows a single train to pull tens of thousands of additional tons of commodity. This economy of scale improves the fluidity of the railroad, frees capacity for additional freight or passenger trains, and expedites freight movements across the country. At the same time, the short-line (Class III) railroads are working to more efficiently serve local customers, with creative crew assignments, prepositioned locomotives, preblocked cars, and multiple switches per day. While low tech, these are customer-focused initiatives.

Railroads have used railcar trip planning for years to plan train consists, crew and locomotive allocation, fuel supplies, and fueling schedules. With the advancements in technologies, railroads are continuing to improve the integration of these functions in a model generically referred to as PSR. PSR allows the railroads to leverage the legacy systems with the efficiencies described above to get more asset utilization, both from the physical plant and rolling stock.

Freight railroads in the U.S. are private organizations that are responsible for their own maintenance and improvement projects. It is anticipated that railroad companies will need to continue investing in their infrastructure as well as adding to their systems to address the growth in rail traffic over the next decades.

4.5.3 Implications of Transportation Industry Trends

Changes surrounding supply-chain management, international shipping logistics, trucking, and rail infrastructure affect where goods will be shipped, in what quantities, and how they will be transported.

Supply-chain matters for freight planning because it affects the location and types of transportation infrastructure investments as well as local land use and economic vitality. Understanding Oklahoma's industrial profile is important, so that opportunities and threats can be recognized, new developments can be observed closely, and forecasts are viewed as guides to the future.

The trucking industry in Oklahoma is strong and plays a significant role in the economy. Trucking in Oklahoma includes every type of carrier from individual haulers and small companies with a few trucks to the largest national carriers. The types of vehicles in operation and the commodities that they carry are equally diverse. Conditions such as driver shortages and HOS—combined with an economy that continues to prefer faster and more customized service—reinforce the need for the continued growth and development of this industry.

Demand for freight-rail service is expected to continue in Oklahoma, enhanced by the state's geographic location. Twenty-one freight railroads, including three Class I carriers, operate in the state. Railroads are regularly implementing new technology to improve the safety and efficiency of rail operations.

4.6 FUTURE GROWTH

Freight tonnage and value growth forecasts for the Plan were developed from FAF (version 5.3), using base year 2017 and forecast year 2045.

As shown in Table 4-2, Oklahoma is expected to add 153.0 million tons of freight moving into, out of, and within the state between 2017 and 2045 (a 35 percent increase). More than half the increase (79.5 million tons) will be for trucking, and 45 percent of trucking growth will be for moves within the state. Pipeline is forecast to grow by 54.8 million tons, with 50 percent of pipeline growth in the inbound direction. Multiple modes is forecast to add 10.2 million tons, mostly inbound and outbound. Rail is forecast to add 6.7 million tons internal and 2.4 million tons outbound, but to lose 3.7 million tons (primarily coal) inbound, for a net increase of 5.4 million tons. Water is forecast to add 3.1 million tons, almost all moving outbound.

Table 4-2. Tonnage Growth, 2017-2045

Domestic Mode	OK Flow Direction	Tons 2017 (M)	Tons 2045 (M)	Growth (M)
Truck	Inbound	42.5	62.6	20.1
	Outbound	48.3	71.6	23.3
	Internal	119	155.1	36.1
	TOTAL	**209.8**	**289.3**	**79.5**
Pipeline	Inbound	63.5	91.4	27.9
	Outbound	81.8	98.4	16.6
	Internal	17.5	27.8	10.3
	TOTAL	**162.9**	**217.7**	**54.8**
Multiple Modes & Mail	Inbound	10.7	16.2	5.5
	Outbound	5.9	10	4
	Internal	1.9	2.5	0.7
	TOTAL	**18.5**	**28.7**	**10.2**
Rail	Inbound	11.9	8.1	-3.7
	Outbound	7.2	9.6	2.4
	Internal	18.8	25.5	6.7
	TOTAL	**37.9**	**43.2**	**5.4**
Water	Inbound	0.8	1	0.1
	Outbound	4.8	7.6	2.9
	Internal	0.7	0.9	0.1
	TOTAL	**6.3**	**9.5**	**3.1**
Air (include truck-air)	Inbound	0.0	0.0	0.0
	Outbound	0.0	0.0	0.0
	Internal	0.0	0.0	0.0
	TOTAL	**0.0**	**0.1**	**0.0**
Other and unknown	Inbound	0.0	0.0	0.0
	Outbound	0.0	0.0	0.0
	Internal	0.0	0.0	0.0
	TOTAL	**0.0**	**0.0**	**0.0**
GRAND TOTAL	**TOTAL**	**435.5**	**588.5**	**153.0**

Source: Analysis of Freight Analysis Framework 5.3, excluding pass-through traffic

As shown in Table 4-3, Oklahoma is expected to add $197.5 billion in value of freight moving into, out of, and within the state between 2017 and 2045 (a 66 percent increase). Trucking is forecast to increase by $141.6 billion, accounting for 72 percent of the growth; growth in all directions is expected, with the largest share for inbound moves. Multiple modes is forecast to add $37.7 billion, mostly inbound and outbound. Pipeline is forecast to grow by $11.7 billion, mostly inbound. Rail is forecast to add $3.0 billion in all directions. Note that although inbound rail tonnage declines, inbound rail value actually increases, because the tonnage loss is largely in coal, a low-value/high-weight commodity. Air is expected to add $2.9 billion, with around two-thirds inbound. Water is projected to add $0.8 billion, mostly outbound.

Table 4-3. Value Growth, 2017-2045

Domestic Mode	OK Flow Direction	Value 2017 ($B)	Value 2045 ($B)	Growth ($B)
Truck	Inbound	79.3	140.2	60.9
	Outbound	62.9	108.2	45.3
	Internal	65.2	100.6	35.4
	TOTAL	**207.5**	**349.1**	**141.6**
Multiple Modes & Mail	Inbound	20.6	39.7	19.1
	Outbound	12.1	26.1	14.1
	Internal	3.6	8.1	4.5
	TOTAL	**36.2**	**73.9**	**37.7**
Pipeline	Inbound	20.3	27.3	7.0
	Outbound	19.4	22.2	2.7
	Internal	3.8	5.8	2.0
	TOTAL	**43.5**	**55.2**	**11.7**
Rail	Inbound	3.2	4.3	1.2
	Outbound	1.6	2.7	1.1
	Internal	2.6	3.3	0.7
	TOTAL	**7.3**	**10.3**	**3.0**
Air (include truck-air)	Inbound	1.9	3.7	1.8
	Outbound	1.7	2.7	1.0
	Internal	0.0	0.0	0.0
	TOTAL	**3.6**	**6.4**	**2.9**
Water	Inbound	0.5	0.6	0.1
	Outbound	1.2	1.8	0.7
	Internal	0.2	0.2	0.0
	TOTAL	**1.9**	**2.6**	**0.8**
Other and Unknown	Inbound	0.0	0.0	0.0
	Outbound	0.1	0.1	0.0
	Internal	0.0	0.0	0.0
	TOTAL	**0.1**	**0.1**	**0.0**
GRAND TOTAL		**300.1**	**497.6**	**197.5**

Source: Analysis of Freight Analysis Framework 5.3, excluding pass-through traffic

As shown in Table 4-4, petroleum and coal products account for 59.6 million tons (30 percent) of projected tonnage growth. Other leading tonnage growth commodities include gravel, chemicals, nonmetallic mineral products, fertilizers, mixed freight, sands, live animals and fish, crude petroleum, and animal feed. Fuel oils, coal, and gasoline tonnages are projected to decline.

Table 4-4. Tonnage Growth by Commodity, 2017-2045

	Tons 2017 (M)	Tons 2045 (M)	Growth (M)
Petroleum and Coal Products n.e.c.	112.8	172.4	59.6
Gravel	35.8	48.8	13.0
Basic Chemicals	6.6	18.9	12.2
Nonmetal Min. Prods.	20.6	29.8	9.2
Fertilizers	6.6	15.0	8.4
Mixed Freight	9.7	16.6	6.9
Natural Sands	16.0	22.6	6.7
Live Animals/Fish	3.1	8.7	5.6
Crude Petroleum	59.2	63.7	4.5
Animal Feed	6.9	11.3	4.4
Plastics/Rubber	3.1	6.9	3.8
Nonmetallic Minerals	8.0	11.5	3.5
Misc. Mfg. Prods.	2.2	5.5	3.3
Wood Prods.	4.8	8.0	3.2
Other Foodstuffs	6.9	9.9	3.0
Cereal Grains	16.1	18.9	2.7
Newsprint/Paper	3.3	5.4	2.1
Chemical Prods.	1.6	3.6	2.0
Motorized Vehicles	2.4	4.1	1.7
Articles-Base Metal	4.3	5.9	1.6
Other Commodity Tons	45.1	59.0	13.8
Fuel Oils	24.0	20.4	-3.6
Coal	8.2	1.3	-6.9
Gasoline	28.0	20.3	-7.8
TOTAL	**435.5**	**588.5**	**153.0**

Source: Analysis of Freight Analysis Framework 5.3, excluding pass-through traffic

As shown in Table 4-5, projected value growth is distributed across a diverse range of leading commodities, including pharmaceuticals; mixed freight; miscellaneous manufactured products; electronics; petroleum and coal products; machinery; live animals and fish; plastics and rubber; and motorized vehicles. Values of coal, fuel oils, and gasoline transported are projected to decline.

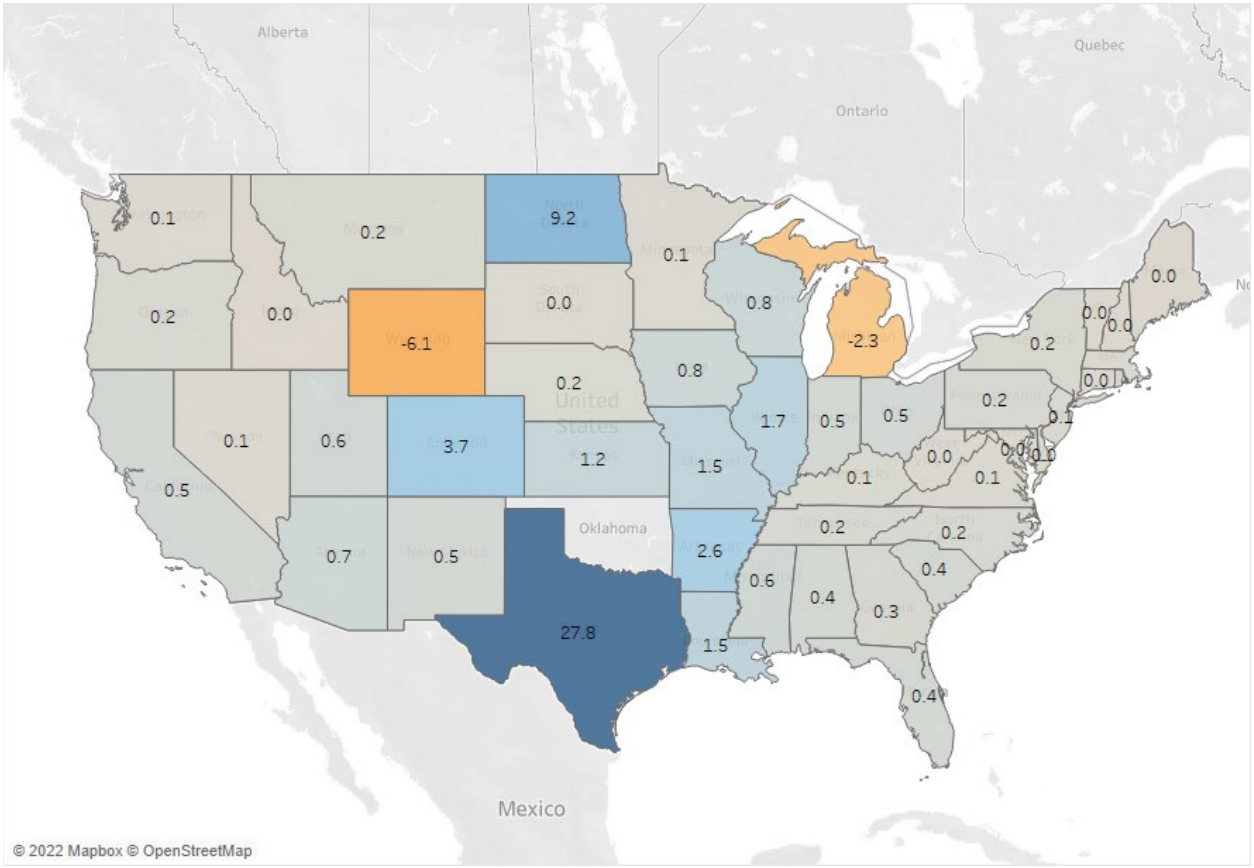
Table 4-5. Value Growth by Commodity, 2017-2045

	Value 2017 ($B)	Value 2045 ($B)	Growth ($B)
Pharmaceuticals	12.1	32.7	20.6
Mixed Freight	28.5	48.4	20.0
Misc. Mfg. Prods.	13.1	33.0	19.9
Electronics	17.4	34.2	16.8
Petroleum and Coal Products n.e.c.	27.2	41.7	14.5
Machinery	21.5	34.4	12.9
Live Animals/Fish	7.0	19.7	12.7
Plastics/Rubber	9.5	20.8	11.3
Motorized Vehicles	14.5	24.0	9.6
Chemical Prods.	6.1	13.8	7.7
Basic Chemicals	4.1	11.5	7.4
Textiles/Leather	6.9	13.7	6.8
Precision Instruments	6.3	12.8	6.5
Articles-Base Metal	12.7	17.3	4.6
Meat/Seafood	7.3	10.6	3.3
Other Foodstuffs	6.5	9.5	3.0
Furniture	3.9	6.6	2.7
Wood Prods.	3.4	5.9	2.5
Paper Articles	3.2	5.6	2.5
Fertilizers	1.8	4.2	2.3
All Other Commodity Value	60.4	76.8	16.4
Coal	0.1	0.0	-0.1
Fuel Oils	11.9	10.0	-1.9
Gasoline	14.8	10.6	-4.3
TOTAL	**300.1**	**497.6**	**197.5**

Source: Analysis of Freight Analysis Framework 5.3, excluding pass-through traffic

Tonnage inbound to Oklahoma is expected to grow by 49.9 million tons between 2017 and 2045. As shown in Figure 4-13, Texas accounts for 27.8 million tons (56 percent) of inbound tonnage growth, followed by North Dakota (9.2 million tons), Colorado (3.7 million tons), and Arkansas (2.6 million tons). Tonnage declines are projected from Wyoming (due to reduced coal tonnage by rail) and Michigan (due to reduced crude oil tonnage by pipeline).

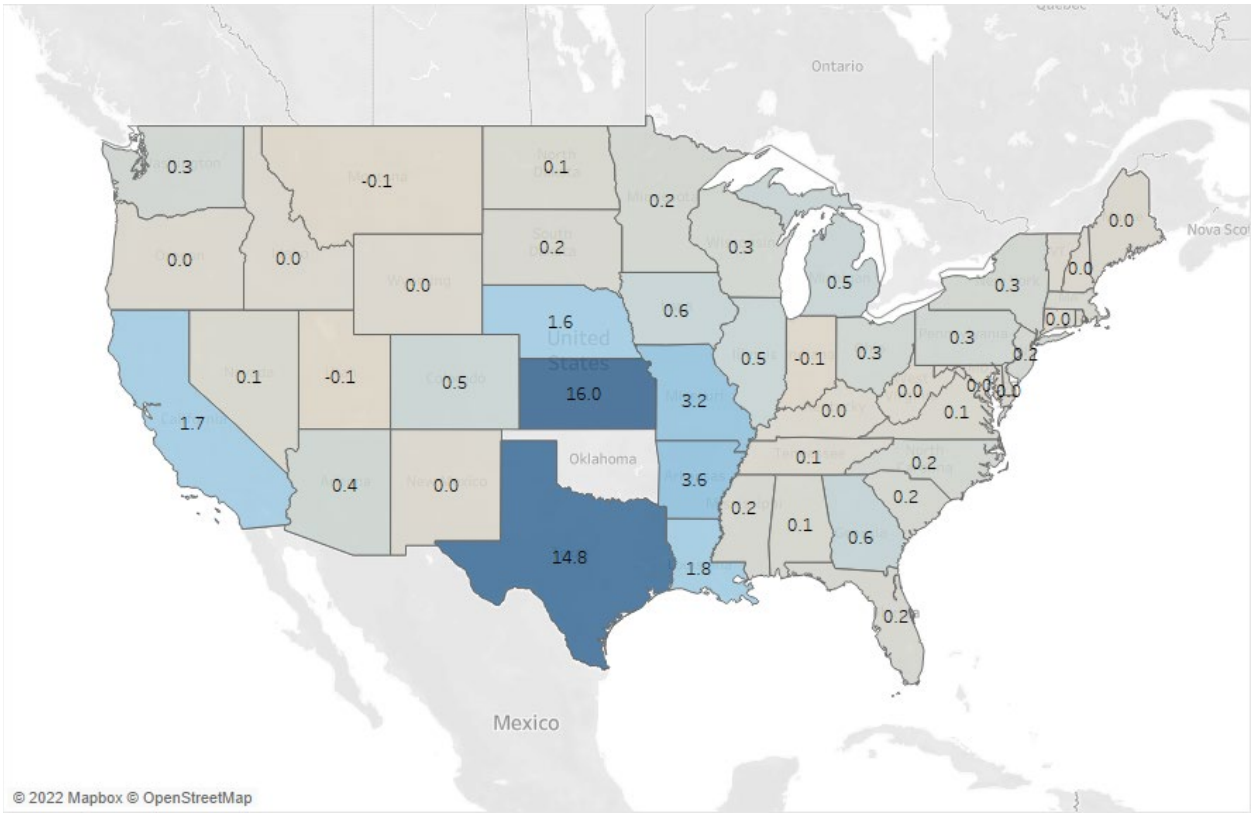
Figure 4-13. Added Inbound Tonnage by Origin State (2017 to 2045)



Source: Freight Analysis Framework 5.3. Excludes pass-through, outbound, and internal traffic.

Tonnage outbound from Oklahoma is expected to grow by 49.0 million tons between 2017 and 2045. As shown in Figure 4-14, Kansas accounts for 16.0 million tons and Texas accounts for 14.8 million tons, representing a combined 63 percent of tonnage growth. Other significant growth states include Arkansas, Missouri, Louisiana, California, and Nebraska.

Figure 4-14. Added Outbound Tonnage by Destination State (2017 to 2045)



Source: Freight Analysis Framework 5.3. Excludes pass-through, outbound, and internal traffic.

4.7 CONCLUSION

Several important trends are likely to affect the demand for and availability of future freight transportation in Oklahoma:

- At a high level, it is anticipated that energy markets will continue to remain volatile in the face of geopolitical concerns, the COVID-19 pandemic, and energy policies.
- Agriculture will continue to be a growth industry, consuming significant amounts of highway, rail, and waterway capacity. However, like the energy market, agricultural commodities will also face challenges based on labor, climate, and international demand.
- The changing retail and distribution trade environment will increase both urban and rural deliveries by truck which, together with overall growth in truck volumes, will exacerbate existing congestion. Urban and suburban communities will face development pressure from warehousing to meet short delivery expectations, as well as pressure on local streets and parking from delivery vehicles.
- Technology advances supporting trucking are expected to improve safety in the short term, but the full vehicle automation will likely remain years in the future, leaving opportunity to address labor and parking challenges in the near term.

Chapter 5 identifies specific bottlenecks and mobility issues that will prevent the smooth flow of freight. Chapter 6 identifies and prioritizes potential projects to eliminate or mitigate them.