ECONOMIC IMPACTS ANALYSIS OF INLAND WATERWAYS DISRUPTIONS ON THE TRANSPORT OF CORN AND SOYBEANS

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EXECUTIVE SUMMARY

What is the Issue?

The Upper Mississippi River and Illinois Waterway (UMR-IWW) is a primary corridor for U.S. grain and oilseeds to export ports at the Gulf of Mexico. A total of 36 locks and dams, 28 on the UMR and 8 on the IWW, are maintained at a 9-foot (ft.) depth navigation channel for barge transportation. A majority of the UMR-IWW locks were built in the 1930s and have surpassed their designed lifespan. Concerns about the navigational efficiency of these aging and constrained waterways have been frequently raised by U.S. grain and oilseed producers. Congress authorized the Navigation and Ecosystem Sustainability Program (NESP) in 2007 to address the capacity constraints on the most congested segments on these waterways. However, the implementation of NESP has been delayed due to a lack of pre-construction and construction appropriations from Congress. An updated economic analysis of the navigability on the UMR-IWW is crucial and timely to the U.S. agricultural sector, and could help justify the need for NESP appropriations.

This study examines the economic impacts of UWR-IWW navigability on U.S. corn and soybean stakeholders and certain sectors of the transportation industry if long-duration disruptions were to occur because of significant lock closures for major unanticipated repairs. Specifically, the net changes in economic surplus of the corn and soybean sector are estimated, along with shifts in transport mode for grain flows, *ex ante* and *ex post*, [1] regarding potential disruptions of the lock system on the UMR-IWW in the next decade. Changes in economic surplus of the corn and soybean sector consider a loss in profit by the producer and increased purchase costs incurred by the consumer resulting from increased transportation costs.

The hypothetical disruptions for the study are lock closures at Mississippi River Lock 25 and Illinois River La Grange Lock, since these two locks are the only two included in both modernization and small-scale navigation improvement under NESP. These locks were also selected because they are good representatives of the other locks used on the UWR-IWW. The reliability and availability of locks on the UWR-IWW is of paramount importance to the agricultural sector. Thus, the economic impacts of the availability of these two locks are analyzed to get a sense of what the impacts might be if a lock on the UWR-IWW was closed for a long period of time for major unanticipated repairs.

For the analysis, two lock closure time horizons are considered for each of the locks. Lock 25 and La Grange Lock are analyzed *independently* in the study. The closure times assumed were: (1) the fall quarter (September through November in 2024/25), and (2) the entire marketing year in 2024/25 (September through August). In addition, three potential changes in rail rates are incorporated in the lock disruptions scenarios: (1) no change, (2) an increase of 5 percent, and (3) an increase of 15 percent. The report looked at how traffic is diverted by a lock closure and the revenue shifts between the modes as a result of reduced navigation. Overall economic impacts are measured by combining the transportation sector impacts with the impacts on the corn and soybean sectors.

[1] Ex-ante meaning "before the event", where the results of an event or action are forecast in advance. Ex-post is the opposite, and means "after the fact"

What Did the Study Find?

The key findings of the economic impacts from lock disruptions are summarized as follows:

- Corn and soybean exports at Gulf of Mexico Ports are reduced up to 5 million tons, a 9 percent decrease, when Lock 25 is closed for the fall quarter. The reduction in exports increases up to nearly 8 million tons, or 13 percent, when the closing horizon extends to the whole marketing year. Disruptions at La Grange Lock also lower corn and soybean exports at Gulf ports with relative less scale (5 percent).
- Pacific Northwest ports are the major alternative routes to the international markets when Lock 25 or La Grange is closed if rail rates do not increase. Exports from Atlantic Coast emerge as an important substitute port area if rail rates elevate after lock closure.
- The ton-miles of corn and soybean hauled by barge reduces considerably when each of these two locks is not accessible. Rail ton-miles for corn and soybeans unsurprisingly escalate. However, increases in rail rates divert some volume to truck and barge transportation.
- Aggregate economic activity related to grain barge transportation reduce $933 million (or 40 percent decrease) if Lock 25 is closed from September to November. The reduction reaches to nearly $2 billion if the lock is unavailable for the marketing year.
- Economic activity associated with rail transportation, on the contrary, increases from diverted corn and soybean shipments. The positive economic impacts surpass the loss of economic activity of barge and truck transportation when rail rates are raised.
- Economic surplus of the corn and soybean sector declines between $171 million for a fall closure and $747 million annually when Lock 25 is inaccessible. Closing La Grange Lock also leads up to $549 million loss per year in economic surplus of the corn and soybean sector.
- Corn and soybean producers in the Corn Belt region suffer the most loss in economic surplus, followed by the Lake State region and Northern Plains region.
- Decline in economics surplus in the corn and soybean sector due to Lock 25 closure could cause a decrease of more than 7,000 jobs, $1.3 billion of labor income, and about $2.4 billion of economic activity (total industry output) annually.
- Similarly, closing La Grange Lock for one year alone could result in a reduction of 5,500 jobs, $900 million labor income, and $1.8 billion of economic activity annually.
- Closing Lock 25 or La Grange Lock creates net negative impacts on jobs, labor income, total value added and total industry output in the U.S. economy.

How Was the Study Conducted?

A price-endogenous, spatial equilibrium, quadratic programming model[2] of the international corn and soybean sectors was applied to USDA's Agricultural Baseline Projections[3] for corn and soybean supply and demand in 2024/25 to determine initial corn and soybean flows. This model was also used to determine producer and consumer surplus of U.S. corn and soybean sector *ex ante* lock disruptions on the UMR-IWW. The disruptions at selected locks and dams on the UMR-IWW were introduced in the spatial model to generate economic surplus of the corn and soybean sector; also the flows and usage of transport across mode, *ex post* lock disruptions. Aggregate economic impacts of the *ex ante* and *ex post* lock and dam disruptions were then obtained from an input-output model, IMPLAN (IMpact analysis for PLANning Version 3.0). The estimated prices, producer and consumer surplus, and economic metrics (employment, labor income, total value added, total industry output) were contrasted to isolate the impacts of lock disruptions on the UMR-IWW.

PROBLEM OVERVIEW

The UMR-IWW is a primary corridor for the movement of bulk commodities in the United States. According to the U.S Army Corps of Engineers, food and farm products are the major commodities transported on the UMR-IWW, accounting for nearly 55 percent of the tonnage by barge on the UMR and around 35 percent on the Illinois River during 2012-2014. Corn and soybeans comprise up to nearly 90 percent of food and farm products on these waterways and are primarily destined for Lower Mississippi River ports. In addition, the UMR-IWW is also an important channel to bring agricultural inputs (e.g., fertilizer, petroleum products) from the ports at the Gulf to the north central agricultural production region. Barge transportation is of great importance to U.S. agriculture because of its comparatively low transport costs as compared to overland modes.

A set of locks and dams on the UMR-IWW maintains a 9-ft. navigation channel for barge transportation. This lock and dam system was primarily built before World War II and the capacity of most lock chambers on the River are 110-ft wide and 600-ft in length, except for three lock chambers with 1,200-ft long chambers (Mississippi River Lock 19, Melvin Price Locks , and Mississippi River Locks 27 on the UMR). The most a 600-ft chamber can process is a tow pushing nine (in a 3 long by 3 wide configuration) covered hopper barges through the lock in a single operation (lockage). However, a modern tow typically pushes 15 hopper barges on these waterways. Thus a 15-barge tow needs to be de-coupled and passes the lock via two separate operations (double lockage). Those barges are then re-jointed to the tow on the other side of the chamber before departing. The duration of double lockage is generally 90 minutes to two hours, while it only takes about 30-50 minutes to complete a single lockage at a 1,200-ft long chamber (Campbell et al. 2009). The additional time spent on double lockage at the 600-ft long chamber creates additional fuel and labor costs to barge operators and ultimately transportation cost of grain and oilseeds (Fellin et al. 2001).

[2] It is a non-linear programming model that allows grain prices to be determined based on grain quantities of supply and demand in spatially separated regions.

[3] The agricultural baseline database provides long run, 10-year projections from USDA's annual long-term projections report, which is published in February each year.
http://www.ers.usda.gov/data-products/agricultural-baseline-database.aspx

Concerns about the navigational efficiency of these aging and constrained transport systems have been frequently raised by U.S. grain and oilseed sector. Grain producers argue that lock delay and congestion on these waterways due to the capacity constraint and deteriorating infrastructure unfavorably influence the competitiveness of U.S. grain in the international market (Yu et al., 2006). The American Society of Civil Engineering (ASCE) projects a loss of $3.6 billion in agricultural exports in the next decade if waterway infrastructure continues to degenerate (ASCE, 2013). The U.S. Congress authorized the Navigation and Ecosystem Sustainability Program (NESP) in 2007 to address the capacity constraints on the most congested segments on these waterways. NESP requests the construction of 1,200-ft locks at Locks and Dams 20, 21, 22, 24 and 25 on the UMR and Lock Peoria and La Grange on the Illinois River, along with other smaller scale navigation projects on other locks and dams, to improve the capacity plus restore the ecosystems on these waterways. Unfortunately, the implementation of NESP has been delayed due to Federal fiscal realities, Inland Waterways Trust Fund shortfalls, and other issues (US Army Corps Engineers 2015).

Enhancing navigation efficiency on the UMR-IWW potentially improves the price received by the producers in the north central U.S. and lowers grain prices to the consumers in the destination markets, which enhances the U.S.'s competitiveness in world grain markets. In contrast, double lockage and unscheduled outages at the aging locks and dams on the UMR-IWW can increase delays and congestions on these waterways and lower the navigation efficiency in the system (Transportation Research Board 2015). Previous studies have simulated the improvement of lock and dam systems on the UMR and found positive economic benefits to U.S. agricultural sector (e.g. Gervais et al., 2001; Fellin et al., 2001; Wilson et al., 2010). Alternatively, several studies investigated the economic impacts of impediments to barge transportation and suggest adverse economic consequences due to lock delay or failure (e.g. Fuller and Grant, 1993; Yu et al., 2006; Fellin et al., 2008). Researchers have also explored various potential strategies of lockage process management, such as scheduling, helper boats, among others, to mitigate delays on the UMR (e.g. Nauss and Ronen, 2004; Meyer and Kruse, 2007; Campbell et al., 2009).

Given the strong linkage between the UMR-IWW and U.S. food and farm products, it is important to have an updated evaluation on the economic impacts of the UWR-IWW navigability on the transport of agricultural commodities. This study examines the economic impacts of the UWR-IWW navigability on the U.S. corn and soybean stakeholders and transportation industry. Specifically we present an estimate of the net changes in economic surplus of the corn and soybean sector *ex ante* and *ex post* potential disruptions of two selected lock facilities on the UMR-IWW in the next decade. Changes in economic surplus of the corn and soybean sector consider a loss in profit by the producer and increased purchase costs incurred by the consumer resulting from increased transportation costs. The changes of grain flows and the shifts in transportation mode usages are also evaluated in the analysis. Departing from the aforementioned studies that typically isolated the revenue or cost changes in the grain and oilseed sector, this study extends the analysis by evaluating the consequent aggregate or macroeconomic impacts derived from economic surplus changes in selected agricultural commodity groups, along with mode shifts in agricultural transportation.

The main objectives of this study are to: (1) estimate the net changes in economic surplus of the corn and soybean sector given the changes in the navigability of UWR-IWW, (2) determine the resulting shift of corn and soybean movements across various modes of transportation, and (3) assess aggregate economic impacts, including: (a) regional industrial output (economic activity), (b) gross domestic product (GDP) (total value added and labor income), (c) employment resulting from changes in economic surplus in the corn and soybean sector, and (d) mode use in grain transportation.

APPROACH AND METHODOLOGY

Approach

The economic impacts of the navigability on the UMR-IWW were analyzed in two steps. First, a price-endogenous, spatial equilibrium, quadratic programming model of the international corn and soybean sectors (Fuller et al. 1993, Fuller et al. 2003, Attavanich et al. 2013) was employed to estimate changes in grain producer prices and revenues that would result from projected traffic interruptions and availability of given locks on the UMR-IWW system. The resulting changes in distribution of corn and soybeans and transport mode utilization were also determined under those scenarios. Second, aggregate regional and national economic impacts of waterway availability were estimated by applying an input-output model to the producer surplus, consumer surplus and mode usage output generated from the first step under each scenario.

The spatial equilibrium model output was initially validated with the 2010/11 supply and demand data from USDA's Economic Research Service (ERS, 2012a, 2012b). Rail and barge transportation costs for corn and soybeans across the nation were extracted from the public waybill data from Surface Transportation Board (2013) and USDA's Agricultural Marketing Service (AMS) ocean vessel rates to international destinations were provided by USDA/AMS. Motor carrier costs were derived from various issues of Grain Transportation Report in 2010/11 from USDA/AMS (2012). The spatial models was then applied to the corn and soybean supply and demand as forecasted for 2024/25 from USDA Agricultural Baseline Projections to generate price, economic surplus and transportation of corn and soybeans, which was considered as the b*aseline case*. Presumed disruptions were then introduced to selected locks on the UMR-IWW *independently* in the spatial model to generate economic surplus of the corn and soybean sector, also the changes in flows and usage of transport across mode. Aggregate economic impacts of the *ex ante* (i.e. baseline) and *ex post* lock and dam disruptions were then obtained from an input-output model. The estimated prices, revenues, and economic output were contrasted to isolate the impact of lock disruptions on the UMR-IWW.

Two locks were selected in the analysis to illustrate the economic impacts of navigability on the UMR-IWW: Lock 25 on the UMR and La Grange Lock on the Illinois River. Lock 25 and La Grange Lock are included in both a *Modernization* and a small-scale navigation improvement under NESP. Both 600-ft locks are located at the lower reach of the waterways and connected to the 1,200-ft Melvin Price Locks. The accumulated south-bound traffic from river elevators above, along with the north-bound traffic passing through the 1,200-ft Melvin Price Locks, contributes to long delays at these locks. The reliability and availability of these two locks are influential to the agricultural sector thus the economic impacts of the availability of these two

locks are of our main focus. Two scenarios related to at Lock 25 on the UMR, and two scenarios associated with La Grange Lock on the Illinois River were evaluated, including:

1. Closure of Lock 25 on the UMR for the fall quarter (September to November) in 2024/25 marketing year.
2. Closure of Lock 25 on the UMR for the whole year in 2024/25.
3. Closure of La Grange Lock on the Illinois River for the fall quarter in 2024/25.
4. Closure of La Grange Lock on the Illinois River for the whole year in 2024/25.

In the case of lock closure, it was assumed that no corn and soybeans can be moved through Lock 25 or La Grange Lock under different scenarios. Also, under each scenario, the potential reaction from rail industry was also considered since rail is the primary substitute for barge transport. The availability of rail capacity to handle diverted grain from the inland waterway and potential pressure on rail rate for corn and soybeans are unknown for the projected period (2024/25). Thus, three potential changes in rail rates based on Fellin et al. (2008) were incorporated in the *ex post* lock disruptions case: a) no change in rail rate [implying sufficient rail capacity], b) an increase of 5 percent, and c) an increase of 15 percent.

Certain assumptions were made in the determination of the projected regional excess supply and demand, including:

1. National corn and soybean demand were allocated to the crop reporting district (CRD) level based on projected feed, food, industrial and seed use.
2. The production and consumption patterns of corn and soybeans at the CRD level remained unchanged between 2010/11 (the data used for model validation) and 2024/25.
3. The relative relationship between barge, rail, truck and ship rates remained unchanged between 2010/11 and the baseline case in 2024/25.
4. Changes in mode use for grain transportation only affect the distribution of corn and soybeans in the 2024/25 period. The supply and demand outlook of corn and soybeans was exogenously determined by USDA's projection and not affected by waterway navigability in 2024/25.
5. River elevators on the UMR are closed above Lock 25 during the winter quarter to reflect river freezing.
6. Structure of the economy in aggregate economic analysis based on the most updated data (2013) in IMPLAN structure.

Grain Transportation Modeling

The International Grain Transportation Model (IGTM) is a price-endogenous, spatial equilibrium, quadratic programming model (Fellin et al. 2001, Fuller et al. 2003, Attavanich et al. 2013). Following Samuelson (1952) and Takayama and Judge (1971), the model maximizes the sum of producers' and consumers' surplus less the costs associated with transportation, storage, and grain handling activities. By solving the model, the price of agricultural commodities in the origin markets and destination markets and the transportation flows of those commodities will be determined. The mathematical programming model includes U.S. regional excess demands and supplies, transportation, storage and grain handling charges at the CRD level on a quarterly basis. Internationally, the country/region level supply and demand curves are used for foreign trading countries except for Canada and Mexico. The harvest quarter varies by country depending on hemisphere. Multiple modes of transportation are considered, including

truck, rail, barge, lake-vessel, and ocean-going ships. Transportation flows determined in the model depict the flows of grains and oilseeds to and from 303 U.S. domestic regions going through 42 U.S. intermediate shipping points and 118 international exporting and importing countries/regions. The structure and mathematical representation of the IGTM is available in Fellin et al. (2001) and Attavanich et al. (2013).

The IGTM includes 32 barge loading/unloading sites on the UMR (7), Illinois (3), Missouri (6), Arkansas (3), Ohio (4), lower Mississippi (5), Cumberland (1), White (1) and Tennessee (2) Rivers. The U.S. excess supply regions are also connected to port elevators on the Lower Mississippi, Texas Gulf, Atlantic, Pacific Northwest, and the Great Lakes via truck and rail. The destinations of the Great Lakes ports can only ship to Montreal in Canada, while the other export ports can deliver grain directly to international excess demand regions through ocean ships.

Economic Impacts Modeling

IMPLAN, an input-output model, was employed to analyze the interdependence of industries in an economy through market based transactions. The model describes the transfer of money between industries and institutions and contains both market-based and non-market financial flows, such as inter-institutional transfers. Output from the model includes the total industry output (TIO) (a measure of economic activity), value-added (TVA), labor income (a component of value-added), and employment for 536 industries in the study region's economy. Total industry output measures the annual dollar value of goods and services that an industry produces. Employment represents estimated number of wage and salary employees (both full- and part-time), as well as self-employed. Total value-added captures estimated employee compensation, proprietary income, other property type income (dividends, interests, rents, corporate profits, and capital depreciation), and tax on production and imports (all business taxes and fees paid to governments including sales and excise taxes). IMPLAN utilizes a National Trade Flows Model (NTFM) (doubly-constrained gravity model) to estimate a new set of regional purchase coefficients and other trade data that predict local purchases based on a region's characteristics. Not only can the model be used to describe a regional economy, but the model also can be used for predictive purposes, by providing estimates of multipliers. Multipliers measure the response of the economy to change in demand or production.

Three types of economy wide impacts were measured in this study: ***direct***, ***indirect*** and ***induced*** effects. The ***direct effects*** include the immediate effects related to the change in the demand for a particular industry, e.g. barge, rail. The ***indirect effects*** capture the secondary effects of production changes in the input supplying industries of the particular industry when inputs needs change due to the impact of the directly affected industry. The ***induced effects*** estimate the response by all local industries caused by increased expenditures of additional household income and inter-institutional transfers generated from the direct and indirect effects of the change in final demand for a specific industry, e.g. barge industry. ***Total effects*** are the sum of direct, indirect, and induced effects. The model constructs multipliers for economic activity (total industry output), employment, labor income, and total value added.

The economic impacts made for barge, rail, ocean freight, and truck utilization in this study were estimated as industry change impacts. The default values for the local purchase percentage (LPP) for barge, rail, water, and truck in each economic region were used in the analysis. For the

loss in profit by the producer and increased purchase costs incurred by the consumer resulting from increased transportation costs, the impacts were classified as changes in labor income and were assigned to Proprietor's Income. A LPP of 100 percent was assumed in the analysis for these expenditures. .

The CRD-level output from the spatial equilibrium model was aggregated into a regional level for the aggregate and national economic effect analysis. The contiguous is divided into a total of 10 regions, defined as Economic Regions in USDA's NASS (2015), including Northeast, Lake States, Corn Belt, Northern Plains, Appalachian, Southeast, Delta Southern Plains, Mountain, and Pacific (see Figure 1). The Corn Belt and Lake States are the major production area of corn and soybeans in the United States. The Mississippi and Illinois Rivers cover the Lake, Corn Belt and Delta regions. All economic output values are presented in 2015 dollars.

Figure 1 Map of Economic Regions Defined by USDA NASS

FINDINGS

Baseline: *Ex Ante* Disruptions on the UMR-IWW in 2024/25

Figure 2 presents corn and soybean ex ante exports at different ports or locations in 2024/25 marketing year on the UMR-IWW. Given the projected national demand and supply by USDA, more than 60 million metric tons (MT) of corn and soybeans are expected to enter international markets via ports at the Mexico Gulf. About 23 million MT of corn and soybeans are exported through Pacific Northwest (PNW) ports, while Mexico and Canada are expected to acquire more than 16 million MT of corn and soybeans from the U.S.

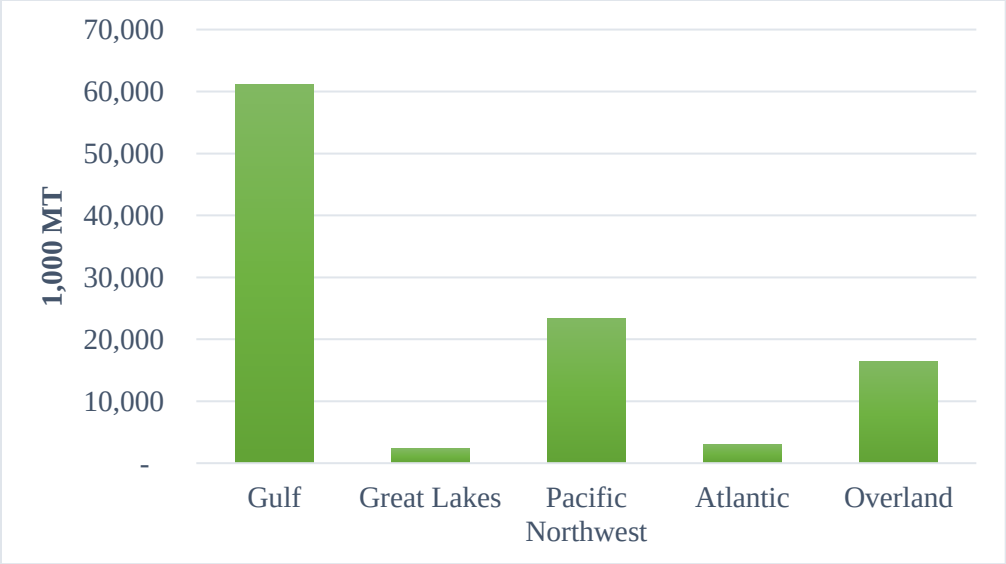

Figure 2 Estimated ex ante corn and soybean exports by ports and location in the baseline

The transport mode usage for corn and soybean shipment in 2024/25 *ex ante* lock disruption is plotted in Figure 3. The mode use includes both domestic and international (overland) transportation. The ton-miles in rail is the highest, more than 70 billion ton-miles, followed by barge transportation (nearly 50 billion ton-miles). Truck transportation for corn and soybeans is primarily for local markets or intermodal purpose.

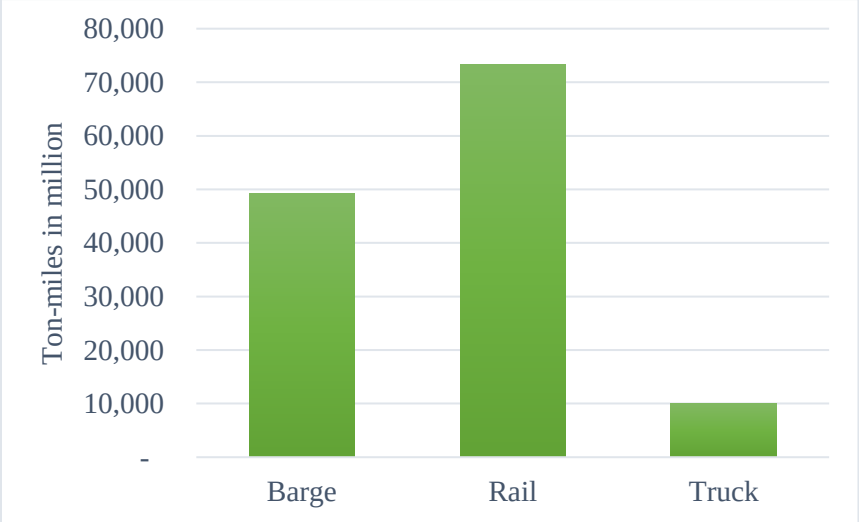

Figure 3 Estimated ex ante corn and soybean transportation by mode in the baseline

Figure 4 depicts total industry output (TIO), one indicator of economic impacts, associated with producer and consumer surplus in the corn and soybean sector by economic region. The major production region of corn and soybeans, i.e. the Corn Belt and Northern Plains regions, gains the most economic activity, reaching more than $70 billion in 2024/25.

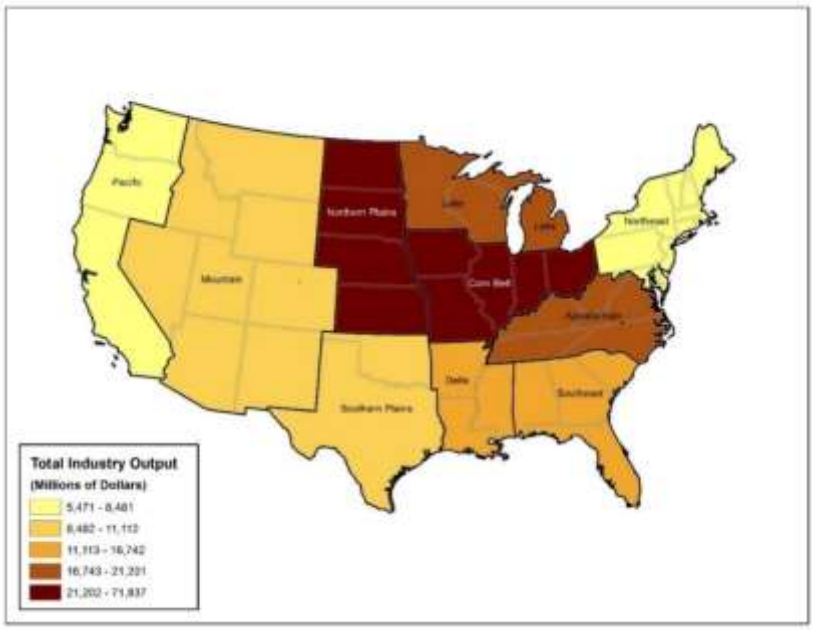

Figure 4 Total industrial output associated with economic surplus in the corn and soybean sector by economic region in 2024/25 marketing year

The TIO of grain movement across various transport modes in 2024/25 *ex ante* lock disruptions is presented in Figure 5. As the supply and demand of corn and soybeans is projected to expand in 2024/25, grain transportation increases accordingly. The TIO related to grain transport makes to $4.2 billion annually in the Corn Belt and Delta State regions.

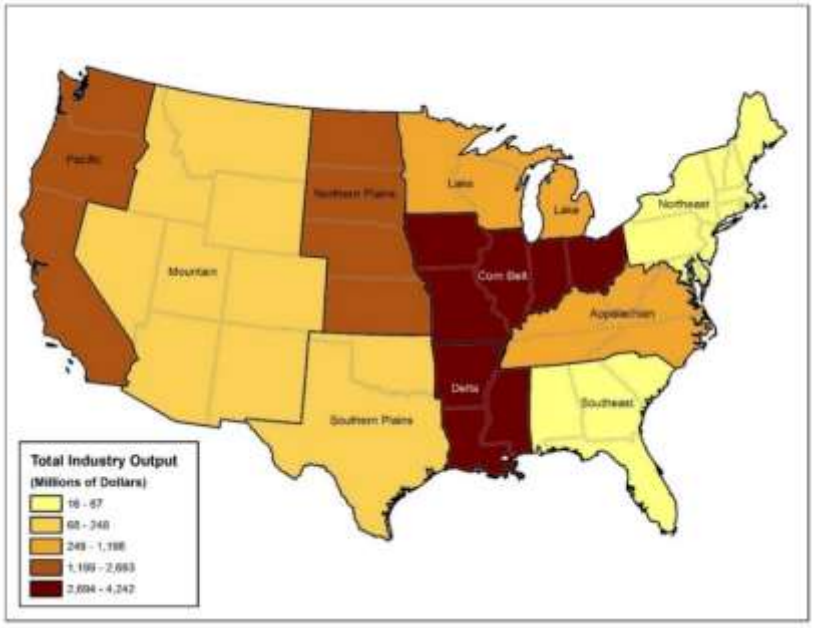

Figure 5 Total ex ante industrial output of grain transportation by region in 2024/25 marketing year

The national economic impact related to producer and consumer surplus in the corn and soybean sector, also corn and soybean transportation, in 2024/25 *ex ante* lock disruptions are summarized in Table 1. The economic surplus in the corn and soybean sector creates more than 828 thousand jobs and $135 billion in labor income. Also, TIO generated from the producer and consumer surplus of the corn and soybean sector reaches $265 billion in 2024/25. Expanding grain transportation activities create nearly 100,000 jobs in 2024/25, and aggregate labor income reaches to $6.5 billion annually. Annual TIO is projected to make more $24 billion considering direct, indirect and induced effects of increasing grain transportation.

Table 1 Total Economic Impact in 2024/25 *Ex Ante* Lock Disruptions

	Unit	Economic impact related to economic surplus in the corn and soybean sector	Economic impact related to corn and soybean transport
Employment	number	828,807	99,587
Labor income	$ million	134,871	6,534
Value added (TVA)	$ million	188,806	11,343
Industrial output (TIO)	$ million	265,324	24,238

Effect of Lock Closure on Corn and Soybean Flows and Mode Use in 2024/25

A total of 12 lock disruption/closure scenarios are analyzed, including a combination of two locks (Lock 25 and La Grange Lock; separately), two lock closure time horizons (fall quarter and one year), and three variations in rail rates (0 percent, +5 percent and +15 percent). Figure 6 illustrates changes in grain exports at ports *ex post* closure at Lock 25 on the UMR for the fall quarter (September through November) only and whole market year in 2024/25 assuming rail rates do not change. Apparently, corn and soybeans exports from Gulf ports decline up to 5 million MT (or 9 percent decrease) due to Lock 25 closure in the fall. The reduction in exports at Gulf ports increases up to nearly 8 million MT (13 percent reduction) when the closing horizon extends to the whole marketing year. The PNW ports become the top route of U.S. corn and soybeans to reach international markets. In addition, quantities of corn and soybeans sent to Atlantic Coast ports from the eastern Corn Belt increase nearly 2 million MT when lock closure extends to a year.

The consequent mode shift for grain transport under this particular scenario is presented in Figure 7. When Lock 25 is closed during the harvest season and rail rates remain unchanged, barge traffic drops by more than 20 billion ton-miles, nearly 40 percent reduction compared to the baseline level. Barge traffic declines further if closing horizon extends to a year, while rail industry receives most diverted shipment if rail rates remain stable.

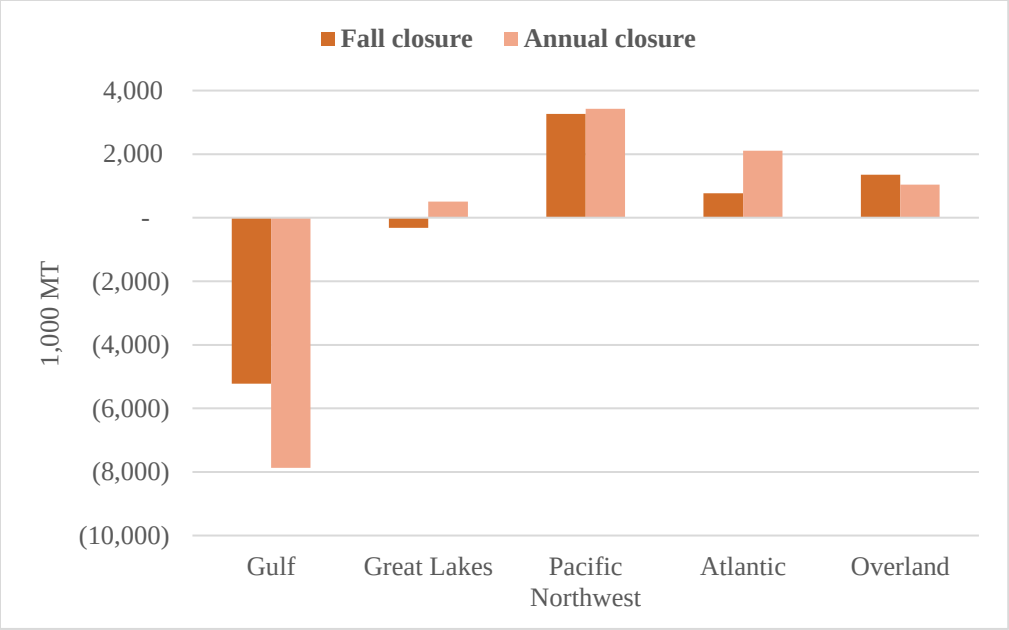

Figure 6 Estimated changes in corn and soybean exports by ports and location when Lock 25 is closed and rail rates remain unchanged

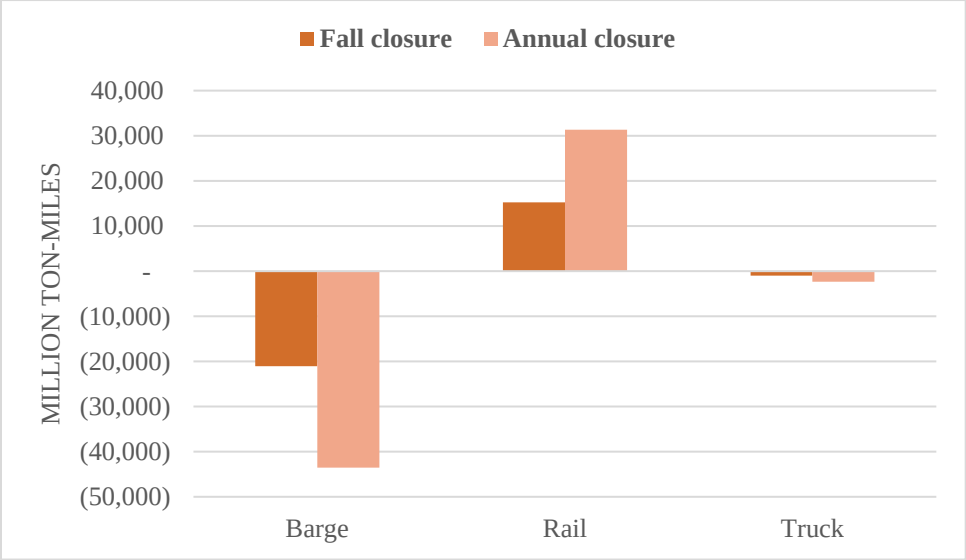

Figure 7 Changes in mode use for corn and soybean transportation when Lock 25 is closed and rail rates remain unchanged

The complete summary of changes in grain flows to port area compared to *ex ante* lock disruptions in 2024/25 for all scenarios is presented in Table 2. Compared to the level *ex ante* lock closure, less corn and soybeans will be exported to Canada/Mexico markets if Lock 25 is closed in the harvest season of 2024/25 but rail rates increase in the fall quarter. More corn and soybeans are exported through PNW ports during the winter season when the UMR is frozen and rail rates return to the lower level. Shipments of corn and soybeans to Great Lakes ports from Illinois and Minnesota also increase. When the closure of Lock 25 is extended to the whole

marketing year, and rail rates increased by 5 percent over this timeframe , a smaller increase in corn and soybean exports in the PNW ports and Canada/Mexico markets. Corn and soybean exports at Atlantic Coast ports and Great Lakes ports eventually gained the most when rail rates increased by 15 percent throughout the year.

Similar pattern is also observed when La Grange Lock is not accessible for the fall quarter except for a relatively smaller reduction (5 percent) in export levels at Gulf ports. Corn and soybean exports at Gulf ports reduce when La Grange Lock is not accessible for the whole year in 2024/25. Exports to Canada/Mexico and PNW ports increase when rail rates remain unaffected. However, when rail rates increase, increasing shipments of corn and soybeans is sent to Ohio River barge loading facilities in the lower reach of that river. Thus, grain exports at Gulf ports increase by 2.3 million tons when rail rates are up by 15 percent for the whole year, while exports through PNW ports and Canada/Mexico are lowered compared to the level *ex ante* lock closure (Table 2).

The impact of lock closure on grain transport by mode in all scenarios is summarized in Table 3. Corn and soybean transportation by barge reduce considerably on the UMR-IWW. The exception is for the scenario of La Grange lock closure for one year assuming rail rate increases by 15 percent over the same period, which is due to corn and soybean shipments from Illinois to the loading facilities on the lower reach of Ohio River. Closing Lock 25 for a year and assuming no rail rate change cause the most reduction in volume of barge transportation, more than 43.5 million ton-miles (Table 3). As expected, rail transportation is the primary substitute for barge.

Table 2 Changes in Corn and Soybean flows to Port Area under 12 Scenarios (thousand tons)

Lock Closure	Gulf	Great Lakes	Pacific Northwest	Atlantic	Overland
Fall closure with 0% rail rate increase					
Lock 25	(5,225)	(322)	3,268	772	1,357
LaGrange	(4,541)	(129)	2,428	795	1,357
Fall closure with 5% rail rate increase					
Lock 25	(5,273)	171	5,057	831	(1,166)
LaGrange	(2,556)	(99)	3,279	759	(1,519)
Fall closure with 15% rail rate increase					
Lock 25	(4,776)	235	7,612	487	(3,863)
LaGrange	(1,191)	235	3,984	405	(3,790)
Annual closure with 0% rail rate increase					
Lock 25	(7,865)	508	3,429	2,107	1,038
LaGrange	(3,477)	26	1,071	953	1,341
Annual closure with 5% rail rate increase					
Lock 25	(5,775)	724	1,559	1,631	839
LaGrange	224	235	(1,269)	829	(509)
Annual closure with 15% rail rate increase					
Lock 25	(2,497)	1,124	(2,574)	2,380	(122)
LaGrange	2,324	520	(2,822)	474	(1,171)

Note: number in parenthesis indicates negative value

Table 3 Changes in Grain Transportation (million ton-miles) by Mode under 12 Scenarios

Lock	Truck	Rail	Barge
Fall closure with 0% rail rate increase			
Lock 25	(986)	15,277	(21,087)
LaGrange	(822)	9,988	(14,770)
Fall closure with 5% rail rate increase			
Lock 25	(865)	16,372	(19,319)
LaGrange	(766)	12,031	(13,652)
Fall closure with 15% rail rate increase			
Lock 25	(337)	15,942	(15,009)
LaGrange	215	5,507	(2,907)
Annual closure with 0% rail rate increase			
Lock 25	(2,361)	31,355	(43,502)
LaGrange	(1,213)	13,829	(20,362)
Annual closure with 5% rail rate increase			
Lock 25	(1,370)	27,685	(41,661)
LaGrange	(108)	5,725	(10,869)
Annual closure with 15% rail rate increase			
Lock 25	(78)	21,494	(39,287)
LaGrange	1,582	(5,115)	1,076

Note: number in parenthesis indicates negative value

Table 4 presents the estimated economic impacts related to mode use change in corn and soybean transport for all scenarios. Detailed economic impacts of grain transportation by mode in each economic region can be found at the link (http://economics.ag.utk.edu/publications/logistics/ModeUse_EconImpacts.pdf). In a national level, compared to the baseline (*ex ante* lock closure), economic output associated with grain transportation decreases when Lock 25 is not available during the harvest season and rail rate remain unchanged Reduction in barge and truck transportation for corn and soybeans causes negative economic effects while positive economic effects occur from increasing rail traffic (See Table 5). For instance, closing Lock 25 in the fall quarter results in an estimated decline of $933 million and $234 million in TIO annually from barge industry and truck industry, respectively, compared to the baseline in 2024/25. When rail rates are adjusted higher (5 percent or 15 percent), economic output of rail transportation for corn and soybeans surpass the loss of economic output of barge and truck transportation given a higher charge of rail transportation. The overall positive economic effects resulting from mode shift for corn and soybean production is enlarged when lock closing time extend, due to more expensive rail services. The strong economic impact associated with the rail industry is based on the assumption that rail industry adjusts the rail rates for all routes for corn and soybean shipment since previous study suggests that rail rates for grain are generally co-moved/correlated in the market (Fellin et al 2008). In addition, this study does not consider the potential constrains of rail service availability.

Table 4 Changes in Economic impacts of Grain Transportation under 12 Scenarios

Lock	Employment (number)	Labor Income ($1,000)	TVA ($1,000)	TIO ($1,000)
Fall closure with 0% rail rate increase				
Lock 25	(989)	(4,296)	(3,940)	(285,776)
LaGrange	(429)	15,596	35,520	(101,695)
Fall closure with 5% rail rate increase				
Lock 25	230	71,661	130,116	28,651
LaGrange	1,337	128,615	237,406	365,409
Fall closure with 15% rail rate increase				
Lock 25	1,374	133,849	231,581	282,374
LaGrange	3,195	215,239	381,334	817,385
Annual closure with 0% rail rate increase				
Lock 25	(317)	114,895	233,152	(23,632)
LaGrange	(589)	22,129	53,115	(121,693)
Annual closure with 5% rail rate increase				
Lock 25	2,599	296,022	528,371	582,500
LaGrange	2,430	187,544	329,048	581,800
Annual closure with 15% rail rate increase				
Lock 25	8,275	660,410	1,139,455	1,844,261
LaGrange	7,325	474,598	805,209	1,677,830

Note: number in parenthesis indicates negative value

Table 5 Changes in Total Industry Output ($1,000) of Grain Transportation by Mode

Lock	Truck	Rail	Barge
Fall closure with 0% rail rate increase			
Lock 25	(233,930)	1,391,453	(933,291)
LaGrange	(212,860)	982,486	(509,252)
Fall closure with 5% rail rate increase			
Lock 25	(209,232)	1,388,437	(793,882)
LaGrange	(207,717)	1,032,270	(454,836)
Fall closure with 15% rail rate increase			
Lock 25	(85,080)	1,230,704	(575,787)
LaGrange	189	383,216	170,162
Annual closure with 0% rail rate increase			
Lock 25	(698,866)	3,080,807	(1,967,318)
LaGrange	(321,255)	1,339,963	(840,880)
Annual closure with 5% rail rate increase			
Lock 25	(425,444)	3,266,980	(1,871,284)
LaGrange	(48,843)	906,473	(299,985)
Annual closure with 15% rail rate increase			
Lock 25	(66,568)	3,792,847	(1,731,096)
LaGrange	371,817	710,475	2,747,271

Note: number in parenthesis indicates negative value

Effect of Lock Closure on Corn and Soybean Producer and Consumer Surplus in 2024/25

Lock closures divert corn and soybeans shipments from the generally more economical barge transportation to a more expensive rail service, resulting in higher transportation costs and lower producer price and revenue. For instance, when Lock 25 is closed during harvest season from September to November and rail rates remain unchanged, corn and soybean prices in Illinois, Iowa and Minnesota regions adjacent to the UMR decrease up to $4.89/mt ($0.13/bu) and $8.25/mt ($0.22/bu), respectively. When the horizon of lock closure extends to one year, corn prices in the regions next to the river decrease $6.61/mt ($0.17/bu) and the soybean prices decline up to $10.81/mt ($0.29/bu) if rail rates remain steady. The producer prices of corn and soybeans drop further when rail rates increase and Lock 25 is inaccessible for a year: prices reduce up to $8.15/mt ($0.21/bu) for corn and $16.33/mt ($0.44/bu) for soybeans. Producer prices reduction varies across region subject to the availability of alternative routes and modes to markets. Similar pattern is also observed when La Grange Lock becomes unavailable.

Table 6 summarizes the net economic surplus of the corn and soybean sector. Annual economic surplus in U.S. corn and soybean sector decline about $171 million with a fall closure of Lock 25 on the UMR assuming rail rates remain the same when compared to the level in the baseline. Similarly, La Grange Lock closure in the harvest season causes a reduction of $135 million annually. Transport costs are even higher when rail rates increase, thus enlarging the reduction of producer surplus in the corn and soybean sector. As expected, total economic surplus decline further by $356 million per year from Lock 25 inaccessibility and $301 million from La Grange Lock closure. Extending the time horizon of closure to one year create more producer surplus loss and a considerable drop in economic surplus by $549 million (La Grange) and $747 million (Lock 25) annually, in the scenario of rail rate up by 15 percent (Table6).

Table 6 Changes in Economic Surplus under 12 Scenarios

Lock	Producer + Consumer Surplus ($1,000)	
	Fall closure with 0% rail rate increase	**Annual closure with 0% rail rate increase**
Lock 25	(170,504)	(206,810)
LaGrange	(135,681)	(140,023)
	Fall closure with 5% rail rate increase	**Annual closure with 5% rail rate increase**
Lock 25	(257,175)	(427,651)
LaGrange	(208,279)	(280,613)
	Fall closure with 15% rail rate increase	**Annual closure with 15% rail rate increase**
Lock 25	(356,461)	(746,680)
LaGrange	(301,451)	(549,422)

Note: number in parenthesis indicates negative value

The direct and induced effects of producer and consumer surplus in the corn and soybean sector under the 12 scenarios are contrasted with that from the baseline in 2024/25. Table 7 shows the summary of deviation of U.S. annual economic effect associated with the corn and soybean sector from the *ex ante* lock closure case. An estimated reduction of more than 3,000 jobs, half a million of labor income, $800 million of TVA, and over one billion dollars of economic activity is related to economic surplus change in the corn and soybean sector when Lock 25 is

inaccessible during harvest season and a 15% rise in rail rates. When lock closure extends to a year and a 15 percent increase in rail rate, more than 7,000 jobs and $1.3 billion of employment income, and about $2.4 billion economic activity decrease from the baseline level. Similarly, closing La Grange Lock for one year with an elevated rate (15 percent) also causes a reduction in negative economic impacts on economic surplus in the corn and soybean sector. The reduction totals 5,500 jobs, $900 million employment income, and $1.8 billion of total industry output.

Table 7 Changes in Economic Effect of Producer and Consumer Surplus under 12 Scenarios

Lock	Employment (number)	Labor Income ($1,000)	TVA ($1,000)	TIO ($1,000)
Fall closure with 0% rail rate increase				
Lock 25	(1,722)	(280,179)	(392,225)	(551,182)
LaGrange	(1,443)	(234,746)	(328,622)	(461,803)
Fall closure with 5% rail rate increase				
Lock 25	(2,563)	(417,128)	(583,941)	(820,595)
LaGrange	(2,150)	(349,787)	(489,670)	(688,118)
Fall closure with 15% rail rate increase				
Lock 25	(3,546)	(577,068)	(807,842)	(1,135,236)
LaGrange	(3,029)	(492,951)	(690,086)	(969,758)
Annual closure with 0% rail rate increase				
Lock 25	(2,112)	(343,734)	(481,195)	(676,210)
LaGrange	(1,511)	(245,877)	(344,206)	(483,702)
Annual closure with 5% rail rate increase				
Lock 25	(4,282)	(696,767)	(975,410)	(1,370,714)
LaGrange	(2,872)	(467,364)	(654,267)	(919,422)
Annual closure with 15% rail rate increase				
Lock 25	(7,430)	(1,209,090)	(1,692,616)	(2,378,582)
LaGrange	(5,478)	(891,385)	(1,247,858)	(1,753,577)

Note: number in parenthesis indicates negative value

Figure 8 presents the changes in economic activity related to the corn and soybean sector across the 10 economic regions when Lock 25 becomes unavailable for the fall quarter. It is apparently the corn and soybean production states in the Corn Belt region suffered the most reduction, a decrease of $350 million annually if rail rates remain unaffected, followed by the states in the Lake Region and Northern Plains Region. Reduction of economic activity grows when rail rates are raised. Similar pattern is also presented in the closure of La Grange Lock.

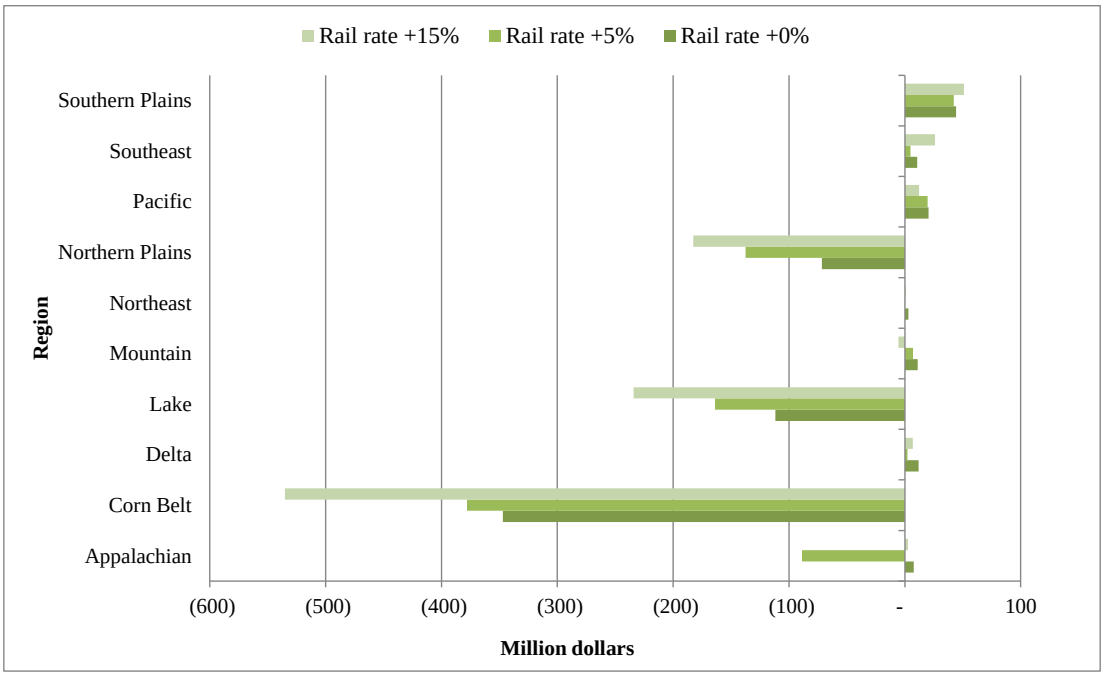

Figure 8 Changes in total industrial output related to the corn and soybean sector by region

Table 8 summarizes the net economic impacts of lock closures, combining the economic impacts related to transport mode use and economic surplus in the corn and soybean sector. In general, closing either Lock 25 or La Grange Lock causes negative net impacts on jobs, labor income, TVA and TIO. The relative magnitude of impacts among 12 scenarios may not be intuitive since it includes the negative impact associated with loss in profit by the corn and soybean producers and increased purchase costs incurred by the consumer resulting from increased transportation costs, as well as declining barge business, and the positive economic impacts related to increases in rail services. For instance, job number drops the most when Lock 25 is closed and no increase in rail rates. However, job loss is improved when rail rates move up and associated positive induced effect to the economy. Also, economic surplus is loss in the corn and soybean sector and rail industry revenue gains generate a mixed impact on TIO when lock 25 is closed.

Table 8: Net Economic Impact Resulting from Lock Closures

			Employment	Labor Income	TVA	TIO
Lock	Length of closure	Rail rate increase (%)	number	$1,000		
Lock 25	3 months	0	(2,711)	(284,475)	(396,165)	(836,958)
		5	(2,333)	(345,467)	(453,825)	(791,944)
		15	(2,172)	(443,219)	(576,261)	(852,862)
	one year	0	(2,429)	(228,839)	(248,043)	(699,842)
		5	(1,683)	(400,745)	(447,039)	(788,214)
		15	845	(548,680)	(553,161)	(534,321)
La Grange Lock	3 months	0	(1,872)	(219,150)	(293,102)	(563,498)
		5	(813)	(221,172)	(252,264)	(322,709)
		15	166	(277,712)	(308,752)	(152,373)
	one year	0	(2,100)	(223,748)	(291,091)	(605,395)
		5	(442)	(279,820)	(325,219)	(337,622)
		15	1,847	(416,787)	(442,649)	(75,747)

Note: number in parenthesis indicates negative value

CONCLUSIONS

The Upper Mississippi River and Illinois Waterway (UMR-IWW) is a primary corridor for bulk commodities in the United States. Food and farm products are the major commodities transported on the UMR-IWW. Central to navigation on the UMR-IWW are 36 locks and dams (28 on the UMR and 8 on the Illinois River) that maintain a 9-foot channel for barge transportation. This lock and dam system was primarily built in the 1930s and the capacity of most lock chambers are not able to handle a tow with 15 hopper barges on these waterways in a single lockage. Concerns about the navigational efficiency of these aging and constrained transport waterways have been frequently raised. Congress authorized the Navigation and Ecosystem Sustainability Program (NESP) in 2007 to address the capacity constraints on the most congested segment on these waterways. NESP requests the new construction of 1,200-ft locks at Locks and Dams 20, 21, 22, 24 and 25 on the UMR and Lock Peoria and La Grange on the Illinois River, along with other smaller scale navigation projects on other locks and dams, to improve the capacity also restore the ecosystems on these waterways. However, the implementation of NESP has been delayed due to limiting funding and other issues.

This study examines the economic impacts of UWR-IWW navigability on the U.S. corn and soybean stakeholders and transportation industry. Specifically we estimate the net changes in economic surplus of corn and soybean sector, along with shifts in transport mode use for grain flows due to the *t* potential disruptions of lock and dam system on the UMR-IWW in 2024/25. The selected lock and dam includes Lock 25 on the UMR and La Grange Lock on the Illinois River. A price-endogenous, spatial equilibrium, quadratic programming model of the international corn and soybean sector and an input-output model are used to estimate prices,

economic surplus, and economic impacts. The outputs of ex ante and ex post lock closure are contrasted to isolate the impact of lock disruptions on the UMR-IWW.

Results suggest that corn and soybean exports at Gulf ports reduce about 5 million MT when Lock 25 became inaccessible during the harvest season in 2024/25. The reduction increases up to nearly 8 million tons if the lock is closed for the whole year. Disruptions in the fall quarter result in an estimated decline of $509 million at La Grange and $933 million at Lock 25 per year in aggregate economic activity related to grain barge transportation if the rail rate does not change.

The reduction for Lock 25 reaches to nearly $2 billion if the lock is unavailable for a whole year if rail rate increases 15 percent. However, positive economic output of rail transport from increasing corn and soybean shipment surpasses the loss of economic output of barge and truck transportation when rail rates are lifted. In addition, producer and consumer surplus of the corn and soybean sector decline between $171 million (with no change in rail rate) and $747 million (with 15 percent increase in rail rate) annually when Lock 25 is not accessible.

If rail rate increases 15 percent, closing La Grange Lock could also lead up to $549 million loss in economic surplus of corn and soybean sector annually. Moreover, decline in producer and consumer surplus in the corn and soybean sector due to Lock 25 annual closure could cause a decrease of more than 7,000 jobs, $1.3 billion of employment income, and about $2.4 billion of total industry output per year, assuming a 15 percent increase in rail rate.

Similarly, closing La Grange Lock for one year, along with a 15 percent increase in rail rate, could result in a reduction of 5,478 jobs, $891 million employment income, and $1.8 billion of total industry output annually. Generally, closing Lock 25 or La Grange Lock on the UMR-IWW results in a net loss in job, labor income, total value added, and total industry output in the U.S. economy.

In summary, the Upper Mississippi River and Illinois Waterway are important transport arteries for U.S. corn and soybean sector and national economy. It is crucial to maintain the navigability of the UMR-IWW systems for U.S. food and farm products. Federal agencies and industrial groups should work closely to expedite implementation of the NESP in the near future.

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