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Agricultural Grain Transportation: Are We Underinvesting and Why?

Kenneth L Casavant

JEL Classifications: L90, O18, R40, Q18, R48
Keywords: Agricultural transportation, Investment, System performance, Rail regulation

The truth of agricultural transportation is the interdependence of agriculture and transportation. Agricultural development was only possible by the advent and availability of transportation, the critical link between the production on our fields and the tables of our domestic and international consumers. Conversely, the growth of agriculture production served as the revenue source for our country's early investments in water, wagon, and rail modes of carriage. As more and more customers are found overseas, it increases the need for efficient and effective service from the massive transportation system that has historically served the United States so well.

But this system is under stress in both the public and private arena. Our ports, highways, roads, and waterways are faced with dwindling investments and support. Institutional changes in and among modes have brought rate changes and service deterioration to our rural parts of the nation. In effect, after designing and building our system for 100 years we have been consuming those investments.

It is especially in the railroad sector of the system that we have searched for the most efficient structure to maintain the service needed by agriculture. Prior to the Staggers Rail Act of 1980 our railroads were on the verge of bankruptcy or even nationalization. The Act partially deregulated the rate and route provisions of the regulatory environment for rail. Massive rail line abandonment as well as the creation of short-lines, was followed by nationwide mergers, resulting in loss of intra and inter rail competitive driven rates and service for agricultural shippers. In this theme, the authors consider the implications of these public and private decisions for transport of agricultural commodities, how we can evaluate system performance, and what we can learn from our neighbor to the north, Canada.

In the first paper Henrickson and Wilson evaluate three of these issues affecting railroad performance in agricultural shipments: consolidation of the rail lines, intra-modal competition, and fuel prices. Rates and service may or may not go in different directions in this partially deregulated environment.

Considering the Canadian Grain Handling and Transportation Policy, Nolan and Peterson reach out and present lessons for improving oversight in the United States. The Canadian system is undergoing major changes; impacts on railroad performance of selected changes can be identified for Canada and projected for the United States.

Babcock then looks directly at wheat, a dominant agricultural trade product and evaluates the impact of intermodal

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competition on the transportation rates faced by American producers. He investigates wheat production locations and attendant modal choices and finds that they are dominant determinants of rates and service performances by railroads in terms of impacts on net shipper supply chain costs.

Finally, Sage takes a broader look at transportation systems, offering alternative means of measuring the benefits of transportation investments, from both public and private/commercial viewpoints. He determines and outlines a rational prioritization framework for investment, one that can handle regional variations in competitiveness, whether highway, railroad, or public versus private.

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Agricultural Transportation by Rail: Consolidation, Competition and Fuel Prices

Kevin E. Henrickson and Wesley W. Wilson

JEL Classifications: L90, L92, Q00, Q19
Keywords: Agricultural Transportation, Deregulation, Railroads

Railroads are a primary source of transportation for agricultural products in the United States. Over the last 35 years there have been numerous changes within this industry, beginning with the partial deregulation of the industry through the Staggers Rail Act of 1980. This Act provided railroads more pricing flexibility, and also eased the legal impediments to mergers as well as the abandonment of unprofitable rail lines. As such, real rates and costs fell dramatically following passage of the Staggers Act. In addition, the years following the passage of this legislation saw massive consolidation of the nation's largest railroads, the so-called Class 1 carriers (MacDonald and Cavalluzzo, 1996; Bitzan and Wilson, 2007). A large economic literature has documented some of the impacts of this 1980 Act (Wilson, 1994; Wilson, 1997; MacDonald and Cavalluzzo, 1996; Winston, 1993). At present, there are a new set of factors affecting the transportation of agricultural products by rail, making it useful to reexamine this industry in the context of the major provisions of the Staggers Act along with some of the changes that have resulted from partial deregulation.

Staggers Rail Act

The rail industry has been regulated since passage of the Interstate Commerce Act of 1887. This regulation was primarily aimed at the perceived problems associated with railroad behavior in markets in which there were few alternative railroads present, such as markets with one railroad acting as a monopolist. As such, the federal regulation was geared towards setting guidelines for how railroads could conduct business, including their rate policies, track operated, and merger activity. Indeed, virtually all rates were subject to regulation after the passage of this legislation, along with tremendous impediments to merger activity and strict rules regarding the abandonment of rail lines. However, over time, both new sources of competition—such as from truck and barge as well as new products like plastics—negatively impacted the industry. These negative impacts, along with the regulatory environment in which railroads operated, limited the ability of these firms to adapt and adjust to these changes. By the 1970s, the industry was largely in financial ruin, with many railroads in bankruptcy. Policymakers recognized the need for revamping regulation, and responded with the passage of the Railroad Revitalization and Regulatory Reform Act of 1976 and the Staggers Rail Act of 1980, which have had a tremendous effect on the industry.

Rate Regulation

Prior to partial deregulation, all rates in the industry were subject to regulatory review and jurisdiction, limiting the railroads' ability to leverage their market power into their pricing decisions. This changed with the Stagger's Rail Act, which gave railroads *some* pricing flexibility, along with some relief to the regulatory agency through the introduction of a staged process for judging the reasonableness of a given rate.

The first step in this process for determining the reasonableness of a rate was to determine whether the railroad in question was "market dominant" (Wilson, 1996; Bitzan and Tolliver, 1998). In order to determine if market dominance exists for a given rate, the regulatory agency first

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calculates the ratio of revenue to variable cost (that is, the costs that vary with service). If this measure is less than 180%, the railroad is deemed to not be market dominant, a finding that is not rebuttable. However, if the calculated ratio is greater than 180%, then the regulatory agency takes a second step in assessing whether competitive factors are present or not. Only if a railroad is found to be market dominant over the movement in question, can the reasonableness of their rate be considered. This implies that only if the revenue to variable cost ratio is greater than 180%, and the regulatory agency finds that competitive factors—such as intra-modal and inter-modal competition—are not present, the reasonableness of the rate can be examined.

Assuming that the above process yields a finding of market dominance, the reasonableness of the rate is evaluated using one of three alternative criteria that are earmarked for “large”, “medium”, and “small” cases. In a large case, the stand-alone cost test (SAC) is used. This test holds that the rate charged cannot exceed the rate that would be charged by a hypothetical stand-alone railroad charging enough to fully cover all of its costs. In practice, the SAC criterion is difficult to implement, the costs to shippers to bring a case is substantial, while the length of time to reach a decision largely eliminates its use in a regulatory proceeding (Pittman, 2010). In a medium-sized case, there is a simplified SAC test with set guidelines on the determination of the hypothetical railroad. Finally, for small cases, reasonableness is determined by a three-benchmark test, which generally compares the markup over costs paid by challenged rates to average markups on comparable traffic. While the methodology for examining medium and small cases is more palatable, the maximum reparations on these cases could not exceed $5 million for medium cases or $1 million for small cases. Recently, however, the simplified SAC limits were removed and the three-benchmark limit was raised to $4 million. This was exceedingly important in that the actual damages awarded were relatively small compared to the advantages gained by the market dominant railroad under the previous rules.

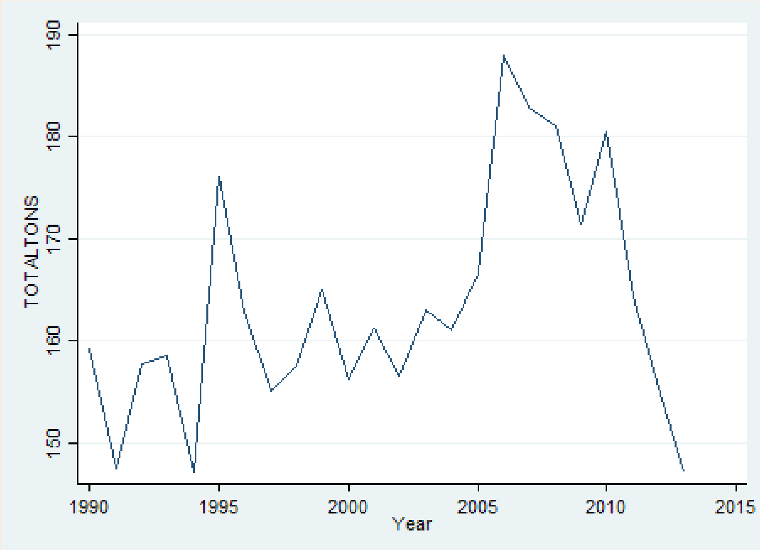
The size of damages and the method for determining whether the railroad is market dominant in general, is particularly significant for agricultural shippers, as most of these shipments emanate from areas that are remote, with limited availability of intra-modal transportation options. Indeed, as shown below, most areas have only one shipping option, a factor made worse in the post Staggers era, as the rail network has shrunk due both to railroads abandoning low density lines, as well as railroad consolidation, limiting the availability of intra-modal competition. While intermodal transportation options are still present, their ability to compete with rail transportation is limited based on location and distance. For example, truck competition is important for short haul distances, but is much more expensive on a per-mile basis, limiting its ability to compete on the longer routes that railroads tend to focus on. Alternatively, barge competition is also a viable alternative, but is limited geographically (MacDonald, 1987; Burton, 1993; Henrickson and Wilson, 2014). Combined, these observations illustrate how most agricultural shipments arise from geographically dispersed locations with little opportunity for intra-modal competition, travel long distances, for which truck is not a feasible option, and only have barge as a viable alternative if the shipper is located in close proximity to a major waterway.

Consolidation and Abandonment Implications

In addition to its impact on rates, the Staggers Rail Act also substantially eased the regulatory impediments to merger activity. As noted in Bitzan and Wilson (2007), the number of Class 1 railroads has fallen dramatically since the passage of this legislation. In 1983, there were 28 Class 1 railroads operating, but by 2003, only seven remained. While six railroads were declassified as Class 1 carriers, the other railroads that existed in 1983 were consolidated into the seven Class 1 railroads in operation today. Bitzan and Wilson (2007) additionally find that consolidation has reduced industry costs by approximately 11.4%. This consolidation of railroads has been a major result of the Staggers Act and, along with easier abandonment of lines, has led to a very different industry today than what was present in 1980. Indeed, these changes have left many shippers without direct service—requiring a truck movement to access rail—or without direct access to a Class 1 carrier, requiring an interchange. These forces, all act together to put upward pressure on rail rates, but the analysis of this effect is somewhat limited in the literature.

The economic welfare consequences of these horizontal mergers are often cast in terms of the so-called Williamson (1968) model of mergers. In this model, there are two different effects: a cost synergies effect, which may have a downward impact on railroad costs, and the direct impact of a reduction in competitors, which places an upward impact on rail rates. Economists have analyzed whether the theoretical effects predicted by economic theory have materialized in the real world of rail markets. For example, Bitzan and Wilson (2007), as well as others (Berndt et al., 1993; Vellturo et al., 1992), find that consolidation has indeed reduced costs to some degree, while a study by Ivaldi and McCullugh (2012) finds that “shipper surplus and total welfare have remained fairly constant in U.S. freight rail markets despite a dramatic degree of consolidation in the industry.” Ivaldi and McCullugh (2012) also find that surplus increased in intermodal markets, while bulk markets

Figure 1: Total Tons by Rail (in Millions)



Source: Calculated from the Carload Waybill Statistics.

Table 1: Major Agricultural Commodities (1990-2013)

Commodity	Tonnage (millions)	Share	Cumulative
Corn	1,760	44.81	44.81
Wheat	1,140	29.02	73.83
Soybeans (Soya Beans)	498	12.68	86.51
Barley	123	3.13	89.64
Sorghum Grains	106	2.7	92.34
Other	301	7.66	100
Total	3,928	100	100

Source: Surface Transportation Board, Public Use Carload Waybill Statistics, 1990-2013

have offset the loss of surplus in general freight. In addition, they conclude that surplus has increased for bulk shippers, but that the majority of that surplus was only realized after most mergers were completed, and were primarily driven by reductions in unit costs. It is also quite noteworthy that that they estimate a measure of markup—defined as the Lerner Index, or rate-marginal cost/rate—for bulk shipments to be about 75%.

Railroad and Agricultural Markets

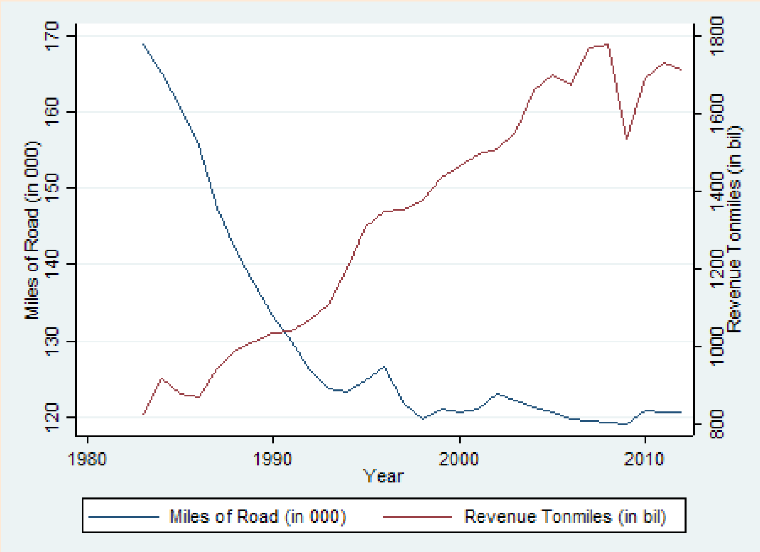
Over the last 24 years, the quantity of rail shipments of agricultural products throughout the United States has increased, as shown in Figure 1. While railroads haul a wide variety of agricultural products, the primary commodities carried are corn, wheat, soybeans, barley, and sorghum, commodities that account for over 90% of annual rail farm product tonnages. Specifically, while there are 93 different classifications of "Farm Products" hauled by railroads at the five digit Standardized Transportation Commodity Codes, corn (44.8%), wheat (29.0%), soybeans (12.7%), barley (3.1%), and sorghum (2.7%) total over 90% of all rail transportation of farm products between 1990 and 2013. As such, we focus on wheat, corn, and soybeans in what follows, with Table 1 summarizing the total tonnages (in millions) over this time

Table 2: Production of Corn, Wheat and Soybeans by State over Time (in millions of bushels)

State	Corn		% Change	Wheat		% Change	Soybean		% Change
	1990-93	2010-13		1990-93	2010-13		1990-93	2010-13	
ILLINOIS	1361	1818	34	66	40	-40	372	437	8
IOWA	1443	2132	48	2	1	-60	324	453	17
NEBRASKA	944	1478	57	70	56	-21	89	248	47
INDIANA	701	842	20	35	23	-35	190	248	13
MINNESOTA	636	1289	102	104	75	-28	166	297	28
KANSAS	218	476	119	397	335	-15	53	116	37
OHIO	403	525	30	60	42	-31	144	217	20
NORTH DAKOTA	35	321	809	375	292	-22	15	139	81
MISSOURI	227	350	54	61	36	-41	135	190	17
SOUTH DAKOTA	228	640	181	114	102	-11	53	159	50

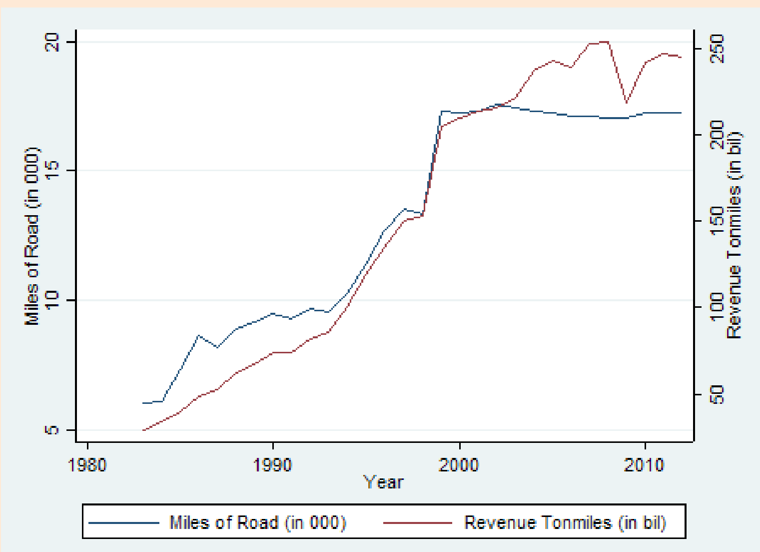
Source: USDA, NASS. The production figures are in millions averaged over a four year time period.

Figure 2: Revenue Tonmiles and Miles of Road



Source: Constructed from R-1 Financial Reports filed with the Surface Transportation Board.

Figure 3: Average Revenue Tonmiles and Miles of Road Per Firm



Source: Constructed from R-1 Financial Reports filed with the Surface Transportation Board.

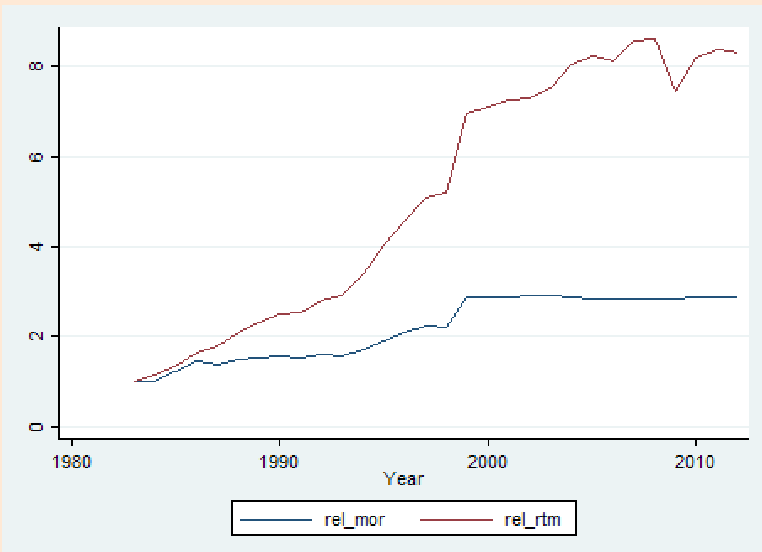
period, along with shares of all farm product traffic.

Given this background, the demand for rail transportation depends critically on the production of these five agricultural commodities. Table 2 contains summaries of state level agricultural production in 1990-1993 and 2010-2013, along with changes by state. It is particularly noteworthy that the top producing states for each commodity during 1990-1993, remain at the top in 2010-2013. However, outside of the top state for each commodity, there are remarkable changes illustrated in Table 2. For example, corn grew for all states, but, in particular, for Minnesota, Kansas, and North Dakota; wheat production fell in all states; while soybean production increased in all states, and, in particular for North Dakota.

As noted above, railroad markets have also changed dramatically over this time period. Between 1990 and 2013, there were multiple mergers in the rail market, reducing the number of Class I carriers from 14 to only 7. Coinciding with these mergers, there was a dramatic reduction in the miles of track operated. Between 1983 and 2012, miles of road operated by Class 1 carriers fell from 168,838 to 120,658 miles, with most of the reduction in the 1980s (Figure 2). This pattern continued into later years, but at a much slower rate, as the miles of road only fell from 133,189 to 120,658 between 1990 and 2012 (Railroad R-1 Reports filed with the Interstate Commerce Commission and the Surface Transportation Board). Also shown in Figure 2 is the doubling of revenue ton miles for Class 1 carriers over this same period of time. Figure 3 presents this same information on an average unit basis, showing that both miles of road and revenue ton-miles per firm have grown together as firm sizes have grown. However, from about 1999 to 2012, output per firm continues to grow, but miles of road have remained relatively constant. A particularly striking result illustrated in Figure 4 is that output per firm increased more than eight times between 1983 and 2012, while the network size (miles of road) has increased only slightly more than two times. This pattern points to substantially more intensive use of the rail network, along with the associated issues that agricultural shippers have faced in gaining access to this network; a result that for some locations has been exacerbated as railroads have reallocated resources to meet the growing demand for the transportation of oil from the Upper Midwest.

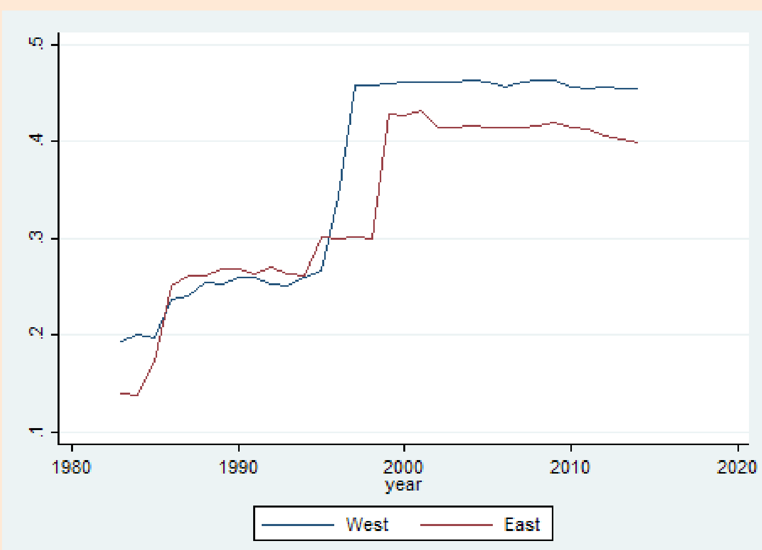
One of the largest issues associated with a smaller network along with fewer firms using the network far more intensely, is the effect on pricing. In particular, as railroads have merged and abandoned, or sold rail lines to regional short-line carriers, the inevitable effect for shippers is less access to rail and/or less competition among Class 1 carriers. Information from the Oakridge National Laboratories allows an assessment of these impacts. In these data, there were 1982 counties with rail service in either 1990 or 2013. In 1990, about 68% of these counties had access to Class 1 rail service, while 32% received service from non-Class I carriers. In 2013, these statistics remain virtually unchanged; however, of the counties that received Class 1 service, about 14% lost service between 1990 and 2013. In short, most counties in the United States do not receive railroad service presently, and even fewer receive Class 1 carriage. However, for those that did receive service in 1990, most continue to have service—only 32 of 1392 have lost service from any Class 1 carrier—while only 14% have lost service from competing Class I carriers.

Figure 4: Average Revenue Tonmiles and Miles of Roads (Relative to 1983)



Source: Constructed from R-1 Financial Reports filed with the Surface Transportation Board.

Figure 5: Concentration – Herfindahl Indices

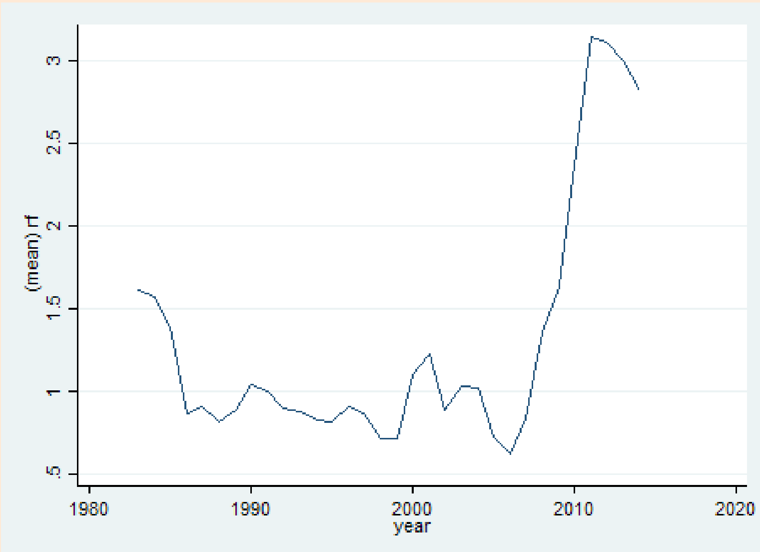


Source: Constructed from R-1 Financial Reports filed with the Surface Transportation Board.

Another measure of the changing competitive environment comes from the railroads' annual reports (the Form R-1 reports). These data allow for the calculation of the Herfindhahl Index, an index of market power. If market power increases, all else equal, markups increase. Henrickson and Wilson, 2014 separated the railroads into east and west railroads, calculating the resulting Herfindahl Index for each region. While this standard measure of market power is somewhat overstated given that it captures only Class I carriers, Class 1 carriers account for over 90% of railroad traffic, which lessens this upward bias. Figure 5 illustrates this measure of concentration for each of these regions, and points to tremendous increases in concentration over time, attributed primarily to the merger and consolidation activity within the market, with only modest differences across regions. The increase in concentration of course reflect greater amounts of outputs held by larger firms, which in turn, points to pricing power and associated higher prices.

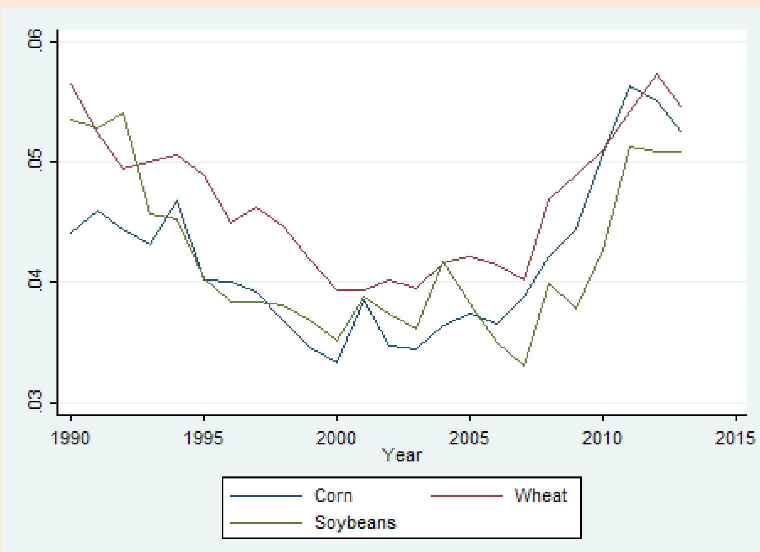
While much of the structural change in rail markets was realized in the 1980s and 1990s, a more recent effect on rail markets has been the tremendous increase in the cost of fuel to railroads which in turn is passed on to the shippers in the form of high rates. Figure 6 presents real fuel prices over time, and points very directly to the significant changes in these costs over the past decade.

Figure 6: Real Fuel Prices



Source: Constructed from R-1 Financial Reports filed with the Surface Transportation Board.

Figure 7: Average Rates for Corn, Wheat, and Soybeans 1990-2013



Source: Constructed from the Public Use Waybill Statistics filed with the Surface Transportation Board.

Railroad Rates over Time

Unfortunately, the effects of these various changes in the railroad industry on rail rates are not clear. While the nation's rail network has decreased dramatically, most shippers that had service in 1990 continue to have service today. Conventional measures of concentration point to dramatic increases, yet the effects of this consolidation may point to efficiency gains, perhaps realize through larger lengths of haul, consolidated shipments, and less interchange, but may also point to higher market power. Yet, most shippers have only one rail option, and fewer yet have direct service from Class 1 carriers, while higher fuel costs have led to fuel surcharges added into rail rates.

To assess some of the changes over time we used the Public Use Waybill available from the Surface Transportation Board (STB, 2015). These data give shipment characteristics and rates at the Bureau of Economic Region level. Using these data, we calculated the average rate per ton-mile, which is shown in Figure 7. As indicated, the rates for each of these commodities vary, with wheat rates tending to be higher. However, rates for each commodity tended to fall through the 1990s, and have been increasing since mid-2000. These patterns are consistent with net efficiency gains realized through consolidation followed by rising fuel prices, and associated fuel charges, over the last 10 years.

While there are only modest changes in service offered to shippers from consolidation, sales and/or abandonment of rail lines by Class 1 carriers, there are differences across shippers in terms of service options available. To capture these differences, we merged the public use waybill data to the Oakridge data by the U.S. Bureau of Economic Analysis economic area code. In the data, there are a total of 188,504 observations for the entire time period in question, of these, 22% of the observations were from counties with no service from Class 1 carriers, 45% were from counties with only one Class 1 carrier providing service, and the remainder have 2 or more Class 1 carriers. Direct comparisons are quite difficult owing to different traffic characteristics of shipments that vary over geographic space, including miles traveled, shipment size, number of interchanges, whether the shipments were in rail owned or shipper owned cars. However, we accounted for these differences statistically, and found that the rates are about 2-3.5%

higher for counties with one Class 1 carrier, and about 3 to 7% higher for counties with no Class 1 service. These findings do point to competitive issues, but the magnitudes are generally quite small.

Limited Options for Class I Service

Partial deregulation of the railroad industry has dramatically changed the level of competition present in much of the United States, directly impacting agricultural shippers. Railroads have consolidated and introduced innovations that have resulted in dramatically lower costs and prices. While the overall rail network has decreased in size, many shippers in this study have experienced little, if any, change in service provided by Class 1 carriers. Analysis of rates, point to significant declines through the 1990s that coincide with several major mergers that offered efficiencies. However, rates have climbed substantially since 2005, which coincides with increasing fuel prices. Yet, the bulk of shipments emanate from areas with no Class 1 service or from areas with a single Class 1 carrier. Thus, most agricultural shippers have limited options for Class I service.

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Grain Handling and Transportation Policy in Canada: Implications for the United States

James Nolan and Steven Peterson

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Keywords: Grain handling, Interswitching, Revenue sharing, Supply chain

The grain handling and transportation system (GHTS) in Canada is currently going through a major transition, both with respect to handling and transportation. Historically, the system has pitted farmers against the railways with respect to securing individual "fair" shares of grain revenues. But with the removal of the single desk marketing and logistics function of the Canadian Wheat Board (CWB) in late 2012, a very interesting and potentially game-changing outcome is emerging with respect to the new functionality of the grain companies in the Canadian system. While historical awareness of rail's natural monopoly position in the grain handling system has kept that sector regulated—in several ways—for close to a century, we are now starting to see the effects of a less than competitive Canadian grain handling sector on revenue sharing, along with renewed movement in the industry with respect to buyouts and potential mergers.

Currently, the on-going regulatory instrument used to regulate grain transportation rates in Canada—called the "maximum revenue entitlement" (MRE) or revenue cap—is under debate because of the introduction a few months ago of a modification to an old regulatory instrument known as extended, or reciprocal, interswitching. As opposed to the revenue cap which is a direct intervention on monopoly behavior, extended interswitching is designed to encourage the major Canadian grain carriers to compete with one another and potentially seek out new traffic (Nolan and Skotheim, 2008). But the most intriguing aspect of extended interswitching is how it might allow a major rail carrier from the United States to solicit grain traffic in some areas of the Canadian grain transportation system.

On the grain handling side, as of 2012 without the CWB to co-ordinate and optimize grain movements on behalf of Canadian farmers, grain companies in Canada initially seemed to be patient about assessing individual operational requirements under their new grain supply chains. But similar to the situation in the United States, a bumper crop in 2013-2014 and new problems with rail transportation (White, Carter, and Kingwell, 2015) generated new marketing opportunities for the grain companies that in effect allowed them to secure higher than normal profits. But this took place mostly at the expense of farmers who were induced to hold or store grain that they otherwise would likely have moved under the control of the former CWB. The situation has created increased skepticism about the broader motives of grain companies in Canada to the point where farmers openly wonder if the railways will remain their major adversary in the GHTS as the system moves forward.

Historical Background on the Canadian GHTS

Similar to the United States, the development of the Canadian GHTS was part of a nation building process to encourage Western settlement by ensuring that new farmers in the vast hinterland had an available transportation system to facilitate the movement of their grain to export position either on the West Coast or through the Great Lakes. As the rail industry in Canada consolidated through the 1920s down to the two Class 1 railways we have today, considerable focus of transportation policy through the rest of the century was concerned with ensuring that grain movement would not be unduly discriminated against by

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the rail carriers (Minister of Public Works and Government Services Canada, 2004). It is worth noting that most other freight transportation sectors in Canada had been gradually deregulated through the 1960s and 1970s (including rail for everything but grain), rendering the continued oversight in grain movement a marked contrast to what was going on elsewhere in freight markets.

Through the 20th century, a series of regulated freight rate regimes coupled in most instances with direct government subsidies to grain movement in Canada were eventually brought under serious re-consideration by the Federal government with the 1997 Estey Review of grain transportation (Nolan and Kerr, 2012). The Estey Review process was initiated by the former CWB because of a critical rail service failure on grain movement in the winter of 1996-1997, coupled with continued complaints by both shippers and carriers that the grain transportation regulatory system was broken and had been for a long time.

Among several other changes including the appointment of a formal grain system data monitor, the key regulatory outcome of the Estey review was a new policy consisting of an annually computed maximum revenue entitlement applicable to each railway for their respective movements of specified grains. Beginning in the 2000-2001 crop year, both Canadian National and Canadian Pacific had their grain movements regulated by the computed revenue cap. The structure of the cap uses a base level of required grain movement as well as some accounting for average length of grain haul in the system, coupled with an allowable rail efficiency gain of about 2% per year built in. In addition, if the cap is exceeded by either railway, that railway is fined an amount equal to the excess, plus 15%. Cap breach has actually happened quite frequently, and to date only a single year (2009-2010) had both railways' grain revenue staying below their respective mandated cap levels. While adjusted on a sporadic basis to keep up with developments in the industry, as of 2013-2014 the cap has gradually risen to about 1.5 times what it was in the initial year—now at well over C$600 million per railway.

Current Regulation in Grain Transportation

As the current grain transportation regulatory policy in Canada, the revenue cap was suggested back in 1998 by one of the Class 1 railways as a regulatory alternative to Estey's actual proposals for improving rail competition and removing rate regulation (which were to implement an open or competitive rail access regime for new entrants). The revenue cap has gradually been embraced by Canadian farmers because freight rates have been relatively consistent and stable under the cap, even with other changes in the system. Freight rates on average movements from 2000 to 2006 actually declined in real terms (from about C$36 to C$35 per metric ton) as the railways gradually adjusted their rate setting under the regime. But grain transportation rates in Canada have risen slowly in recent years, up to an average of approximately C$50 per metric ton as of 2013-2014. What has happened is that the revenue cap effectively induced the railways to seek and operationalize ways to lower their costs to improve profits from grain movements. The railways did this by moving ever longer unit trains as well as favoring, through rate reductions, those grain loading sites that had larger rail sidings to load their longer and more cost efficient trains. But since about 2009 it seems these relatively easy to implement cost reductions in grain movement have been more or less exhausted, and this helps explain why average rates under the cap have been slowly increasing since that time.

Beginning earlier this year, the railways have been making numerous public appeals to have the revenue cap regime removed (Atkins, 2015a). Among other items, their public rationale is that the cap is limiting their ability to invest in more cost effective infrastructure, including new hopper cars. While this is mostly true, the cap is being defended by farmers because in a spatially monopolistic rail market, they don't want to see rates completely deregulated. There are fears that Canadian grain rates will rise to levels well above current ones and in fact closer to those that can be found in similar regions in the United States—more specifically, the Northern Plains states. While it is sometimes difficult to make such comparisons because the levels and sources of transportation costs and competition are very different, evidence indicates that current applicable U.S. grain rates are at least 20% higher than for similar movements in Canada (USDA, 2015).

Changes in Regulation for Grain Movement in Canada—Extended Interswitching

As part of yet another review of transportation policy in Canada (Transport Canada, 2011), consideration was again given to grain shipper complaints about rail service, even under the revenue cap. Under the Canada Transportation Act as administered by the Canadian Transportation Agency, there are prescribed several "remedies" for shippers who request rate or service relief that are permissible under the Act.

One of these remedies is known as "extended interswitching", or equivalently as "reciprocal switching" in the United States. In Canada, the long-standing extended interswitching policy was constrained by a radial limit on the allowable interswitch of just 30 kilometers (km) which is about 18 miles (Grimm and Harris, 1998). What this meant was that while theoretically useful as a means to enforce some competition between separated rail carriers, in practice the policy was almost never used by shippers in Canada who could potentially benefit from it, like grain shippers. However, geographic simulation analysis done by Nolan and Skotheim (2008) showed that the extant Canadian interswitching limits would need to be increased by several orders of magnitude in order to benefit grain shippers in particular, the latter being mostly dispersed across the prairies and often located some distance from an applicable interswitch point between the two Class 1 Canadian railways.

Skotheim and Nolan (2008) identified those interswitching distances for which a given grain shipper would be able to access both Canadian Class 1 railways much more readily than under the existing 30 km limit. Using 2002 grain system data, we estimated potential shipping cost savings under various new interswitching distances, savings which were in the millions of dollars because of the ability of these shippers to access another carrier for transportation. As designed, extended interswitching should not only encourage more competitive freight rates through some actual movements initiated by a competing carrier, but also through simply the threat that this could happen if freight rates are allowed to grow to unreasonable levels. Given the few actual Class 1 carriers in Canada, the new interswitching policy will likely not generate many actual regulated interswitches, but the theoretical ability of shippers to access that second railway should serve to keep grain rates close to average cost levels.

Using the work of Skotheim and Nolan (2008) and assessing the current situation in the grain handling sector, the legislation now being used is based on an interswitching distance of 160 km which is about 95 miles. Figure 1 shows the extent and coverage of the policy under current Canadian regulations. Under the 160 km interswitch range, it is estimated that grain shippers would save between C$15 and C$18 million in freight charges, and that a 160 km interswitch would offer about 70% of all grain elevator locations across the Prairies (by volume) access to the second railway. Given the topology of the rail system in Western Canada, it was clear that a regulated interswitching distance would have to be very large to actually capture all grain shippers in the region. The latter distance falls on the order of over 300 km (180 miles). This would be somewhat onerous on the railways from an operations perspective. Therefore, the 160 km limit seems to be a reasonable compromise, balancing the need for competitive discipline in this market with a manageable distance to complete the transaction.

One more point about extended interswitching as a North American, not just Canadian, policy. As implemented, at least one Class 1 U.S. railway can gain access to some Canadian grain shipments under the new extended interswitching limits. As of the most recent information publicly available, that railway has sought only very limited access agreements into Canada, including accessing the track of one border shipper as well as a Canadian railway located on the border (Canadian Transportation Agency, 2014). So while extended interswitching can give at least one U.S. railway access to Canadian grain shippers over Canadian track (Figure 1), the converse is not the case.

It is worth noting that the Surface Transportation Board in the United States is currently hearing support for implementation of some form of reciprocal switching in the region (Transportation Research Board, 2015). Like Canada, it is being considered primarily as a means to encourage more inter-rail competition in bulk shipping (Szakonyi, 2014). While the exact details of a U.S. version of this are a long way from being worked out, it seems likely that a distance of between 30 and 50 miles would be a starting point for any shipper negotiations with the STB and railway interests.

For illustration and by way of comparison, Figure 2 is a hypothetical mapping of potential coverage available under the maximum suggested

Figure 1: Current Canadian Extended Interswitching Map (for wheat/grain)

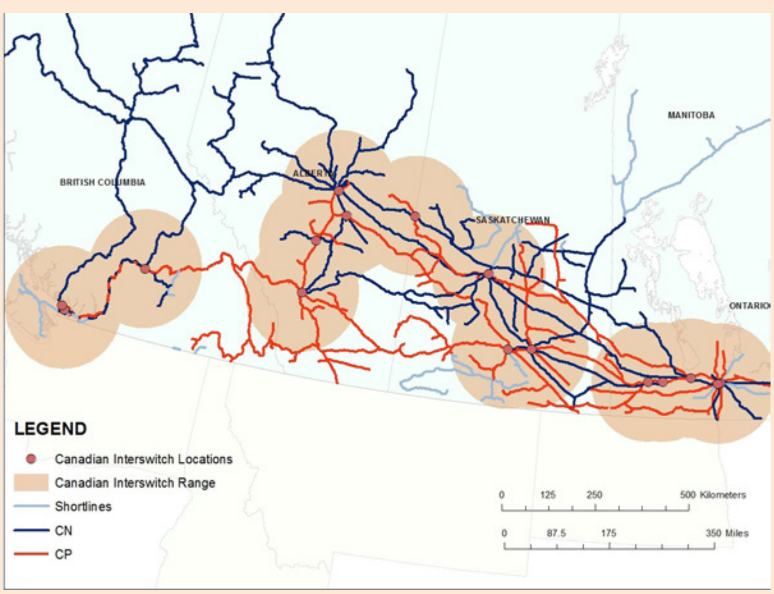
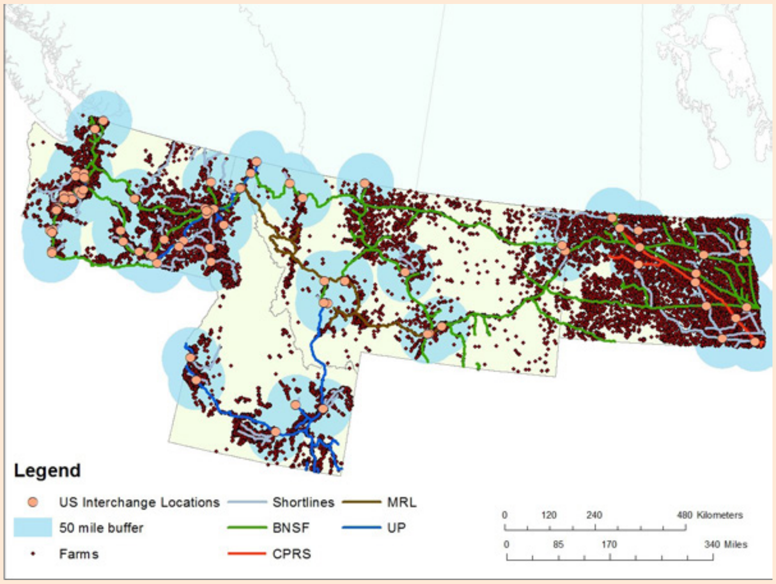


Figure 2: Hypothetical Northern Great Plains Reciprocal Switching Map, 50 Mile Radii Using Known Interchange Points (for non-livestock farms)



U.S. reciprocal switching limits, while also including major regional shortline railways as possible switching competitors. Shortlines in Canada are generally considerably smaller than their U.S. counterparts, and partly because of this, in Canada the current extended interswitching limits only apply to Class 1 railways.

Also layered on this map are locations of regional farms, done to give an approximate sense of comparable (to Canada) agricultural cover. The GIS layer shown (taken from Dun and Bradstreet Worldbase data) lists farms producing "oilseeds and grain" as well as "other crops", so Figure 2 shows all farms in the region that are non-livestock. While overestimating the total number of strictly grain producing farms, compared to Canada, the total likely represents farms that could well be affected by a future reciprocal rail switching policy. While there are just over thirty thousand farms, the map shows that just over 75%, or about 26,000 farms, are contained within the hypothetical reciprocal switching limits. While encouraging, there are still notable regional differences across the four states. We conclude that while large areas of crop production could be positively affected by reciprocal switching as suggested, in fact there are still large areas of regional crop production that would be left unaffected, even under the proposed maximum 50 mile reciprocal switching radius.

Other Recent Canadian GHTS Issues

As the Canadian GHTS transitioned from the era of the CWB as sole marketer and logistics coordinator to a new era with the grain companies controlling their logistics operations independently, change began gradually. The first crop year of the post-CWB era (2012-2013) was normal or slightly below normal by historical standards, with most aspects of the new GHTS looking the same from a broad system perspective. But like in the United States, the subsequent bumper grain crop year of 2013-2014 precipitated several changes in the system and led not only to temporary heavy-handed regulations on grain movement, but it also showed that grain companies in the new era meant business and were quite willing to put their own profits ahead of farmer welfare or system efficiency.

As in the United States, explanations of the rail system slowdown that started in the fall of 2013 are still debated. The Canadian railways maintained that particular winter was especially rough on their equipment, leading to considerable delays on the operations front trying to assemble trains and deliver grain to the Port of Vancouver. Other issues, including a trucking strike at the Port (Constantineau, 2014) may have also compounded the ability of Canadian railways to move export grain to port in a timely manner. But according to many observers, the growing role of rail in shuttling crude oil throughout North America for refining was the primary reason for the unprecedented delays in grain movement that occurred through the fall and winter of 2013-2014 (Economist Magazine, 2014).

The transportation delays throughout the supply chain eventually led to very high basis levels (for example, the differential between port and on-farm prices) for prairie grain (Gray, 2014). In effect, grain companies were lowering their country bids while still obtaining high port prices to prevent farmers from delivering into the backlogged system. So while basis levels typically only reflect transportation and handling costs, the basis levels achieved during this time were new to the industry, and in many cases 200-300% higher than normal. Gray estimated that this situation and its duration likely cost Canadian producers on the order of C$2 to C$3 billion for the 2013-2014 crop year. Considering the situation from the perspective of the Canadian grain companies, recall that Canadian railways are capped on grain movement revenues, so most if not all of the excess basis would have been retained by the grain companies.

Grain companies were notably silent on what was happening during this time of historic basis levels.

On the rail regulatory side, whatever the actual reasons for the ongoing grain transportation delays in Canada, the Federal government eventually intervened and on March 7, 2014 enacted the so-called Fair Rail for Grain Farmers Act. While the Act also contained modifications to regulated extended interswitching as described above, as a more temporary measure the Act also mandated that both Class 1 railways move a minimum volume of grain (500,000 metric ton, or approximately 5000 grain hopper cars) each per week in an effort to reduce the enormous grain backlog. If a railway could not meet these requirements, it would be fined for non-compliance. As might be expected, the railways lobbied hard over the next few months to get the volume requirement lifted, but it was finally repealed a year later in March of 2015 (Atkins, 2015b). In spite of this, currently there is still a significant amount of grain carryover in Canada. It will be interesting to see whether or not the falling price of oil will affect the wherewithal of the railways to eliminate the remaining grain backlog in a timely fashion.

Revenue Sharing in the Supply Chain

Without question, 2013-2014 was a "perfect storm" for grain transportation in Canada and the situation is still in flux. During this time some industry observers highlighted a new situation where the historically trusting relationship between grain companies and farmers, and the historical distrust between farmers and rail companies had been shifted. Without a Canadian Wheat Board to act on their collective behalf and ensure grain grown was grain moved, many farmers found out the hard way that it is not only the railways who will pursue profit maximizing behavior when confronted with a favorable economic situation. The new situation in fact raises a broader question not addressed very often in the modern supply chain literature—how does market power among the players affect revenue distribution in a modern supply chain?

Motivated in part by the evolving grain handling situation in Canada, Cakir and Nolan (2015) developed a model of the grain supply chain that allowed us to simulate the effects of relative market power as exhibited by the players in the chain on the revenues of each of the participants (dividing the revenue pie, so to speak). Building on well-established work simulating market power in vertical markets (Sexton and Zhang, 2001; Sexton et al., 2007), we found that market power exercised by the oligopolistic railways in the supply chain always generated greater overall welfare effects within the supply chain compared to market power exercised by the oligopolistic grain companies. In effect, equal amounts of market power exercised in the rail and grain handling sectors will always generate a revenue distribution favorable to the railways, less so for the grain companies. As might be expected, a competitive farming sector always suffers more than either of the other supply chain participants exercising some degree of market power.

While somewhat intuitive, the analysis would also seem to help explain some important current issues as well as help forecast the future of the Canadian grain supply chain. First, the newfound desire of the railways to have the revenue cap policy completely removed (Atkins, 2015a) after years of relative quiet about it would seem to indicate that the cap was a real constraint on the ability of the railways to extract surplus in the backlogged supply chain from the larger than normal basis. If there was approximately C$2 billion or so "on the table" in 2013-2014 that the railways could not access because of the revenue cap, then it is not surprising they would suddenly want to get the cap removed in case this situation continues or arises again in the near future.

In addition, the analysis would predict that in order to garner the greatest share of available revenue in the grain supply chain with an unregulated oligopolistic rail sector, the grain handling sector in Canada will likely further consolidate. Currently, just three companies in Canada account for 75% of the export grain market (White et al., 2015; AEGIC, 2015). While merger and acquisition activity in the Canadian grain handling sector has been quiet for the past several years, with the recent entry of a major international player on the Canadian scene we expect this sector will once again attempt more mergers and acquisitions over the next 3-5 years as the Canadian grain supply chain continues to find its new long-run equilibrium.

Looking to the Future

Since railways necessarily possess large economies of scale in bulk movement, railways in Canada have always been regulated with respect to grain transportation. While Canadian rail regulation has changed somewhat over time, recent events have helped to place a new set of regulations on grain movement with the hope that the sector will now be governed by competitive pressures.

The removal of the marketing and logistics functionality of the Canadian Wheat Board in August 2012 was also intended to inject more commercial discipline into the grain handling and transportation system in Canada. While a laudable goal, one issue that was not addressed was whether or not the grain handling industry in fact possesses characteristics of a natural monopoly, potentially resembling the rail sector in organization. If this is the case, the Canadian grain handling sector will likely require some form of new regulatory oversight in grain handling as the industry trends towards its natural equilibrium.

To our knowledge, very little work has been done to estimate the level of scale economies in modern grain handling. While a potentially tricky exercise for today's complex grain handling business, what past work has been done in other similar jurisdictions is strongly indicative of large economies of scale in the sector (Dagher and Robbins, 1987; Quiggin and Fisher, 1988). While currently mostly unregulated with respect to prices and output, Canadian policy analysts would be wise to keep an eye on merger activity in grain handling and hopefully avoid a "double-duopoly" within this important trade based sector of the Canadian economy. In any case, the evolution of the supporting markets in the GHTS could lead to major changes in the Canadian grain farming sector, likely pushing the economic scale of grain farming to a level even larger than at the present.

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Railroad Competition and Wheat Rates

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Railroads are important for transporting agricultural commodities from producing regions to domestic processing locations and export ports. These shipments involve large scale movements of low value, bulk commodities over long distances and thus rail service is virtually the only cost effective shipping alternative available. U.S. Department of Agriculture (USDA), Agricultural Marketing Service (2015) reports that railroads transported 83% of Montana and 80% of North Dakota grain and oilseeds during the crop marketing years from 2009 to 2012. Though not as critical as for Montana and North Dakota, rail transportation is significant for many other states producing grain and oilseeds. The corresponding percentages for South Dakota, Minnesota, Kansas, Oklahoma, Idaho, and Washington were 39%, 35%, 34%, 46%, 30%, and 31%, respectively.

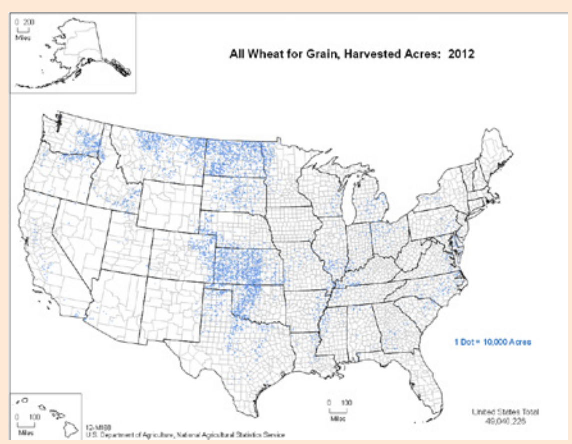
U.S. Wheat Production Location Largely Determines Mode of Transport

Wheat production in the United States is generally concentrated in some of the most sparsely populated areas of the country (Figure 1). The reliance of wheat shippers on rail transport is higher than the percentages for all grain and soybeans. For example, Montana ships nearly 100% of its wheat by rail.

According to USDA research, 9 of the top 10 wheat producing states are more than 150 miles from barge transportation on the Mississippi and Columbia Rivers which provides the most significant competition to railroads for long distance movements of wheat to export ports (Harbor, 2000). The average distances to barge loading locations for the nine largest wheat producing states are 206.2 miles for Idaho, 219.9 miles for Kansas, 128.8 miles for Minnesota, 364.6 miles for Montana, 381.9 miles for North Dakota, 186.4 miles for Oklahoma, 214.8 miles for South Dakota, 276.7 miles for Texas, and 57.4 miles for Washington.

Wheat shippers in the central and northern plains states simply have no cost effective transportation alternative to railroads. Wheat produced in these areas move long distances to domestic processing and consumption locations or to export ports. Wheat shippers in these areas do not have direct access to barge loading locations and truck transport provide no competition for these movements. In contrast, transport of grain produced in more eastern regions has little reliance on rail transportation. For example,

Figure 1



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the significance of barge competition for rail transport of grain is indicated by the percent of grain shipped by rail for states bordering the Mississippi River: 14%, 16%, 32%, and 6% for Iowa, Missouri, Illinois, and Arkansas, respectively (USDA, 2015).

The Rail System and Competition

The Class I railroad system of today was formed to take advantage of the long haul cost advantages of railroads relative to other types of transport. The Class I system of today was formed by railroad mergers occurring since 1980. For example, there were 40 railroads designated as Class I in 1980 but today there are only seven. The Regional (Class II) and Local (Class III) railroads are bridge carriers for the Class I railroads. However, depending on the railroad network, Class II and III railroads may contribute to competition among Class I railroads. For example, in North Dakota, the Dakota, Missouri Valley and Western (DMVW) is an affiliate of the Canadian Pacific (CP) but it serves areas of the state that the BNSF Railway does also, but not the CP. Thus DMVW competes with BNSF for these wheat shipments. Also, in North Dakota, the Red River Valley, and Western is an affiliate of BNSF but serves many areas of the state where there is a strong CP presence. Thus RRVW competes with CP for these shipments. Thus the Class II and III railroads compete on behalf of their affiliate Class I railroad.

The Staggers Act of 1980 contained provisions that make railroad abandonment easier. As a result many miles of branch line serving rural areas were abandoned. However, the Class I railroads also sold branch lines to short-line (Class II and III) railroads. As a result the number of short-lines boomed in the 1980s and the 1990s. Between 1980 and 1999, 332 short-lines were created, operating 41,448 miles of track. Some of these short-lines are still "stand-alone" companies, but many have been absorbed by large firms that own and operate several short-lines under a common ownership.

Short-lines have several advantages that have enabled them to successfully serve rural areas. These advantages include lower labor costs than Class I railroads and the ability to more likely be able to operate low traffic density lines profitably. Since they have a relatively small number of shippers, short-lines are able to provide superior shipper service. Also short-lines reduce the number of truck shipments resulting in less highway maintenance and rehabilitation costs in rural areas.

Table 1: Railroad Mileage by State and Class, 2013

State	Class I	Percent of Total	Class II, III	Percent of Total	Total
Idaho	995	58.20%	714	41.8	1,709
Kansas	2,790	59.5	1,896	40.5	4,686
Minnesota	4,634	83	951	17	5,585
Montana	2,139	65	1,153	35	3,292
North Dakota	2,064	63.2	1,204	36.8	3,268
Oklahoma	2,360	64.9	1,274	35.1	3,634
South Dakota	1,487	80.5	361	19.5	1,848
Texas	12,173	87.2	1,783	12.8	13,953
Washington	2,165	64.1	1,215	35.9	3,380
Source: State Departments of Transportation					

The Class I railroads serving wheat areas are the Union Pacific (UP) and the Burlington Northern Santa Fe (BNSF). Table 1 displays the railroad network in the nine major wheat producing states.

As the data in Table 1 indicate, Class I railroads dominate the rail networks of these states, accounting for 58% to 87% of the rail mileage, but in six of the nine states, Class II and III railroads account for 35% to 42% of the railroad network.

Further insight can be gained regarding the degree of competition between Class I railroads by examining railroad mileage of each of the Class I railroads in each of the nine major wheat producing states.

The data indicate that some states have potentially more competition among Class I railroads than others. States dominated by one Class I railroad include Idaho (UP), Montana (BNSF), North Dakota (BNSF), and Washington (BNSF), while Kansas, Minnesota, Oklahoma, and Texas have relative balance between the mileages of at least two Class I railroads. Thus, the latter group would be expected to have more competition and thus lower railroad wheat transport prices.

In an early study to determine the preferences of over 300 shippers using short-line railroads in Kansas and Iowa, shippers were asked to rate the performance of their short-line railroad on 17 price-service characteristics relative to their previous Class I railroad and motor carriers (Babcock et al., 2010). It was found that grain shippers prefer short-line railroads while non-grain shippers prefer motor carriers. However, when the entire shipper sample is considered, more shippers prefer short-lines than any other type of transport. Short-line profitability is related to carloads per mile of mainline track, railroads to which a short-line connects, railroad firms operated by a parent firm, and gross miles of mainline track operated

Table 2: Class I Railroad Mileage by State, 2013

State	BNSF	% of Total	UP	% of Total	KCS	% of Total	CN	% of Total	CP	% of Total	Total
Idaho	118	11.90%	877	88.10%	-	-	-	-	-	-	995
Kansas	1,237	44.3	1,535	55	18	0.6	-	-	-	-	2,790
Minnesota	1,686	36.4	665	14.4	-	-	479	10.3	1,804	38.9	4,634
Montana	2,003	94.1	125	5.9	-	-	-	-	-	-	2,128
North Dakota	1,714	78.1	-	-	-	-	-	-	482	21.9	2,196
Oklahoma	1,037	43.9	1,173	49.7	150	6.4	-	-	-	-	2,360
South Dakota	889	59.8	-	-	-	-	-	-	598	40.2	1,487
Texas	4,929	40.5	6,336	52	908	7.5	-	-	-	-	12,173
Washington	1,633	75.4	532	24.6	-	-	-	-	-	-	2,165
Source: State Departments of Transportation											

by the short-line (Prater and Babcock, 1998).

Historically, North Dakota and Montana have had the highest railroad wheat transport prices (rates). However, recent evidence from USDA is inconclusive on whether Montana and North Dakota rail wheat rates are higher and have increased faster than other states. In the 1988-2007 period Prater et al., (2010) found that in the case of rail revenue per ton, Montana and North Dakota had the smallest increases of the 10 grain producing states evaluated. Iowa, Nebraska, South Dakota, and Kansas had the largest increases. For revenue per ton mile, Colorado, Kansas, Indiana, and Missouri had the largest increases while Montana and North Dakota had the smallest increases. In fact, North Dakota rail revenue per ton-mile actually decreased during the 1988-2007 period.

For revenue/variable cost ratios (R/VC) the states with the largest increases were Kansas, Missouri, Colorado, and Nebraska. Montana's ratio remained virtually unchanged. North Dakota and Indiana had the lowest increases in R/VC ratios for the 1988-2007 period. USDA reported that Montana had the 7th lowest and North Dakota the 8th lowest average grain and oilseed rates per ton-mile in the 2006-2010 period for 36 states.

A recent 2014 study by Babcock, McKamey, and Gayle addressed the issues of railroad competition and its effect on railroad prices for North Dakota, Montana, and Kansas wheat using rigorous statistical techniques. Since Kansas has two Class I railroads of approximately equal size while North Dakota has one, the authors were able to examine if competition among rail lines is stronger in Kansas, leading to lower Kansas rail wheat prices than North Dakota and Montana rail wheat prices. The authors found for North Dakota—but not Montana— that the railroad average wheat rate per ton-mile were higher than the average Kansas wheat rates due to greater rail competition in Kansas.

Future Impacts from Structural Change in Rail Transport

Since the price received by producers is approximately the destination price minus the price at the origin, if railroads raise their prices, the price received by producers is correspondingly reduced. The lower prices have a direct effect on farm income, reducing crop receipts. An USDA study of the rail service disruption that occurred in the Upper Midwest in 2014 concluded that transportation cost increases for corn, wheat, and soybeans from the Upper Midwest to the Pacific Northwest ports and the Gulf of Mexico ports could have depressed local crop prices on average by between $0.11 per bushel to as much as $0.18 per bushel in 2014 (USDA-AMS, 2015).

Over the last 25 years, railroads have been gradually shifting the cost of wheat transport to rail car leasing companies and shippers. In 1990, railroads owned 63% of the rail cars and car leasing companies and shippers owned 37%. By 2013, the railroads owned 35% of the rail cars and the shippers and rail car leasing companies owned 65%. How this shift in risk within the supply chain will affect U.S. grain producers and U.S. competitiveness, will be evident in the coming years.

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Benefits of Transportation Investments: How You Measure Matters

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Congestion in the truck transportation industry results in significant costs throughout the economy. For example, a 2011 survey of Washington state freight-dependent industries found that a 20% increase in congestion faced by the freight dependent industries would result in an impact of nearly 1,800 jobs lost and a reduction of $244 million in regional output from the state's Central Basin region alone (Taylor et al., 2013). Much of the output of the Central Basin is agriculturally-driven. The estimated impact is largely generated as a result of the freight dependent businesses increasing spending on resources to counteract the increased congestion. In turn, prices of freight dependent goods are increased and consumers must decrease purchases of services and non-freight dependent goods to pay for the increased costs of freight dependent goods. In essence, congestion causes general inefficiency, requiring the truck transportation industry to be less productive.

Given the economic inefficiency of congestion, infrastructure investments that reduce freight travel time and operating costs along the supply chain can be considered to represent a technology improvement that permits the industry to become more productive, for a given level of capital and labor. These efficiencies are generally realized through reduced driver time on the road resulting in reduced labor costs; reduced vehicle repair and operating costs; and increased trip miles per unit of time per vehicle, resulting in more productive individual vehicles and requiring fewer trucks to accomplish the workload.

It is a widely held view that our country is underinvesting in all types of infrastructure at a time of high need. In their most recent grading of the U.S. infrastructure, the American Society of Civil Engineers identified a backlog of more than $3.5 trillion in overdue maintenance. This backlog, among other conditions, earned the U.S. infrastructure a D+ average. The roadway system fell on the low end of the report card, earning only a D (American Society of Civil Engineers, 2013). At the federal level, major funding and authorization legislation governing surface transportation investment includes the most recent 2012 Moving Ahead for Progress in the 21st Century Act, commonly referred to as MAP-21 (U.S. Department of Transportation, 2015).

While much of the political discussion has focused on the source of revenue for infrastructure projects, with so great a need, it is not totally clear where the greatest return to public investment lies. An important contribution to that discussion is through economic analysis of investment impacts. The impacts of various investment options—and underinvestment—in infrastructure are important for the general public, and especially policy decision makers, to understand. Given that the impacts are systemic and challenging to capture quantitatively, economists have used multiple ways to estimate these impacts. Each approach has its limits and differing assumptions; and the right approach depends on the specific question and data at hand.

As we progress further into the 21st Century, the language of current and future federal transportation funding and bills, like MAP-21, point to a growing need among agencies for rigorous analysis of the economic impacts generated via efficiency and productivity gains resultant of infrastructure investment. The two most common methods used by transportation agencies in evaluating economic

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impacts are (1) the often used status quo Input-Output (I-O) model and (2) the Computable General Equilibrium (CGE) model. The CGE model is a more sophisticated method which has gained popularity over I-O in academic literature as well as among federal government agencies for a variety of applications—for example, the U.S. Environmental Protection Agency's Economic Model for Environmental Policy Analysis CGE—but not necessarily among state-level government agencies.

Efficient freight mobility is largely a result of successfully balancing the demand for transportation capacity and service with the quantity supplied of those services and capacities. In order to prioritize the investment in infrastructure and capacity to achieve efficient freight mobility, an accurate assessment of transportation demand, and the costs and productivity of transportation services is required. The need for prioritization arises particularly when funds are limited, requiring infrastructure investments be allocated to where the marginal returns of mobility are the highest—that is, where the biggest bang for the buck is to be had. These economic truisms are as applicable to the public sector as they are to the private sector. However, public sector entities, unlike their private sector counterparts, often experience difficulty in determining the impacts that result from public investments in freight-related infrastructure and activities, in assessing the costs of providing those facilities, and in determining the economic feasibility and viability of any infrastructure investment. In the private sector, decision makers must be responsible to the company's bottom line. In the public sector however, the bottom line is multi-faceted and includes public benefits and the ability to generate economic impacts to the region, not just one firm, or one sector.

Not only is an efficient freight system valuable for statewide interests, but also for the economic interests of rural agricultural communities within the state or region, as these communities are highly dependent upon the ability to efficiently deliver goods to local and world markets. A growing number of communities recognize that efficient freight movement is directly associated to the health of their local and regional economies. As a result, federal, state, and local governments are increasingly being asked to improve freight mobility through operational improvements and new public infrastructure.

To prioritize public investments in freight systems and to insure consideration of the contribution of freight to the overall system performance, states, and regions need a reliable method to analyze freight benefits associated with proposed highway and truck intermodal improvements that would lead to enhanced trade and sustainable economic growth, improved safety, and environmental quality, and goods delivery. In addition to quantifiable performance measures that aide in the identification of how well a project can meet a set of goals, public agencies need to effectively communicate the decision justifications to the public.

Options for Quantifying Economic Performance: Choosing the Right Approach

While the development of I-O models was groundbreaking, their limitations, largely due to flexibility of assumptions, can prove to be overly simplistic and without a real world practicality. These limitations continue to lead to various attempts to overcome them. The first of these came in the early 1960s with the development of Linear Programming (LP) models which allowed for the explicit introduction of input constraints and prices to the models. The CGE model can be thought of as an extension of these early LP models but borrowing from the I-O framework as well. The seminal work on CGE modeling is attributed to Johansen (1960), and is as a blend of neoclassical theory applied to contemporary policy issues (Bandara, 1991). Since the development of CGE models, there have been few credible attempts to argue for the use of I-O over CGE. One of these comes from West (1995) who maintains that in cases for which data is limited and the scope of the project is only for a small region the I-O model may be the only practical option. Rose and Liao (2005) add further argument with the suggestion that the difference between direct and indirect impacts is clearer in an I-O framework. However, they also provide a method for making that distinction in a CGE model. Most peer-reviewed articles dealing with the topic recommend always using CGE over I-O if possible (Seung, Harris, and Macdiarmid 1997; Rose and Liao, 2005; Dwyer, Forsyth, and Spurr, 2005; Dwyer, Forsyth, and Spurr, 2006; Partridge and Rickman, 2010; Cassey, Holland, and Razack, 2011).

Rose and Liao (2005) point out that because of these I-O limitations, it provides only an upper bound estimate of the impacts of a policy or project. Similarly, Dwyer, Forsyth, and Spurr (2005) suggest the method has "inherent biases that overstate the impacts on output and jobs." Attempts have been made to deal with these assumptions by extending I-O models (Rose and Liao, 2005). However, the basic problems remain.

In contrast, within the context of a CGE model, the restrictions found in I-O models, namely fixed prices, supply, and budget constraints, can be relaxed—albeit at the cost of adopting a new set of assumptions. The underlying premise of all CGE models is the assumption that if all markets in a given economy are in equilibrium, then any individual market within that economy will also be in equilibrium and therefore a market clearing price and quantity exists for any individual sector of the economy, as well as the whole regional economy. The conceptual flow of activities is relatively simple and straightforward with all firms in an economy producing their own unique goods from inputs—labor and capital—which are provided by the households. These goods, services, and commodities are then either utilized as inputs for other firms or consumed by households at the respective market clearing price.

Impacts vs. Net Social Benefits

Another issue that ought to be discussed when dealing with regional policy decisions is the difference between economic impacts, as measured through economic impact analysis, and net social welfare, generally estimated using Benefit-Cost Analysis (BCA). Welfare is touted as the more appropriate metric for decision making (Edwards, 1990; Abelson, 2011); however impact is very widely used. This is not for theoretical reasons, but rather because impacts are more readily understood by a general audience. An impact can be stated as a change in the number of jobs—a very easy to understand and increasingly demanded performance metric; net social benefits are defined in terms of utility, something only economists tend to discuss. It also could be the case that impacts are so popular due to the long-time dominance of I-O models in regional science. Unmodified I-O models are incapable of estimating net social benefits, leaving impacts as the only available metric.

CGE models, on the other hand, can be used to directly estimate social welfare—generally by calculating an economic measure, referred to as *equivalent variation* (Hirte, 1998; Böhringer and Welsch, 2004).

A Comparison of Results for Highway Improvements in Washington State

To date, most analyses of the impact of highway infrastructure improvements on state transportation system performance have focused on the impact on passenger traffic or the total vehicle count. However, there are important differences between passenger and freight transportation that need to be considered to accurately assess the impact of highway infrastructure improvements. This is particularly true when it comes to the consideration of such improvements on congestion and travel time reliability and determining the appropriate dollar value to use for changes in reliability for freight. It quickly becomes apparent that the matter is much more complicated than for passenger travel.

For passenger travel, the total value of a trip is calculated as the value to the driver and any passengers on board. The value to these occupants of the change in reliability is generally accepted to be their value of time multiplied by the change in travel time. While there is still a debate in the literature regarding the appropriate value of time to use (that is, is it the average hourly wage rate in the area—or should it be half of that for travel time, or other options), and whether the relationship between a reduction in reliability and social value is a simple relationship, it is clear that these issues pertain to the driver and occupants of the vehicle and thus are directly related to the operation of the vehicle.

Some have interpreted the valuation of time for freight transportation in a parallel fashion by using the hourly wage of the truck driver. However, the driver's wage reveals only part of the true value of time in a freight operation. Freight transportation typically involves at least a shipper and a carrier. The value placed on a reduction in travel time differs considerably across shippers of different products, distances involved in point-to-point shipments, transport mode, and other factors. Additionally, the perishability of a product, particularly fruits and berries, generates a freight value of time that moves beyond an operating cost perspective. As the perishability of product increases, the time sensitivity of the shipper increases, thus placing more concern the ability to reliably deliver products on time, without significant degradation.

The role of freight movement in a region is strongly tied to its relationship, to its 'core' and 'traded' industries. With several major west coast ports, the Northwest's economy is tightly bound to these traded industries, where we understand traded industries to be those industries that produce and sell more goods than what can be consumed locally, and thus are selling products to a national or international market and provide a flow of incoming dollars to the local economies. In Washington state, this is largely comprised of agricultural commodities including wheat, apples, and hay. Since the development of the interstate highway system, manufacturing industries have become interdependent upon the trucking industry. The degree to which an industry is dependent upon this system varies considerably. In their evaluation of Portland's traded industry use of transportation, the Economic Development Research Group, Inc. identified the agricultural industry (NAICS 111) as relying upon Truck usage for 73 percent of their transportation needs, while publishing industries (NAICS 511) are 35 percent reliant upon Truck and 36 percent on postal.

In Washington State, recent intercept surveys of trucks heading west on Interstate-90 towards the Puget Sound were significantly comprised of agricultural products. More than half (56%) of all trucks surveyed (n=2610) originated within the state and often destined for distribution centers (38%) and international ports for export (15%). Of those trucks destined for major ports (Seattle and Tacoma), the most prevalent commodities consisted of Hay, French Fries, and Apples; all strong

Washington based agricultural products. While these products all originate in the more rural eastern portion of the state in which congestion is a limited concern, their destinations route them through dense traffic that is frequently plagued by congestion, thus making highway investment in congestion relief a very relevant concern for the state's Agricultural regions.

Results Using the CGE Model

To assess the value in using a CGE based model to estimate the impacts generated by infrastructure investments, researchers utilized Washington based travel demand models (TDMs) to visualize the travel related impacts. In the scenarios assessed, the TDMs suggest congestion relief stemming from the infrastructure improvement. With congestion relief comes a reduction in cost of freight dependent good that in turn produces a positive effect, in that they simulate consumers increasing purchases of services and non-freight dependent goods, as well as a negative effect that simulates the trucking industry's response of reducing employment. Though it's potentially counterintuitive, the results indicate losses in trucking based jobs as a result of their newly gained capacity to increase their output with fewer trucks and drivers.

In addition to the jobs modeled to be lost in the trucking sector, the sector associated with other transportation modes and warehousing also projects some, though markedly fewer, losses in the CGE model. Most of the sectors demonstrate only marginal changes in employment levels, with most experiencing less than a five job changes. The sectors where job gains are substantial enough to take notice are found in several heavily freight dependent sectors. This is particularly true for the manufacturing sector, as well as agriculture and forestry. These two sectors combined more than offset the losses experienced in the truck-transport sector. Other notable sector employment gains include retail trade gains.

Results Using the I-O Model

It is important to preface the I-O model results by noting that the I-O will never produce a negative number when modeling an increase in output by a sector; getting back to some of the concerning limitations of such models. This goes for the sectors directly impacted as well as all the indirect and induced effects. In essence—due to lack of information about the number of trucks added or reduced—only one piece of the potential response is modeled. Congestion relief from the project is seen as producing a positive effect, in that it stimulates consumers to increase purchases of services and non-freight dependent goods (consumer benefit). The I-O model does not account for the trucking industry becoming more efficient and able to do more with fewer trucks. Given this, it is not surprising that in most of the sample scenarios conducted, the I-O model results in higher job growth estimates. However, taking the output change under consideration, CGE models result in greater changes than their I-O counterparts. This observation is a result of the flexibility built into the CGE model through increases in the productivity of the trucking sector for given levels of capital and labor (Sage et al., 2013).

Looking to the Future

Infrastructure improvement projects that reduce operating costs and travel time of freight users on the roadway is an activity that inherently affects the productivity and economic efficiency of the user; two critical components that are addressed in the National Freight Policy provisions of MAP-21. As readily available and user friendly as I-O models are, their major drawback is the inability to simulate a change in productivity directly. To assess the economic impacts of such infrastructure improvement projects, the benefits experienced by the users must be manually translated into a change in demand by freight users. Despite being able to compute the change in demand, the I-O model described here is not able to fully account for the improved productivity of the trucking industry, and thus does not confidently model how the trucking sector meets the increased demand.

Where infrastructure projects are large enough and productivity is increased to the point that now fewer trucks—and therefore fewer drivers—can meet the demand needs, we may experience a reduction in employment in the transport-by-truck sector. The I-O model does not pick this up. However, the CGE is able to directly model increased productivity of an industry and are thus able to model the entire economy-wide reaction to the infrastructure improvement that is a result of decreased operating cost and travel time. It is for this specific ability to model productivity changes that a regional CGE model should be incorporated into the prioritization. By implementing an economic impact study alongside the typical BCA, these analyses will better inform agency prioritization decisions with regard to the affect infrastructure projects have on freight systems and the regional economy that is necessarily interwoven with them. As more benefits accrue and are accounted for, the impact on the economy will continue to grow. Thus, as capabilities to account for benefits stemming from increases in reliability are developed, a more complete impact can be assessed.

The applicability of the above defined economic impacts models do not stop at the level of on-highway investments. Intermodal facilities such as truck-to-rail facilities frequently employed in agricultural regions--where goods are transferred from truck to rail for shipment to domestic markets, or through gateways to international markets--are often offered as a means of improving the efficiency of the freight movements in some marketing situations by taking advantage of the comparative advantage of one mode over another. Proposed public investment in such intermodal facilities raises at least two questions:

- Will the facility succeed in the private market place by generating a sustaining return as a commercial investment?

And

- Is any public investment justified based on the public benefits, or externalities, produced?

The intermodality adjustments are of particular importance in consideration of commodities like wheat and other bulk grains that frequently involve rail, truck, and barge transportation in route to the export market (Freight Policy Transportation Institute, 2015).

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