# EVALUATION OF THE SOCIAL COST OF MODAL DIVERSION: A MULTI-MODAL SAFETY ANALYSIS

## FINAL PROJECT REPORT

by

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**16. Abstract**

A multifaceted controversy surrounds the evolving use of rail lines for the movement of coal and oil out of the Midwest to West Coast ports. From environmental concerns over blowing coal dust, to recent catastrophic derailments and subsequent explosions of rail cars carrying Bakken oil out of North Dakota, to the closure of the *Cold Train Express* from Quincy to Chicago and the massive delays on obtaining rail cars for Midwest grain, the Northern Corridor rail lines are undoubtedly in a state of change and necessary evaluations. Multiple agencies, from state and federal departments of transportation, to the USDA and state Ecology Department, have ramped up interest and involvement in the development of future planning and policy. As each of the above interests and concerns are addressed, the interplay of capacity, safety, efficiency, and reliability will, and has, impacted Washington agricultural producers. This begins the development of the necessary economic performance metrics in line with the needs of the agricultural and transportation communities.

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# Contents

## FIGURES

# TABLES

## Executive Summary

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# Chapter 1 Introduction

The Washington State Department of Transportation's (WSDOT) Rail Division recently released its *Washington State Rail Plan: Integrated Freight and Passenger Rail Plan 2013-2035* (Cambridge Systematics, 2014). Among the plan's identified strengths and challenges is the recognition that the volume of freight moved on the state's rail network is expected to more than double by the year 2035, to more than 260 million tons (up from 116 million in 2010). While these figures represent a positive outlook for the state's economy, they pose multiple challenges for agencies, operators, and communities throughout the state. Atop these challenges is the successful navigation of the growing rail utilization in a safe and effective manner. Though not accounted for in the state's rail volume forecast, the increasing demand of coal for export and the transport of volatile crude oil out of the Bakken oil fields in the upper Midwest add several layers of safety and environmental health concerns for the region. These added volumes have the potential, without continued coordinated planning and action by all stakeholders, to place significant capacity constraints on the system and those users dependent upon it. Inevitably, capacity constraints on rail lines will, and already have, diverted freight traffic onto the roadways. Capacity constraints manifest in at least two stages. First, as volumes increase on the rail line toward capacity, some users will be incentivized to divert to other modes. Second, as the level of service declines because of new safety standards to minimize the threat of derailment, the likelihood that shippers will divert to truck shipment increases. Both factors tend to increase the volumes of trucks on the roadway, generating further safety concerns.

The factors above form the basis for this research. We reviewed the potential for safety concerns and economic implications stemming from rail utilization from several avenues. Specifically, this research reviewed the current rail use by traditional users and demands of oil on rail.  It was not the focus of this project to evaluate the efficacy of energy movement by rail but to determine the impacts of increased oil/coal movement, and the safety actions concerned with this movement, on the overall transportation system and its users.

## Chapter 2 Safety Risks of Oil by Rail

Increased utilization of rail by oil and its transportation system-wide effects on capacity possess three direct safety risks for the communities and economies of the Pacific Northwest and beyond.

**Capacity Induced Diversion:** Increased rail demand under capacity constraints diverts hauls back to the roadways, necessarily implying that there will be increased trucks on the roadway at a time when many states are seeking to divert more trucks to rail.

**Derailment Abatement:** Oil car derailment poses direct threats to the safety and security of all communities that oil passes through. Consideration of rail safety-based legislation is under way throughout the region. These actions pose a significant likelihood of slowing down rail or altering movement, making it less attractive to shippers and shrinking available capacity. Thus, these safety actions have the potential to compound the effects of capacity constraints and further induce diversion to the roadways.

**At-Grade Crossings:** Oil export terminals in the Pacific Northwest are located within some of the most populated cities of the region. Increased exports pose significant safety concerns, as the necessary number of at-grade crossing delays will dramatically increase as train volumes increase. Similarly, smaller towns are also faced with congestion and traffic impacts.

Opportunities for the evaluation of safety projects directly or indirectly related to each of the above risks are detailed case by case in the following sections. It is important to note that this study did not evaluate proposed methods to increase safety of oil on rail. Rather, it considered the spillover social costs (safety) effects of oil on rail to the broader transportation system as a result of diversion from rail to road, based on capacity constraints and reduced level of service on the rail line for other shippers.

2.1 Capacity Induced Diversion

Throughout the nation, states and regional planners are actively devising and implementing projects and policies to divert truck freight traffic away from interstate corridors and onto rail lines or waterways where feasible in an effort to minimize the added social cost of long-haul and through-truck traffic volumes on their roadways. Several examples of such actions include the following:

- Feasibility Plan for Maximum Truck to Rail Diversion in Virginia's I-81 Corridor[1]
- Valuation of Rail Infrastructure Proposals (Tennessee DOT)[2]
- Rail Preservation Programs: A Survey of National Guidance and State Practice (CTC & Associates, 2011).

These efforts are largely motivated by congestion and truck volumes, as the Federal Highway Administration estimates a 62 percent increase in freight volumes on the U.S. transportation by 2040 over 2011 values.[3] While these increased volumes and coinciding increases in congestion offer their own safety concerns, additional stimulation for diversion is a direct result of safety gains that can be achieved through the utilization of alternative modes, including the following:

[1] http://www.ctb.virginia.gov/resources/2010/April/cm_5_Update_I-81_041410.pdf
[2] http://www.tdot.state.tn.us/publictrans/RailPlan/
[3] FHWA. Freight Facts and Figures 2012. https://ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/12factsfigures/

- For every one fatality (injury) in the inland marine sector, there are 22.7 (125.2) fatalities in the rail sector, and 155 (2171.5) fatalities on the highway sector.[4]
- External costs of accidents related to general freight trucks are estimated to be $0.59 per ton-mile as opposed to those of trains at $0.17 per ton-mile (Forkenbrock, 2001).

However, as previously indicated, not only are roadway traffic volumes attributable to large trucks increasing and pressing capacity, but so too are rail lines feeling, or soon will be, their capacity constraints. Therefore, despite considerable effort to relieve roadways of the external or social costs of freight transportation (safety, pollution, congestion, and noise), the actual performance of the measures and investments may be limited by the realities of intermodal competition.

**Box 1: Cold Train Death**

As of November of 2013, Washington based producers of apples, pears, potatoes, carrots and cherries, among numerous others, were moving nearly 1,000 containers per month out of the Port of Quincy on the *Cold Train Express.* The *Cold Train*, as it is commonly called, is an intermodal carrier transporting many Washington goods to Chicago, Ill., for further distribution in the broad market for Washington's agricultural products. Taking advantage of the reliability and on-time percentage in excess of 90 percent found on the *Cold Train*, Washington producers were nearly guaranteed a three-day transit time to Chicago; a significant boon for an industry whose products are highly perishable. However, as of August 2014, the *Cold Train* has indefinitely ceased all movement. The 90 percent on time performance had drastically dropped to 5 percent according to *Cold Train* executives. A 5% on-time rate and an expected transit time of nearly six days cost the *Cold Train* much of its perishable business as producers were forced to find another, more reliable and potentially more costly mode of transport for their 1,000 containers a month: truck.

[4] Texas Transportation Institute, Waterways: Working for America. http://www.marad.dot.gov/documents/water_works_REV.pdf.
Both rail and truck statistics include incidents involving only vehicular crashes or derailments.

As evident in *Box 1*, diversion from truck to rail may begin facing an uphill battle in our region as market forces operating on eastbound transits have already forced some refrigerated goods shippers to divert away from the rail and back onto the roadway.

## 2.2 Derailment Abatement

Prior to 2010, the volume of oil movement on the Northwest's rail lines was rather insignificant, as much of the oil entering the region did so by pipeline or tanker from the north. However, by 2013, 714 million gallons were transported in Washington, with an expectation that 2015 could be witness to 3 billion gallons, and estimates suggest that 17 billion is not an unthinkable number by 2035. Concern over the safety and environmental concerns of this rapid increase is evidenced by the recent legislatively mandated report completed by the Washington State Department of Ecology (Etkin et al., 2014). Threat of derailment of the highly volatile Bakken Crude came to the forefront of community and transportation planners' minds as Quebec suffered a catastrophic derailment that killed 47 people. Eight other significant derailments of crude occurred through 2013 and 2014. State, and federal managers have since been developing response and prevention plans to prevent or minimize the potential for future occurrences. Given the expected increase in oil trains through the state and the fact that the oil train lines pass through 22 cities with populations in excess of 3,000 residents per square mile, this is a major issue for Washington.

While threat of derailment is undoubtedly a rail transportation issue in the direct sense, roadway safety is brought into the mix by means of the following:

- New rail safety measures may alter the speed and routing of trains, potentially further limiting the capacity and efficiency of rail operations, thus diverting traffic to roadways (Box 2).

- Railways often run parallel to or cross roadways in high density areas. Derailments will impede regular transportation flows.

- Multiple at-grade crossings have been identified that pose higher than average risk of derailment and/or collision.

**Box 2: Freight Rail Conundrum: Speed vs Safety**

"U.S. railroads are rallying customers, including lumber and steel executives, to fight a government safety proposal to slow trains hauling another commodity: crude oil. In response to the proposed speed limits, railroads have rallied more than a dozen companies and business groups (to warn) regulators that cutting speeds to 40 miles an hour from 50 would have a cascading effect, delaying other trains sharing the tracks carrying cargo such as furniture, grain and electronics," - Jim Snyder, Bloomberg News

http://www.planetizen.com/node/71737

## 2.3 At-Grade Crossings

While at-grade conflicts with trains carrying Bakken crude certainly have unique conflict and safety concerns, by and large the safety concerns over at-grade crossings are not contained to a single commodity. Rather, safety concerns of at-grade crossings are generated primarily by frequency of delays; in other words, the frequency with which roadway vehicles have the opportunity to come in contact with a passing train. As of 2009, the U.S. had more than 136,000 public at-grade crossings, of which just more than 42,300 were gated. Incidents (1,896) at these crossings included 247 deaths and 705 injuries.[5] While these figures do not represent insignificant outcomes, nevertheless many jurisdictions report that congestion is 'the' major concerns over at-grade crossings

Thus far the potential economic and safety impacts of increased rail traffic due to Bakken Crude, as well as coal shipments, have not been fully evaluated within the Pacific Northwest. However, some early findings produced by the Puget Sound Regional Council (PSRC) in regard

[5] FHWA. http://safety.fhwa.dot.gov/xings/xing_facts.cfm

to a single coal terminal expansion (Gateway Pacific Terminal) for coal movement shed initial light on the potential for a growing conflict:[6]

- Pedestrian mobility and safety could be impacted at crossings located within regional growth centers with high pedestrian traffic.
- Accidents and safety generated concerns can lead to compounded scheduling and economic activity impacts.
- Increased trains per day (increased gate down time) may lead to diverted roadway and pedestrian traffic onto less safe roadways unable to handle the added volumes.

WSDOT, the Association of Washington Cities Rail Committee, the Freight Mobility Strategic Investment Board (FMSIB), the Washington Public Ports Association (WPPA), and the Washington Utilities and Transportation Commission (UTC) are taking steps to prepare for the rapid growth of multiple commodities – grain, energy, and intermodal—on the mainline freight rail system in the Pacific Northwest. These entities and other stakeholders are working together to develop methods to analyze and prioritize current and future system-wide grade-crossing issues. The method will be based on state and federal policies, community values that include safety and local mobility, freight mobility, and maintaining and growing the economic vitality of the region. This project directly complements these activities and evolving processes.

[6] PSRC, 2014. http://www.psrc.org/assets/11744/StaffSummary.pdf.

## Chapter 3 Rail Market Shares

Grains, oil, and coal are three goods that rely heavily on the transportation network because they have mostly fixed production sites and widespread consumption locations. When production sites are far from shipping destinations and not located near navigable waterways, then the importance of rail transport is increased. This section discusses grains, crude oil, coal, and refrigerated goods, the rail market share of transportation for these goods.

### 3.1 Grains and Oilseeds

Grains and oilseeds include corn, wheat, soybeans, barley, canola, flaxseed, millet, oats, peanuts, rice, rye, safflower, sorghum (for grain), and sunflower. Most rail revenue from grains is from corn, wheat, and soybeans.

Most grain is not tied to rail. According to the Association of American Railroads (AAR), grain makes up only about 4 percent of rail carloads. According to a report conducted by the Agricultural Marketing Service (AMS), grain is transported by about 65 percent truck, 25 percent rail, and 10 percent barge. Since the early 1990s, trucks have transported the majority of grain, and the truck share of grain transport has been increasing while the relative use of rail and barges has been decreasing.[7] Grain that is exported, however, is more reliant on rail transport for the long haul because of the need to arrive at ports, which may be a long distance from grain production locations. About one-fourth of all grain produced is exported (AAR- Railroads and Grain), and imports and exports make up nearly one half of all intermodal transport (AAR- Rail Intermodal). Two major port locations are the Pacific Northwest and the Gulf of Mexico. The

[7] Transportation of U.S. Grains: A Modal Share Analysis, https://www.ams.usda.gov/services/transportation-analysis/modal

majority of grain, however, is grown in the Midwestern states (figure 1), and the majority of exports from these states is shipped to ports in the Gulf States (table 1).

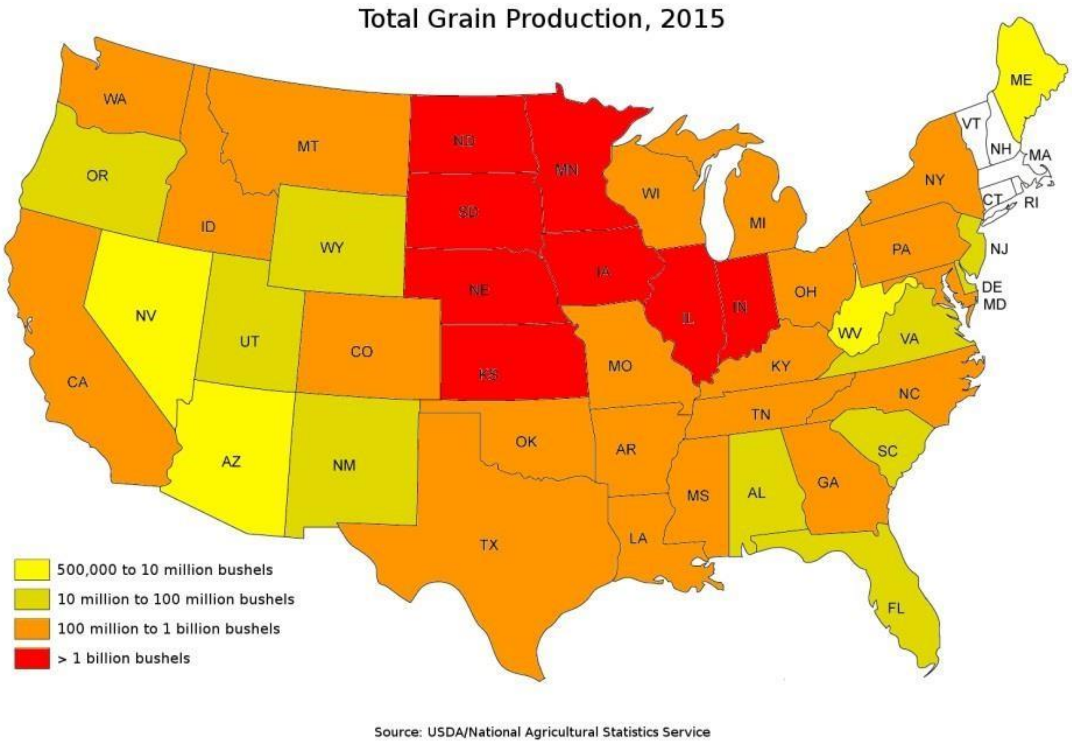



**Figure 1.** Total grain production by tate, 2015

**Table 1.** Grain exports from highest grain producing tates

| Grain Origin | Total Grain Exported (K tons) | % PNW | % Gulf |
|---|---|---|---|
| Kansas | 5921.3 | 0.30% | 91.40% |
| Illinois | 4929.5 | 9.00% | 82.80% |
| Iowa | 4778.5 | 8.20% | 74.40% |
| Nebraska | 1526.8 | 0.20% | 94.50% |
| Minnesota | 929.3 | 3.30% | 76.20% |
| North Dakota | 615.7 | 2.30% | 81.40% |
| Indiana | 179.5 | 0.70% | 10.00% |
| South Dakota | 36.7 | 0.50% | 74.30% |

Notes: The majority of grain exports out of Indiana are trucked through Michigan into Canada.

The upper Midwest (e.g., Montana, North Dakota, and South Dakota) is an area not easily accessible by trucks or barges. The long distances required are too expensive for trucks, and the lack of waterways prohibits any shipping by barge. Any goods produced in this region that are shipped elsewhere are therefore heavily dependent on rail (figure 2). The reliance on rail is dependent on many factors such as how much of the grain production is exported, the distance to waterways, etc. Chapter 5 Estimation of Sub-regional Agricultural Demand for Rail discusses the relative demand for rail transport of grain in more detail.

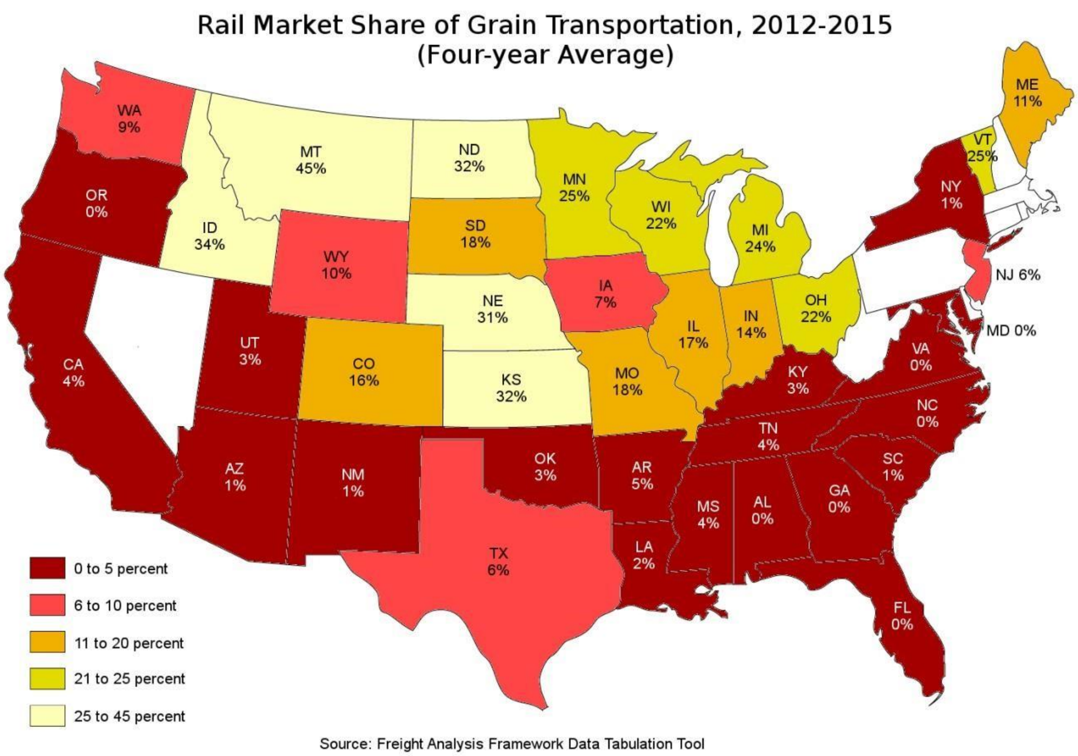
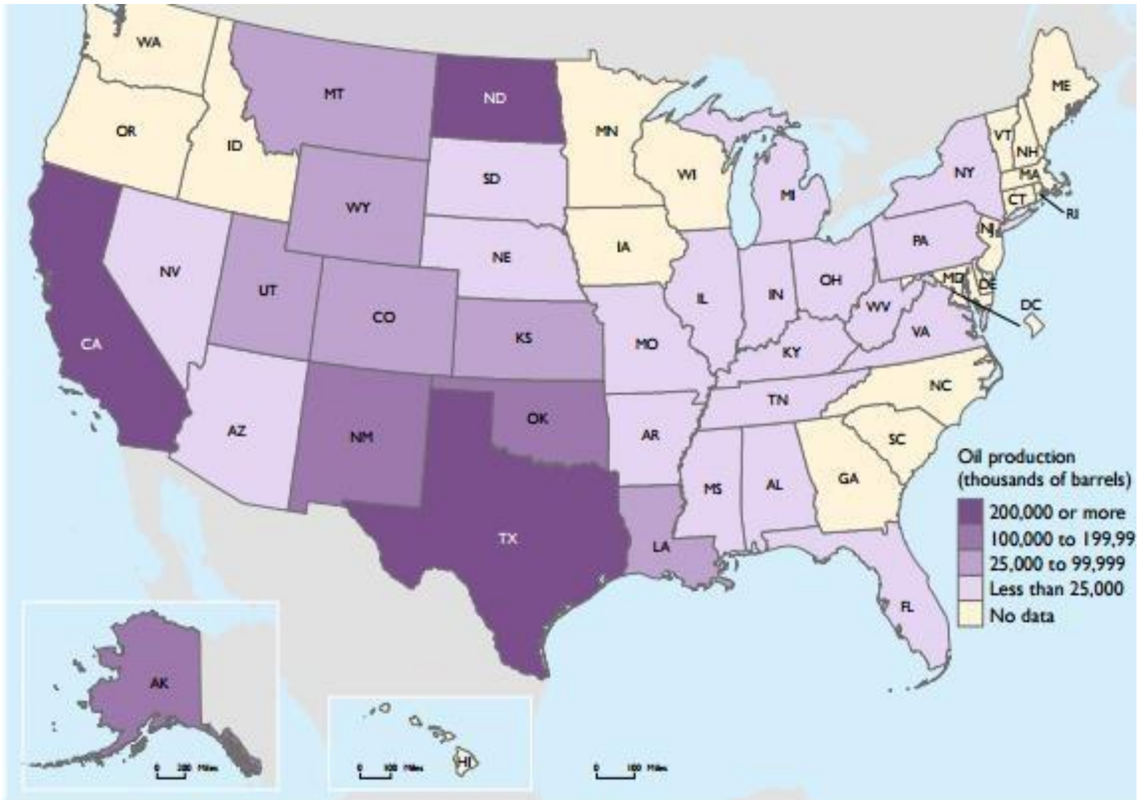



**Figure 2.** Rail market share of grain transportation, 2012-2015

Grain's future demand for rail is difficult to predict because it depends on weather, harvests, and market conditions that are all relatively volatile. Furthermore, because weather and market events affect different types of grain differently (e.g., some grains are planted or harvested earlier or later in the season), projections for grain production and demand for transportation is likely to vary from crop to crop. Generally, agricultural production are expected to increase as farming becomes more efficient. As demand for agricultural products is likely to remain high in all locations where humans or animals exist, it is reasonable to expect that agricultural demand for transportation is likely to generally continue to increase in the future.

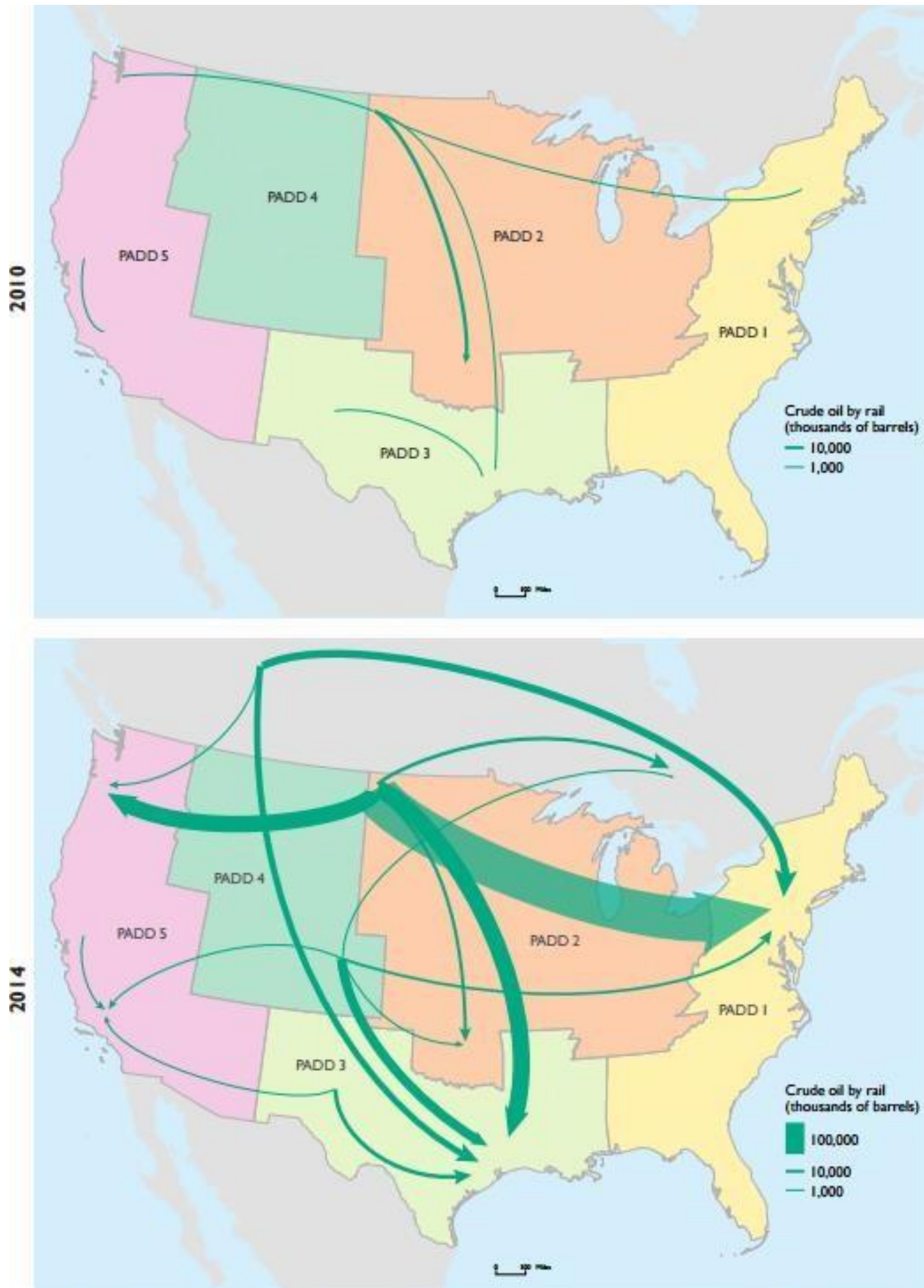
### 3.2 Crude Oil

Oil transport also represents a relatively small portion of overall railroad traffic (1.6 percent of originated carloads in 2014 (AAR FCS)). In 2013-2014, however, the rapid production of oil due to fracking, particularly in North Dakota and Canada, increased demand for rail as existing pipelines are at or near full capacity. Oil production in North Dakota has increased over 1000 percent since 2004 (U.S. Energy Information Administration (EIA)). Figure 3 shows the overall production of crude oil in 2014, by state. In order to be processed, crude oil must be shipped to refineries, which are at relatively fixed locations that may not be near production sites. Figure 4 shows how crude oil shipments by rail changed from 2010 to 2014. Notice the large increase of rail shipments from North Dakota, Colorado, and Canada to locations in the Pacific Northwest, the Gulf, and the Northeast. Rail shipments of oil were 20.3 million barrels in 2010 and rose to 383.2 million barrels in 2014 (EIA).




**SOURCE:** U.S. Energy Information Administration, available at www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm as of October 2015.

**Figure 3.** Crude Oil Production by State: 2014




NOTE: Crude-by-rail movements greater than 1,000 barrels per day are represented on the map and the arrows are illustrative; PADD denotes Petroleum Administration for Defense District.

SOURCE: U.S. Energy Information Administration Petroleum Administration for Defense Districts based on data from the Surface Transportation Board and other information, October 2015.

**Figure 4.** Crude oil shipments by rail: 2010 and 2014 (PADD to PADD)

Traditionally, most oil is transported by pipelines from production sites to refineries to be processed. Pipelines are slow to build (especially because of long approval processes) and are less geographically flexible than rail. Refineries could be built closer to new oil, but they have regulatory barriers similar to those of new pipelines. In 2009, the Bureau of Transportation Statistics estimated that pipelines transported 79.8 percent of crude oil, water carriers transported 19.4 percent, motor carriers transported 0.5 percent, and railroad transported only 0.3 percent.[8] In the first six months of 2015, railroad was estimated to have transported 22.6 of crude oil.[9] Figure 5 shows the change in modal share of oil production from 2010 to 2015.

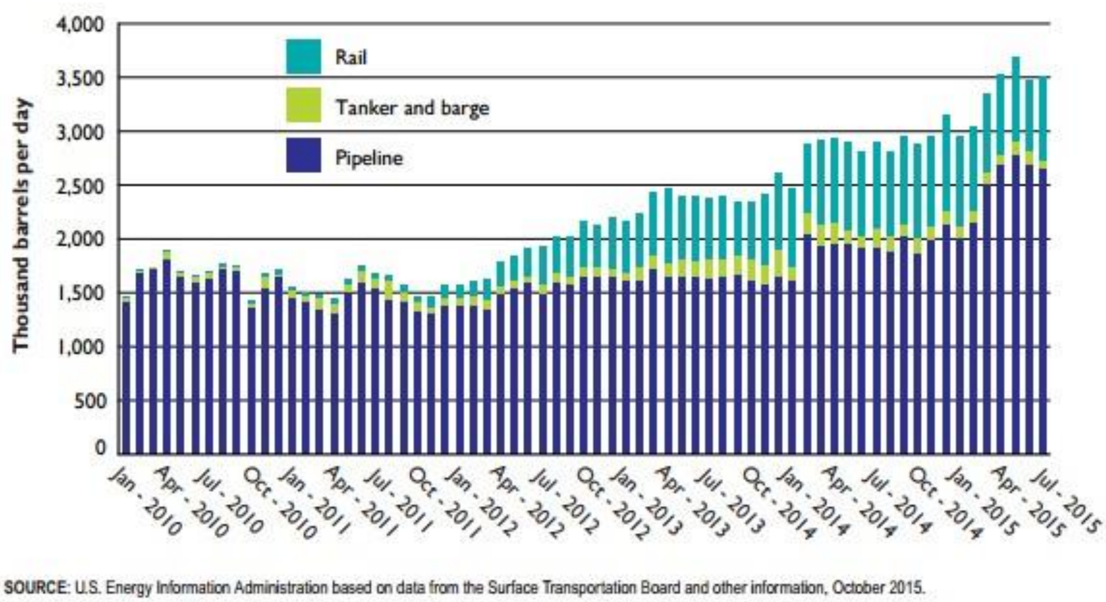



**Figure 5.** Shipments of crude oil moved by pipeline, tanker and barge, and rail: January 2010-July 2015

[8] http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_61.html

[9] U.S. Bureau of Statistics, Freight Facts and Figures 2015. https://www.bts.gov/content/freight-facts-and-figures-2015

Currently, oil prices are relatively low. In February 2009, the West Texas Intermediate (WTI) price of oil dropped to $39.09 per barrel in the wake of the recession. The price rose slowly to a peak of $105.79 in June 2014. By December 2015, the price had again dropped below $40 per barrel, and the price has fallen even more to a low of $30.32 in March 2016 (EIA).

Oil production is difficult to forecast as it depends heavily on the price of oil. If the price remains low, for example, some production locations (for which extraction is relatively more expensive) will need to shut down. Demand for oil depends on global economic conditions, policy uncertainty with fracking, and other difficult to predict factors.

### 3.3 Coal

Coal is heavily reliant on rail transport, and coal has long been a mainstay of railroad traffic, but production and consumption of coal have been decreasing recently. Rail transports about 70 percent of coal delivered to power plants in the U.S. (AAR- Railroads and Coal). Almost 40 percent of rail tonnage is from coal, and about 20 percent of rail carloads are coal (AAR- Railroads and Coal). Energy consumption, however, has been dropping since 2008 because of the recession and environmental concerns. As energy from natural gas and from renewable sources has been increasing over this time, the fraction of energy provided from coal has also been in decline. The main exception is the production of coal in the Western region covering Wyoming and Utah, which has been increasing since the 1990s because of an increased demand for coal with a relatively low sulfur content. Fortunately, this coal is not generally transported through the upper Midwest and does not therefore contribute to the congestion issues in that region (EIA).

The future of coal production and transport is also hard to predict because of policy uncertainty (potentially against coal or against fracking or both), economic uncertainty (energy consumption), and the viability of other energy options.

### 3.4 Cold Train

Refrigerated goods include milk and dairy products, bakery and confectionery products, beverages, and fresh fruits and vegetables (apples, cherries, pears, etc.). Frozen goods include ice cream and other frozen dairy products, processed meat, fish and other seafood, and bakery products. All of these products must be maintained at a specific low temperature for the entire duration of transport.

Refrigerated rail is an extremely small fraction of cold transit, but it is growing. Most refrigerated transport occurs in refrigerated trucks, but the development of refrigerated containers has replaced the need for specialized ports or terminals and increased the ability of rail to transport refrigerated goods. For example, in 1980 33 percent of refrigerated sea transport was containerized, and by 2013 this share was up to 72 percent.[10] In 2015, 8.5 percent of refrigerated truck revenue was from intermodal transport using rail.[11]

The 2014 Upper Midwest capacity problem led to the complete shutdown of one refrigerated rail provider, Cold Train Express. Refrigerated goods tend to be extremely time sensitive, and the rail delays in 2014 were too large and too sustained for the company to endure. Other refrigerated rail operators were not similarly affected by the delays because they did not completely rely on the rail services in the upper-Midwest region.[12]

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[10] Rodrigue, J-P. and Notteboom, T, The Cold Chain and Its Logistics. https://transportgeography.org/?page_id=6585
[11] IBIS World, Long-Distance Refrigerated Trucking. http://clients1.ibisworld.com/reports/us/industry/ataglance.aspx?indid=5402
[12] http://www.joc.com/rail-intermodal/usrefrigerated-rail-operators-confident-despite-cold-train%E2%80%99s-death-raildelays_20140812.html

# Chapter 4 Capacity Problems

Freight traffic has been generally increasing over time, with rare periods of decline as in 2008 and 2009 in the wake of the recession. As freight traffic continues to expand faster than infrastructure investment, demand for all transportation modes approaches and often exceeds capacity. The nature of freight traffic demand is that it varies widely by time of day or time of year. Addressing capacity issues can be challenging in part because increasing infrastructure is expensive and if future demand is overestimated then rail companies can fail to generate enough revenue to cover the high costs. Rail companies have historically had severe problems because of over-expanding track and rail lines. Part of the solution is to increase rail capacity by using a combination of tools that includes building more infrastructure, increasing the power and efficiency of locomotives, managing crews more efficiently, and developing more efficient operating strategies. For more information on general capacity issues associated with railroad transport, see McClellan, Railroad Capacity Issues.

Since the 1980 Stafford Act, rail companies have greatly consolidated the rail network and abandoned many miles of rail (figure 6). This large-scale change in railroad infrastructure has been coupled with an increased efficiency of existing rails, including larger cars, double-stacked containers, and more unit trains and shuttle shipments. One result is that many farmers have to truck their goods farther in order to reach rail facilities, and many locations have become increasingly reliant on a smaller number of rail pathways (complaints reported in AMS report, Chapter 8, data from Surface Transportation Board (STB)).

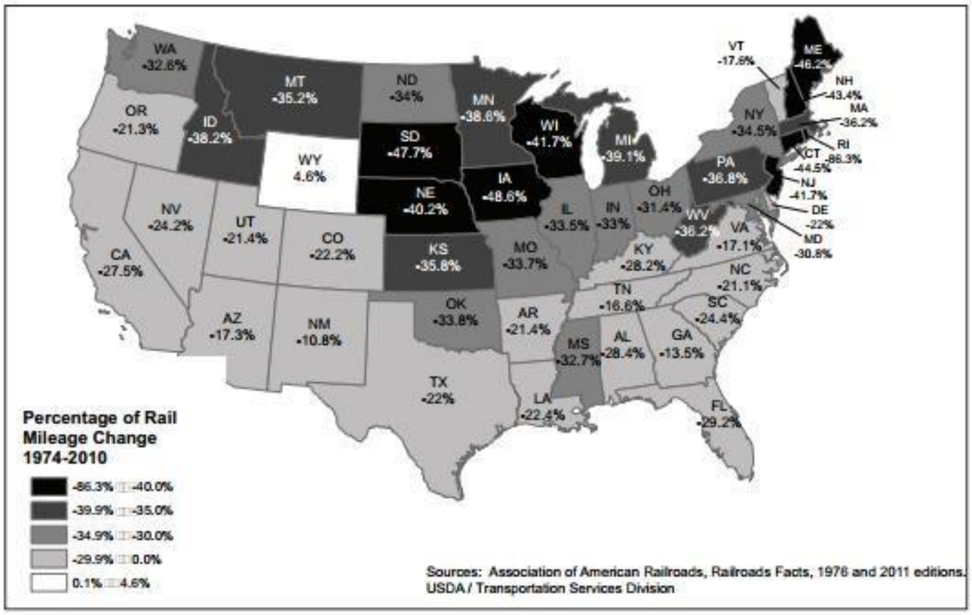


**Figure 6.** Percentage change in railroad route miles by state, 1974-2010
Source: http://www.trforum.org/journal/downloads/2013v52n2_07_RailMarketShare.pdf

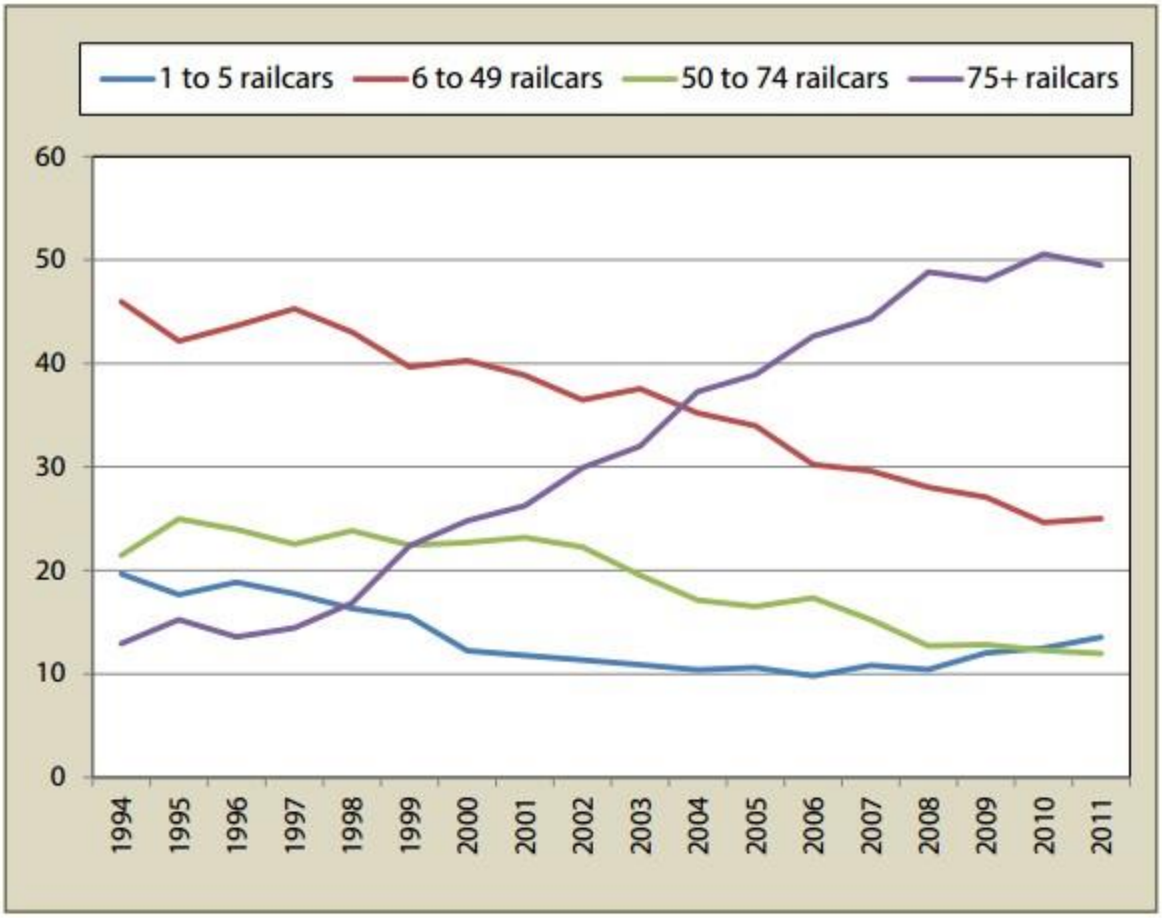



**Figure 7.** Percentage of grain and oilseeds by movement size
Source: [https://www.ams.usda.gov/sites/default/files/media/The%20Effects%20of%20Increased%20Shut tle-Train%20Movements%20of%20Grain%20and%20Oilseeds.pdf](https://www.ams.usda.gov/sites/default/files/media/The%20Effects%20of%20Increased%20Shuttle-Train%20Movements%20of%20Grain%20and%20Oilseeds.pdf) USDA, 2013)

The 2013-2014 harvest year was a perfect storm for rail shortages in the upper Midwest. Both oil and grain are produced there, and both heavily rely on rail because of a lack of other transport options (no waterways, too far for truck, shortage of pipelines). At the same time that oil production skyrocketed, grain harvests were unexpectedly record-breaking. Furthermore, an unusually cold winter slowed rail traffic even more.

According to a report for the American Farm Bureau Federation (Kub, 2015), at the end of 2013, grain companies in the Upper Midwest reported fully loaded railcars waiting between 10 and 29 days before they could move their grain on the congested rails. According to a survey conducted by the Soy Transportation Coalition (2014), over half of the grain shippers who responded in November 2014 (which was after the worst congestion had eased) indicated past due orders for railcars with an average number of 13.4 days past due. About 20 percent of respondents reported having to stop receiving grain from farmers from between 1 and 20 days. In response to the extreme delays, the Surface Transportation Board decided to require all Class 1 railroads to publicly file weekly reports including data related to rail service issues beginning in October 2014. The data include average train speeds, total cars on line, origin dwell times, etc. These data will be extremely helpful in future analyses to examine the determinants and effects of these variables.

When shortages occur, rail companies will auction off cars to the highest bidder. In the grain industry, these extra costs are passed mostly to the farmers, who receive lower prices for their grain. If capacity restrictions are severe enough, grain companies are likely to be late in fulfilling contracts, grain producers may not be able to sell their grain at all, or grain companies that purchase too much grain may not be able to store it. This can result, as it did in 2014, in grain being produced that never reaches any consumer before it rots on the ground. The USDA estimates that farmers in the upper Midwest made $570 million less than they could have if rail had not been delayed (USDA, 2015).

According to Wilson and Dahl (2011), a one-dollar increase in grain transportation costs is associated with an average decrease of 0.71 dollars in origin cash prices. This suggests that the burden of higher rail costs is not fully passed to grain producers. Traditional economic theory would predict that during periods of high demand, more of the costs can be passed to the consumer. It is difficult to tell to what extent the high costs of rail congestion were borne by producers and how much was passed to consumers. According to the USDA (2015), some ethanol plants had to reduce or temporarily halt production because of shortages of grain shipments. It appears, however, that overall the market was able to adjust such that the U.S. was still able to meet export demand. For more on the complexities of grain market prices, see Chapter 3.

According to the U.S. Department of Transportation, freight transport for all modes is expected to increase in the future (table 2). In order to anticipate future congestion issues, researchers should evaluate which regions in the U.S. may be susceptible to similar upsets. In particular, it will be valuable to evaluate commodities and locations for which production is geographically tied to a specific region and where shippers have limited modal choice. For example, figure 8 shows the proportion of rail shipments that are related to agriculture, by location. We can anticipate that areas in which agricultural transportation is a major portion of all transportation will be particularly susceptible to congestion during years of higher than average harvests.

**Table 2.** Weight of freight by mode, 2015 and 2045

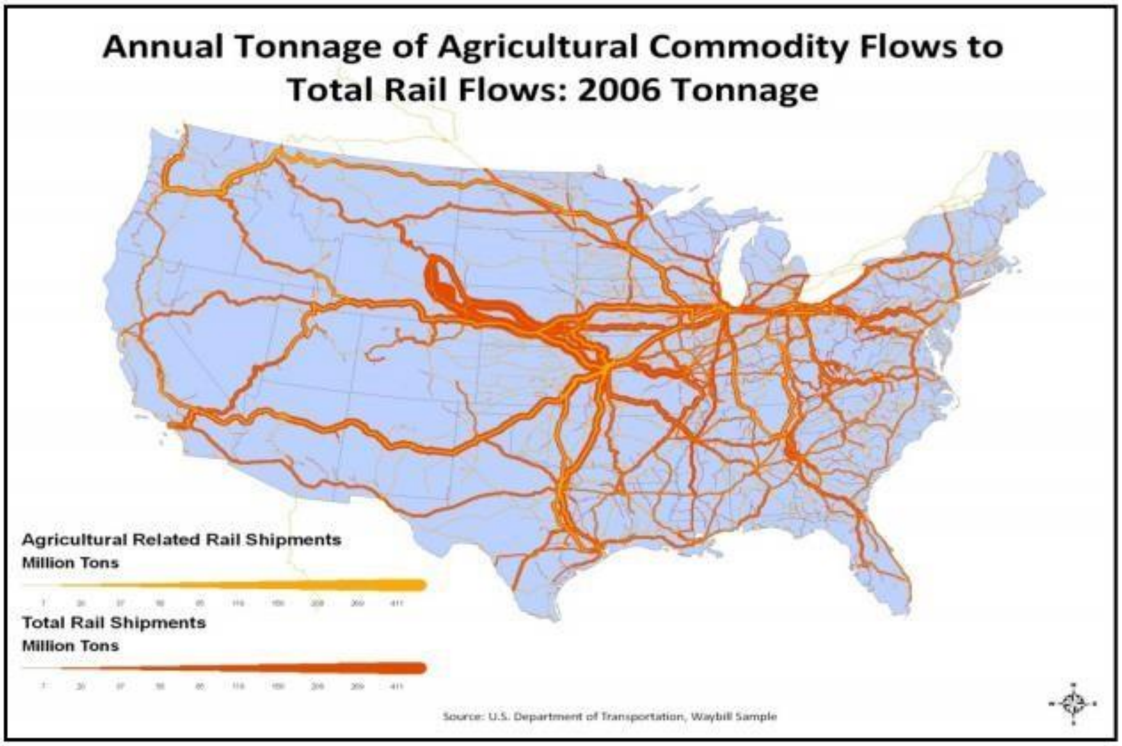
(million tons)

| Mode | 2015 | 2045 | Change |
|---|---|---|---|
| Truck | 11,513 | 16,529 | + 44% |
| Pipeline | 3,303 | 4,554 | + 38% |
| Rail | 1,694 | 2,094 | + 24% |
| Water | 835 | 1,156 | + 38% |
| Multiple Modes and Mail | 398 | 646 | + 62% |
| No Domestic Mode* | 273 | 297 | + 9% |
| Air | 7 | 24 | + 234% |
| Total | 18,056 | 25,331 | + 40% |

**Source:** U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.1, 2016.

Note: Total includes total includes shipments by other and unknown modes that are not shown in the table.

* Includes crude petroleum imports that arrive by water at a waterside refinery.




Source: U.S. Department of Transportation, Waybill Sample

**Figure 8.** Annual tonnage of agricultural commodity flows to total rail flows: 2006 tonnage

# Chapter 5 Estimation of Sub-regional Agricultural Demand for Rail

In this section, we examine the current literature on estimating transportation demand in order to develop a framework for estimating and predicting agricultural demand for rail and particularly how demand may differ in regions where different modes are available (e.g., the Pacific Northwest and the inland Midwest).

Much research has evaluated the determinants of mode choice for individual freight shippers. These studies have relied on stated preferences, revealed preferences, and experiments to estimate elasticities and willingness to pay for different shipping modes. Most models examined the effects of rates, haul times, and reliability on mode choice (e.g., Train and Wilson, 2006; Brooks et al., 2012, Arencibia et al., 2015). Others also examined the role of shipment size and shipper capacity (e.g., Holguin-Veras et al., 2009; Mitra, 2013) or shipment weight, distance, and value (Samimi et al., 2011). Train and Wilson (2007) also found that mode choice depends on shippers' access to rail and barge markets, relative rates, and number of railcars. For a detailed review of studies that have estimated price/cost elasticities of demand for multi-modal freight transport and discussed the different data and methods used, see Beuthe et al. (2014).

Many countries (particularly in Europe) have developed national transportation models to be used by national governments in evaluating potential policy decisions. Jong et al. (2016) discussed some of the issues and trends surrounding these models, including the development of models that aggregate individual- and firm-level logistical decisions and the potential use of big data. For a review of the state of the art of incorporating logistics into freight transport demand models, see Tavasszy et al. (2012). For a review of all types of freight transport models in Europe, see Jong et al. (2012).

Few recent studies have attempted to estimate demand for railroad (especially more recently than evaluations of the 1980 Staggers Act). Babcock and Gayle (2014) reviewed the highlights of the literature on railroad demand models and introduced a two-region spatial equilibrium model to estimate the demand of wheat, corn, sorghum, and soybeans for rail transport in the United States. The model estimates demand for rail based on region, transport prices, and grain production. Because rail prices are likely to be endogenous in estimations of demand, it is important to instrument for price. The authors used measures of rail input costs (e.g., number of railcars, fuel prices, and labor costs) as instruments. This model was built on the methodology of Yu and Fuller (2005), who estimated barge demand and also included in their model transport rates for different modes, agricultural supply, grain exports, season, and closures due to adverse weather conditions (in this case, floods).

Prater et al. (2013) used variation across states and time to examine what variables affect specifically the rail market share of grain transportation in the United States. They found that both the increase in domestic grain used for biodiesel and ethanol and the geographic concentration of grain-consuming animals have contributed to rail's decreasing market share since 2000. Other variables that were found to significantly affect rail market share of grain include relative rates of truck to rail, access to waterways, export volumes, and the prominence of unit trains (i.e., those with 50 or more railcars). Also, states that produce relatively more wheat, cottonseeds, or flaxseed were shown to ship more grain by rail (as compared to states that produce a higher proportion of other grains).

Table 3 summarizes the types and sources of data used in the above estimations of grain agriculture's demand for rail freight. Other research highlights the importance of competition in transportation prices and demand (e.g., Anderson and Wilson, 2008). Future demand models may also benefit by the inclusion of some measure of competition between railroad companies (e.g., the number of Class 1 railroads operating in the region).

**Table 3** Transport variables and common data sources

| Variable | Data Source |
|---|---|
| Rail rates | STB Waybill Samples |
| Rail input costs (to instrument for rail rates) | Freight Commodity Statistics (AAR) |
| On-highway diesel fuel prices (as proxy for truck rates) | Energy Information Administration<br>Petroleum Administration for Defense District |
| Truck rate index | American Trucking Association |
| Barge rates | Agriculture Marketing Service (USDA) |
| Distance to waterway | FIPS (U.S. Department of Commerce, National Institute of Standards and Technology) [3] |
| Ethanol production | Renewable Fuels Association [1]<br>Official Nebraska Government website [1]<br>Energy Information Administration [2] |
| Biodiesel production | National Biodiesel Board |
| Animal feed concentration | National Agricultural Statistics Service (USDA) [4] |
| Exports | U.S. Census Bureau, Foreign Trade Statistics [5] |
| Shipment size | STB Waybills |
| Grain production | USDA Crop Production Annual Reports |

1 For estimating the distribution of state-level ethanol production capacity
2 For the actual national production of ethanol
3 For the calculation of distances between counties
4 State-level grain-consuming animal units calculated by multiplying the number of each type of animal by the appropriate conversion factor
5 For national export values, which can be divided by state according to the distribution of production

Finally, Miller (2004) discussed the types of forecasts that must be made in order to predict future transportation demand. Changes in socioeconomics (e.g., population and income), public policy, and freight characteristics all affect future transportation demand and use. Each of these factors tends to influence each other, and some are easier to predict than others. Future changes in policy and freight technology may be the most difficult to forecast. The author concluded that demand forecasts will be more reliable if they (a) depend on elements that are less likely to experience sudden changes, (b) cover larger geographic regions, (c) are projected over a shorter time horizon, and (d) use larger data sets and more variety of data. Also, the author cautioned that long-range forecasts should be updated frequently as more information becomes available.

## Chapter 6 Cross-Market Basis Differentials

This section examines the effects of railway congestion on basis differentials, and what can be learned by studying the interactions of congestion and basis. There exist two interconnected types of market for grain: cash markets and futures markets. Cash markets are when grain is traded immediately for a price, and futures markets are when a price is paid for a contracted future delivery of grain. Both the cash price and the futures price of grain can vary by location. Basis is the difference between the futures price and the cash price, and it can be either positive or negative.  When cash prices are relatively high with respect to futures prices, basis is referred to as being "stronger" than when cash prices are low. Basis levels can also vary by location.

A grain company is an organization that purchases grain from grain producers and then stores that grain to sell locally at a later date or transport for sale at a different location (e.g. as an export at port). Grain producers are tied to the land and generally must sell at whatever price is available locally. Grain companies are the grain shippers; they have access to cheaper long-distance shipping options than grain producers alone because they can store grain and move it at higher quantities. The ability of grain companies to make a profit depends on the price paid to producers, storage and transportation costs, and the price received from consumers.

For a grain company, the basis represents revenue; it is the value of arbitraging grain from local producers to future consumers. The profit for a grain company is reflected in the difference between the basis and the costs of storing and/or shipping grain to the buyer by the date of the futures contract. In a market with perfect competition, the basis is equal to these storage and transportation costs. More specifically, the basis at the origin of grain production reflects only the storage costs and the basis differentials between locations (often called the spread) reflects the costs of transporting grain between those locations. All things being equal, regions farther from delivery locations (e.g., ports, ethanol producers, etc.) will have a weaker basis because of higher transportation costs. Likewise, regions that must rely heavily on a single transportation mode will likely have a weaker basis, and the basis will be more susceptible to conditions on that mode. For example, we expect that basis levels in the Pacific Northwest were stronger during the 2014 rail congestion crisis than basis levels in the Upper Midwest because of the access to other shipping options (e.g., inland waterways).

In the face of market shocks, basis levels may temporarily be higher or lower than the costs of shipping grain from that location. If the basis is unusually strong in an area, grain producers in that area can benefit from selling more grain locally rather than selling it to companies to ship elsewhere. If the basis is unusually weak, producers will want to wait or try to sell their grain in other markets if possible.

### 6.1 Capacity Restrictions

Railway congestion leads to an oversupply of grain (more grain in a location than can be transported or sold locally). As the expected transport time increases, so do the costs of storage and transport. Rail companies tend to capture the rents of congestion by raising rates (e.g., auctioning rail cars to highest bidder). This will lead to a weakening of the basis, as grain companies can only remain viable by demanding higher prices from futures consumers at delivery locations or by offering lower cash prices to producers. The closer a delivery location is to an international hub like a port, the less likely grain shippers can sell at any price different from the world market price for the grain. Generally, however, grain companies can afford to offer lower cash prices to grain producers without losing customers, as grain producers are a captive market. The end result tends to be a transfer from grain producers to rail companies.

6.2 How Producers and Shippers React to These Changes

Production locations are fixed in the short run, but they are likely to adjust in the long run in the face of persistent rail shortages. For example, if basis levels were to remain relatively weaker than normal in the Upper Midwest, this could theoretically lead to a decrease in grain production due to a lack of ability of producers to cover the costs of production. Alternatively, as this would decrease the demand for rail in the region, we might expect rail companies to have an interest in increasing capacity. Ultimately, rail companies have to balance the costs of lost demand from agriculture with the costs of infrastructure investment and the demand from other industries such as oil.

6.3 The Economic Impacts of These Changes

The major impact of rail congestion is loss of revenue to grain producers. In order to estimate this impact, we need to estimate the difference in prices associated with the congestion and the amount of grain sold at the lower prices. Traditional efforts at estimating the effect of congestion on grain prices rely on comparing basis levels during periods of high congestion to levels in previous years. Several studies have found, however, that while train speeds and transportation costs play a significant role in local cash prices for grain, they are not the only factors that influence basis levels (e.g., USDA, 2015; and Wilson and Dahl, 2011). Other factors that must be controlled for include destination (e.g., Pacific Northwest vs. Gulf of Mexico), outstanding export sales, and concentration in grain handling industry, the ratio of grain stocks to storage capacity, barge and ocean rates, commodity fundamentals, and fluctuations in futures prices. According to the USDA (2015), the explanatory power of these models are still relatively low, suggesting that much of what influences basis levels is so far unexplained.

Additionally, it is difficult to know how much grain was actually sold at the lower prices and how producers and shippers would have behaved differently in the counterfactual. When prices are low because of rail congestion or any other factors, producers often choose to delay sale, sell on futures contracts, or ship to consumers on alternative transportation (e.g., trucks).

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