PROCEEDINGS OF THE 40TH ANNUAL MEETING OF THE TRANSPORTATION RESEARCH FORUM

Philadelphia, Pennsylvania
October 29-31, 1998

Volume 1

Wilks
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Welcome to the Transportation Research Forum's 1998 Annual Meeting

These proceedings contain those papers presented at the 40th Annual Meeting of the Transportation Research Forum, held in Philadelphia from October 29-31, 1998, that were received by the deadline publishing date. All papers were reviewed by the Program Vice President to assess their suitability for inclusion in these volumes. Additional papers may be made available by some of the presenters at the time of the Conference.

The Transportation Research Forum (TRF) is an independent organization of transportation professionals providing pertinent and timely information to those who conduct research and those who use and benefit from research. It functions as an impartial meeting ground for carriers, shippers, government officials, consultants, university researchers, suppliers, and others seeking an exchange of information and ideas related to both passenger and freight transportation. The Transportation Research Forum started with a small group of transportation researchers in New York in 1958 and the first national meeting was held in St. Louis in 1960. National meetings have been held annually since 1960 at various cities throughout the U.S. and Canada.

Numerous TRF members and supporters aided in the development of this year's Forum, but it is authors of the papers, the organizers and contributors to the various panels, and the session chairs who make TRF annual meetings so worthwhile and enjoyable. The conference program simply reflects the interests, enthusiasm and commitment of those members of the transportation community. Special thanks go to Patrick and Judy Little who graciously agreed to assemble this year's proceedings for me. Without their help, the job of Program Chair would have been much more of a burden.

A number of other TRF members also assisted in the development of this meeting. Randy Resor and Jim Blaze were constant sources of ideas and encouragement. When help was asked for, they came through repeatedly. Other TRF members provided help with the program in their areas of interest. I want to thank Alan Bender, Michael Belzer, Ken Ericksen, Paul Gessner, Harold Kurzman, Scott Ornstein, Clint Oster, and Peter Smith for their help. Claire LaVaye at the University of Texas assisted with promoting the meeting on TRF's website. Finally, Rick Guggolz provided valuable assistance on the businees arrangements for the conference.

We are also grateful to those companies and organizations who have sponsored awards or made other contributions to the success of the Forum. These include: LTK Engineering, The Metropolitan Transit Association, and RailTex. Among our own members, we are especially indebted to the TRF Foundation, the Cost Analysis Chapter and the Aviation Chapter for their assistance and support.

These proceedings are prepared and distributed at the TRF Annual Forum as a means of disseminating information and stimulating an exchange of ideas during the meeting. Every effort has been made to reproduce these papers accurately. TRF, however, assumes no responsibility for the content of the papers contained in these volumes.

Richard Golaszewski
Program Vice President
October, 1998

An Analysis of the Grain Transportation Capacity of the Upper Mississippi and Illinois Rivers

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Abstract

A recent study indicates the demand for transportation on the upper Mississippi and Illinois Rivers will nearly double by 2050. Inadequate trust fund resources to rehabilitate and expand locks in combination with the backlog of structures which require attention has generated concern regarding future transportation. Agricultural interests in the Midwest are particularly concerned regarding the upper Mississippi and Illinois Rivers since these arteries originate and carry about one-half of U.S. corn exports and one-third of U.S. soybean exports to lower Mississippi River ports. Spatial models of the international corn and soybean sectors in combination with an estimated lock delay equation are used to explore the implications of increased traffic levels on these Rivers. Results show increasing quantities of corn/soybeans diverted from the upper Mississippi River as traffic levels, congestion, tow delay, and ultimately barge costs increase. If traffic levels were to increase 50 percent, about 30 percent of the corn would be diverted from the upper Mississippi and a doubling of traffic would divert about 58 percent of the corn. Supply regions at comparatively distant locations from the River would initially divert, whereas sites near the River would not be diverted at any traffic level. Regional corn/soybean prices and revenues declined as traffic levels and barge costs increased; based on current production levels and prices, a 50 percent increase in traffic would reduce annual producer revenues $45 million and a 100 percent increase in traffic would lower annual revenues $97 million. In summary, the projected doubling in demand for waterway transportation on the upper Mississippi and Illinois Rivers will have an important influence on tow delay and barging costs. It seems unlikely that the analyzed Rivers would carry the projected increase in tonnage since economic forces would divert much of this traffic prior to reaching the projected traffic level.

Summary

Spatial, intertemporal models of the international corn and soybean sectors in combination with an estimated lock delay equation and a barge cost model are used to explore the implications of projected increases in traffic levels on upper Mississippi and Illinois Rivers. Results show increasing quantities of corn/soybeans diverted from the upper Mississippi River as traffic levels, congestion, tow delay, and ultimately barge costs increase. If traffic levels were to increase 50 percent, about 30 percent of the corn would be diverted from the upper Mississippi and a doubling of traffic would divert about 58 percent of the corn. As expected, regional corn/soybean prices and revenues declined as traffic levels and barge costs increased. It seems unlikely that the Rivers would carry the projected increase in tonnage since economic forces would divert much of this traffic prior to reaching the projected traffic level.

An Analysis of the Grain Transportation Capacity of the Upper Mississippi and Illinois Rivers

The inland waterways are important transportation arteries for many commodities and products. Unfortunately, nearly half of the lock chambers in the inland waterway system are over fifty years of age and in need of rehabilitation or expansion. Trust fund resources are not adequate to rehabilitate or expand all locks, thus concern regarding the growing backlog of structures that require attention and the implication of this for future transportation (Bronzini, 1997). Of concern to agricultural interests in the Midwest are the upper Mississippi and Illinois Rivers which are central to the transportation of corn/soybean exports to lower Mississippi River ports (Kerkhoff, 1996). The upper Mississippi and Illinois waterways include 40 lock chambers whose average age is about 57 years. It is estimated that states bordering these Rivers (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) ship over 90 percent of their export-destined corn/soybeans to the lower Mississippi River port area and about 95 percent of these shipments are transported via these two Rivers (Larson, Smith, and Baldwin (1990), Fruin, Halbach, and Hill (1990)). Further, about one-half of U.S. corn exports and one-third of U.S. soybean exports originate on these two waterways.

A recent study commissioned by the U.S. Army Corps of Engineers, Institute for Water Resources projects traffic on the upper Mississippi and Illinois Rivers to increase about 90 and 86 percent, respectively, by 2050 (Jack Faucett Associates, 1997). Further, it estimates grain/soybean traffic as a share of all traffic to increase from 48 to 61 percent on the upper Mississippi and from 36 to 50 percent on the Illinois River. In view of the substantial delay that now exists at selected locks on these waterways, agricultural interests have expressed concern regarding the projected increase in waterway traffic and its implication for congestion, lock delay and ultimately barge rates on these important transportation arteries. The objective of this study is to estimate how projected increases in traffic on the upper Mississippi and Illinois Rivers will affect the cost of barge transportation, producer prices and revenues, and flow patterns. The analysis is accomplished with an estimated lock delay equation and spatial, intertemporal equilibrium models of the international corn and soybean sectors.

Background

The upper Mississippi River includes 28 lock sites and 32 lock chambers while the Illinois Waterway is comprised of eight lock sites and chambers (Figure 1). Nearly all locks and dams on the upper Mississippi and Illinois Rivers were constructed during the 1930's, the exceptions include lock 19, the Melvin Price and lock 27. Lock chambers at most newer facilities are 110 feet wide and 1200 feet in length and are ideal for handling tows made up of jumbo hopper barges (35' x 195') that are three barges wide and four or five barges in length. Because chambers at most remaining locks are 600 feet in length, virtually all tows must be double locked. Break-up and reassembly of the tow plus the two lockage operations require about an hour and a half whereas lockage at a 1200 foot chamber involves a single operation that is accomplished in 20 to 30 minutes. Further, as tonnage moving on the river system has increased over time, tows have experienced an increase in delay. Since operating costs of a tow boat range from $400 to $500 per hour, double lockages and delay impose a cost on operators that add to the shipper's transportation cost (U.S. Army Corps of Engineers, 1992a).

Greatest average delay is associated with those locks on the lower portion of the upper Mississippi; this is expected since these facilities handle comparatively large tonnages and their short chambers (600 foot) require double lockage of most tows. Based on annual lock performance statistics collected by the U.S. Army Corps of Engineers during 1991 through 1995, highest average delay per locked tow was at locks 22, 24, and 25, where average delay per tow ranged between three and four hours. Average delay at locks 17, 18, and 20 were comparatively high with average delay per locked tow ranging from two to three hours. Locks 14, 15, 16, and 21 had average delay per tow ranging from one to two hours as did all locks on the Illinois River except the T. J. O'Brien in Chicago, Illinois (U.S. Army Corps of Engineers, 1992b, 1993, 1994a 1994b, 1995).

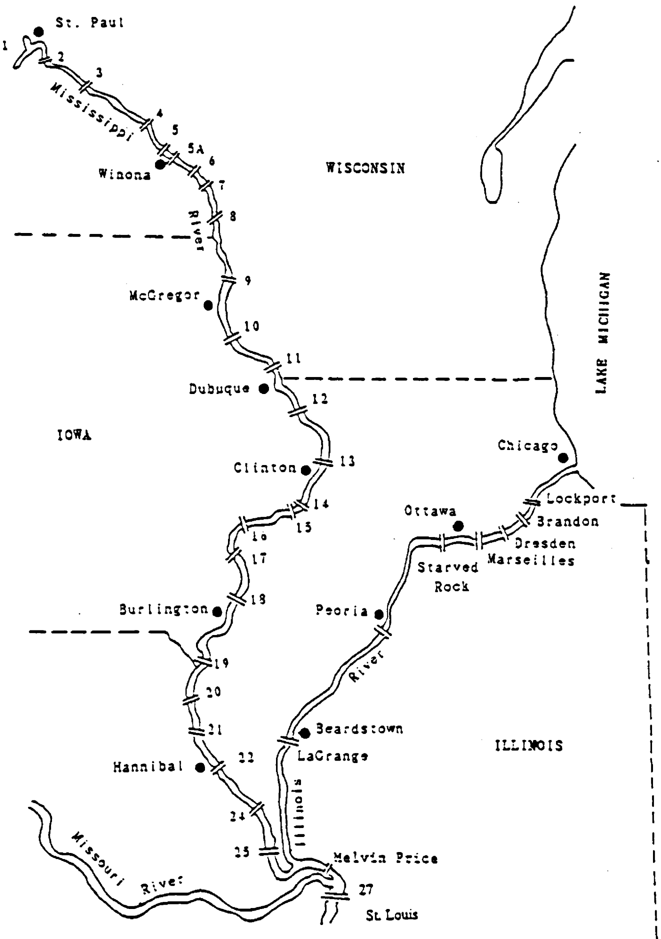
Procedures, Model and Data

Research was carried out in three phases. Initially, efforts were made to estimate the effect of increased traffic levels on tow delay for each lock on the upper Mississippi and Illinois Rivers. This was accomplished by adjusting traffic levels upward 25, 50, 75, 100, 125, and 150 percent over the average of the 1991-1995 level and then estimating the associated average delay at each lock with a regression equation that relates average delay per tow as a function of utilized lock capacity. Then, the estimated average delay per tow for each lock was entered into a barge cost model and the cost of barge transportation estimated for corn/soybeans that entered the Rivers at various sites. Finally, the estimated barge costs were entered into spatial equilibrium models of the international corn and soybean sectors and the models solved to determine the affect on flow patterns and producer prices and revenues.

Estimated Lock Delay Equation and Barge Costs

A variety of forces affect tow delay at locks, however, *The 1992 Inland Waterway Review* indicates the most important long-run factor affecting lock delay is portion of lock capacity which is utilized. Further, the *Review* indicates lock delay increases exponentially as a lock

Figure 1. Upper Mississippi and Illinois Rivers



approaches capacity. To develop insight on the relationship between tow delay and utilization of lock capacity, a regression equation was estimated that was based on the 1991-1995 annual lock performance monitoring system data for 23 upper Mississippi locks whose chambers were 600 feet in length. The specified equation included average annual delay per locked tow as the dependent variable and portion of lock capacity utilized as the independent variable. Portion of lock capacity utilized was based on estimates of annual lock capacity presented in *The 1992 Inland Waterway Review.* The specified equation assumed tow delay increased exponentially as lock utilization increased. The following estimated lock delay equation was obtained with generalized least-squares; t-ratios are shown in parenthesis.

$$\text{Average Delay per Tow} = \underset{(-12.430)}{-4.348} + \underset{(14.010)}{3.543} \text{ Exp (Caputd)}$$

R-Square = .9034 N = 115

where,

Average Delay per Tow is in hours, and
Caputd = portion of lock capacity utilized.

Barge transportation costs from selected barge loading sites on the upper Mississippi and Illinois Rivers to lower Mississippi River ports were estimated for 25, 50, 75, 100, 125, and 150 percent increases in River traffic with the tow delay equation, annual lock capacity information and a barge costing model. Estimates of tow delay were obtained for each lock at the six traffic levels; these estimates were subsequently included in the barge cost model for purposes of estimating the cost of barging grain from selected barge-loading sites to the lower Mississippi River ports. To provide a benchmark, barge transportation costs that reflect recent historical traffic levels are shown; these are referred to as "base"estimates in Table 1.

Spatial Equilibrium Models and Data

Spatial equilibrium models of the international corn and soybean sectors are used in combination with the estimated barge costs to evaluate the effect of congestion, lock delay, and higher barge costs on grain flows, and producer prices and revenues. The spatial models include regional corn/soybean demands and supplies and transportation rates and costs representative of the 1992-1994 period, whereas estimated barge costs reflect the heightened congestion and delay associated with the 25, 50, 75, 100, 125, and 150 percent increase in traffic. Thus, results measure rerouted flows, and prices and revenues that would result if the anticipated congestion, delay and associated barge costs were imposed on the current production, marketing and transportation industries. The effect of increased congestion and lock delay are measured by contrasting model solutions representative of current lock delay patterns (base solution) with model solutions representing the heightened lock delay and barge costs associated with the six traffic levels.

The spatial, intertemporal equilibrium models include the domestic and international corn and soybean sectors. The quadratic programming models generate interregional trade flows and prices that result from maximizing producer plus consumer surplus minus grain handling, storage, and transportation costs (Samuelson (1952), Takayama and Judge (1971)). The models include considerable detail on regional excess demands/supplies and logistics/transportation costs in the United States and Mexico. Other trading countries are treated as an excess supply or excess demand region. See Fellin and Fuller (1998) for a mathematical representation of the spatial models.

The international corn model includes sixty U.S. excess demand regions, nineteen Mexico excess demand regions, sixty-five U.S. excess supply regions, nineteen Mexico excess supply regions, seventeen U.S. ports, eight Mexico ports, twenty-five foreign excess demand regions and five foreign excess supply regions. Thirty-seven barge loading sites are included on the Mississippi and Ohio River systems and tributaries. The seventeen port areas include two Atlantic ports, five Gulf ports, five Pacific ports, four Great Lakes ports, and a port near Quebec, Canada which can serve as a transhipment location for grain exiting the Great Lakes. To reflect freezing of the Great Lakes and upper Mississippi waterways, the models disallow shipping via these arteries in the winter quarter. The five major U.S.-Mexico inland crossing locations are included as are five Mexican ports on the Gulf and three on the Pacific. The U.S. excess supply and excess demand regions are linked by truck, railroad, and barge transportation costs while U.S. ports and foreign excess supply regions are linked to foreign excess demand regions and Mexico ports by ship rates. Mexico excess supply and demand regions are linked by truck and railroad costs/rates as are Mexican ports and Mexico excess demand regions. Grain handling and storage costs are incurred in United States, Mexico, and foreign excess supply regions; handling costs (loading/unloading) are incurred at U.S. excess supply locations, barge loading, and unloading locations, and ports while inspection fees and interlining costs are incurred at U.S.-Mexico border crossing sites. The corn model includes four quarters and represents the commodity crop year (October 1 - September 30). The international soybean model is structured similarly to the corn model except it includes twenty-four U.S. excess demand regions and sixty-eight U.S. excess supply regions.

Table 1. Estimated Barge Costs for Selected Routings to Lower Mississippi River Port Area with 25, 50, 75, 100, 125, and 150 Percent Increase in Traffic Levels[1]

	Barge Costs ($/Metric Ton)						
Origin	Base	25%	50%	75%	100%	125%	150%
		-----	-----	-----$-----	-----	-----	-----
St. Paul, MN	9.79	10.27	10.79	11.41	12.10	13.05	13.98
Winona, MN	9.10	9.56	10.04	10.62	11.26	11.99	12.06
McGregor, IA	8.61	9.04	9.49	10.02	10.63	11.27	12.03
Dubuque, IA	8.30	8.69	9.11	9.59	10.16	10.39	11.09
Clinton, IA	8.03	8.39	8.78	9.25	9.80	10.20	10.69
Burlington, IA	7.19	7.37	7.61	7.91	8.26	8.52	8.77
Hannibal, MO	6.60	6.68	6.83	7.02	7.25	7.49	7.87
St. Louis, MO	5.63	5.63	5.63	5.63	5.63	5.63	5.63
Ottawa, IL	7.37	7.45	7.52	7.62	7.73	7.85	7.98
Peoria, IL	6.76	6.84	6.90	6.97	7.05	7.10	7.15

[1] Represents a 25, 50, 75, 100, 125, and 150 percent increase in average 1991-1995 traffic levels.

Model Data

To construct the spatial models it was necessary to estimate domestic and foreign excess demand and supply equations; grain handling and storage costs; railroad, truck, barge, and ship costs/rates; and applicable tariffs and quotas.

The United States and Mexico regional short-run excess supply equations were obtained with an estimated regional excess supply elasticity, regional exports, and price. Regional excess demand equations for the United States and Mexico were estimated from the regional excess demand elasticity, regional imports, and prices. The excess supply and demand equations were based on formulations by Kreinen (1983) and Shei and Thompson (1977).

$$E_{es} = Q_d / Q_e \, |E_d|$$
$$E_{ed} = Q_d / Q_i \, E_d$$

where,

E_{es} = excess supply elasticity of region
E_{ed} = excess demand elasticity of region
Q_d = quantity demanded or consumed in region
Q_e = quantity exported from region
Q_i = quantity imported into region
E_d = own-price demand elasticity

The United States and Mexico demand elasticities were taken from Sullivan, Roningen, Leetmaa, and Gray (1992). Regional crop production data (crop reporting districts) in the United States came from the USDA's Agricultural Statistical Service while prices came from *Agricultural Prices.* Regional estimates of demand or consumption were necessary to estimate excess supply and demand since consumption was subtracted from production to determine whether the region was an excess supply or demand region.

Regional corn consumption by the dairy, livestock, and poultry sectors in the United States was calculated with estimates of regional populations and rations. The *1993 Milling Directory* provided information on regional corn processing capacity and in combination with national estimates of processed corn output was used to estimate regional demands (USDA, *Feed Situation and*

Outlook Report). Information on ethanol plants and capacities was supplied by the Department of Energy. This information in combination with national output data was used to estimate corn use by ethanol processors. The Department of Treasury provided data on regional corn consumption by breweries and distilleries. Regional soybean crushing demands were estimated with plant capacity estimates from the National Oilseed Processors Association and national data from *Fats and Oils: Oilseed Crushings* and *Oil Crops Yearbook.*

Regional corn and soybean production and consumption data for Mexico came from *Estimated Regional Production/Consumption of Corn, Wheat, Sorghum, and Soybeans in Mexico.* Regional prices in Mexico were imputed from U.S. Census data that related quantity and value of U.S. exports to Mexico by border crossing site and marine port.

The motor carrier, railroad, and barge transportation costs for the U.S. portion of the model were estimated with Reebie Associates models. The estimated transportation costs were compared with rates or other cost estimates to determine their representativeness. The barge costing code incorporated a variety of information relating to origin and destination, commodity, tons per barge, tow type, barges per tow, and fixed and variable costs. Costs for a particular shipment were calculated by simulating barge movement over a complete cycle. An internal routing table determined links in the river network to be used by a tow. Transit time was computed for each link based on distance, speed, and lock delays. The estimated lock delays associated with the 25, 50, 75, 100, 125, and 150 percent increase in traffic were entered into the cost model for purposes of estimating the affect on barge cost. Barge costs reflecting historical traffic levels and congestion were compared to average actual rates over the 1991-1993 period for St. Paul, Minnesota; St. Louis, Missouri; and Peoria, Illinois. Barge rates from St. Paul, Peoria, and St. Louis to lower Mississippi River ports averaged $9.37, $7.30, and $5.40 per ton, respectively, while estimated costs were $9.79, $6.76, and $5.63 per ton. In all cases, the historical average rate and estimated cost differed by less than 7 percent.

Information from the Public Waybill regarding rail shipment characteristics, in combination with the rail cost code was used to estimate variable and total railroad costs for each potential routing. Rates on selected corn and soybean transportation corridors were statistically compared to estimated costs to determine their similarity; the analysis of variance yielded F-ratios that failed to reject the hypothesis that mean rates equaled mean costs. The estimated motor carrier costs were representative of five axle, 42 foot hopper trailers carrying 25 tons of grain. The average cost of this configuration in grain haulage was estimated to be \$1.13 per mile. Dooley, Bertram, and Wilson had estimated commercial grain trucking costs to be \$0.89 per mile in 1986. This cost parameter when compounded at 3 percent to 1993 yielded a per mile cost of nearly \$1.10 per mile or only slightly below the estimated cost of \$1.13 per mile. This comparative analysis suggested the truck cost parameter to be representative. Ship rates linking U.S. ports with Mexican ports and foreign excess demand regions came from an estimated regression which was based on data taken from *Chartering Annual* (Fellin and Fuller).

Mexican railroad and truck cost/rate parameters came from *El Costo Y La Competitivdad Del Transporte Ferroviario De Granos Y Oleaginosas*. Per mile trucking costs in Mexico average about 25 percent above U.S. rates. This is due to the higher interest rates and truck repair costs in Mexico which tend to more than offset the lower wages paid to Mexican drivers.

Grain handling and storage costs for U.S. country elevators, inland terminals, and port terminals were based on a national survey of grain handlers. Mexican grain handling and storage costs were based on communications from Boruconsa and Bodegas Rurales Conasupo which are Mexican government agencies involved in grain assembly and storage. Port discharge costs in Mexico came from Klindworth and Martinsen (1995).

The excess supply/demand relationships for foreign exporters and importers were derived from an excess supply (demand) elasticity, and information on quantity exported (imported) and price. The short-run excess supply/demand elasticities were obtained from formulations similar to those used to estimate U.S. excess supply/demand elasticities (Shei and Thompson (1977), Kreinin (1983)).

$$E_{es} = Q_p / Q_e \, |E_d|$$
$$E_{ed} = Q_d / Q_i \, E_d$$

where,

E_{es} = excess supply elasticity of foreign supplier

E_{ed} = excess demand elasticity of foreign importer
Q_p = quantity produced by foreign supplier
Q_e = quantity exported by foreign supplier
Q_d = quantity demanded or consumed by foreign importer
Q_i = quantity imported by foreign supplier
E_d = own-price demand elasticity of foreign supplier/importer

The own-price demand elasticities of foreign exporters and importers were taken from Sullivan, Roningen, Leetmaa, and Gray (1992). Production, prices, exports, and imports were taken from *World Grain Situation and Outlook, World Oilseed Situation and Market Highlights* and the Production, Supply and Distribution (PS&D) database.

Results

The effect of projected increases in River traffic on producer prices and revenues, and flow patterns was determined by contrasting the base solution of the corn and soybean models with model solutions that represented a 25, 50, 75, 100, 125, and 150 percent increase in traffic. The 100 percent increase in traffic approximates anticipated flows on the upper Mississippi and Illinois Rivers in 2050 while the 125 and 150 percent increases in traffic offer perspective on seasonal surges as well as periods of keen export demand.

Corn and Soybean Flow Patterns

Analysis shows the anticipated increase in traffic to divert substantial quantities of corn from the upper Mississippi River (Table 2). For example, a 50 percent increase in traffic was projected to divert 5.03 million metric tons from the upper Mississippi, a 27 percent reduction in quantity of corn transported via this transportation artery. With a 75, 100, 125, and 150 percent increase in traffic, corn flow on the upper Mississippi River was projected to decline 5.39 (30.0%), 10.78 (58.0%), 11.27 (61.0%), and 13.30 (72.0%) million metric tons, respectively, relative to historic levels (1991-1995). The anticipated increase in traffic also diverted soybeans from the upper Mississippi, however, the quantities were comparatively modest (Table 2).

Corn on the Illinois River was projected to increase as a result of the projected growth in traffic. The analysis shows a 50 percent increase in freight traffic would increase corn transportation on the Illinois River by 2.7 million metric tons (Table 2). This occurs because barge transportation costs increase modestly on the Illinois River relative to the upper Mississippi at increased traffic levels. For example, a 50 percent increase in traffic was estimated to increase barge costs on the upper Mississippi about 10 percent while similar increases on the Illinois River increase costs about 2 percent. As a result, Illinois corn supplies become increasingly attractive to excess demand regions (buyers) in this short-run analysis, thus the increase in Illinois River corn shipments at higher traffic levels. Further, corn shipments on the Ohio River were projected to decline as traffic levels and barge costs on the upper Mississippi and Illinois Rivers increase. Because of the higher barge costs on the upper Mississippi River, corn which had historically been routed from this River to southeast U.S. excess demand regions via the Tennessee River was now replaced by rail shipments of corn from Indiana supply regions. These Indiana supply regions in the past had shipped via the Ohio River to lower Mississippi River ports, thus, the decline in Ohio River corn shipments.

Although important quantities of grain were diverted from the upper Mississippi and the lower Mississippi River port area at higher traffic levels and barge costs, total exports were only modestly impacted (Table 2). In particular, with a 100 percent increase in traffic, corn exports at lower Mississippi River ports were projected to decline 6.03 million metric tons; however, this decline was virtually offset by increases in exports at Great Lakes and Pacific northwest ports of 2.78 and 3.14 million metric tons, respectively (Table 2).

Corn flow patterns in Iowa and Minnesota were more affected than other states by increased traffic levels on the upper Mississippi and Illinois Rivers. The analysis showed east Iowa corn supplies were not diverted from the upper Mississippi River at any analyzed traffic level, whereas central and west Iowa commenced diverting corn at the 100 and 50 percent levels, respectively. Diverted corn was routed to the Pacific northwest, central Illinois demand centers (processors) and the domestic market in the southwest U.S. (Texas, California). Iowa's corn shipments to central Illinois processors replaced Illinois corn which was increasingly directed to the Illinois River for export. Iowa shipments to the southwest U.S. replaced Nebraska corn which was subsequently directed to Pacific northwest ports. Southeast Minnesota continued to ship to the upper Mississippi at all traffic levels while southcentral and central Minnesota diverted corn shipments from the upper Mississippi at the 125 and 100 percent increase in

Table 2. Estimated Changes in U.S. Corn and Soybean Flows Via River Segments and Ports Resulting From a 25, 50, 75, 100, 125, and 150 Percent Increase in Traffic on Upper Mississippi and Illinois Rivers

	Corn					
	25%	50%	75%	100%	125%	150%
	Metric tons (millions)					
River Segment						
Upper Mississippi	-1.87	-5.03	-5.39	-10.78	-11.27	-13.30
Illinois	0.00	2.74	3.00	2.90	2.90	1.37
Mid and Lower Mississippi	0.00	0.00	0.00	0.00	0.00	1.54
Ohio	-1.74	-1.76	-1.70	-1.39	-1.36	-0.78
Total	-3.61	-4.05	-4.09	-9.27	-9.73	-11.17
Port Area						
Lower Mississippi	-1.66	-2.04	-2.13	-6.03	-6.49	-7.93
Other Gulf ports	0.00	0.00	0.00	-0.29	-0.29	-0.29
Atlantic	0.00	0.00	0.00	0.00	0.00	0.00
Great Lakes	0.48	0.65	0.66	2.78	2.79	4.07
Pacific Northwest	1.09	1.21	1.21	3.14	3.46	3.51
Total	-0.09	-0.18	-0.26	-0.40	-0.53	-0.64

(Continued on next page)

Table 2. Continued

	Soybeans					
	25%	50%	75%	100%	125%	150%
	----------Metric tons (millions)----------					
River Segment						
Upper Mississippi	-0.05	-0.06	-0.18	-0.33	-0.79	-1.98
Illinois	0.00	0.00	0.00	0.00	0.00	0.00
Mid and Lower Mississippi	0.00	0.00	0.00	0.00	0.00	0.00
Ohio	0.00	0.00	0.00	0.01	0.01	0.01
Total	-0.05	-0.06	-0.18	-0.32	-0.78	-1.97
Port Area						
Lower Mississippi	-0.01	-0.01	-0.13	-0.27	-0.72	-1.91
Other Gulf ports	0.00	0.00	0.01	0.14	0.21	0.22
Atlantic	0.00	0.00	0.00	0.00	0.00	0.01
Great Lakes	0.00	0.00	0.11	0.12	0.37	1.53
Pacific Northwest	0.00	0.00	0.00	0.00	0.13	0.13
Total	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02

traffic levels, respectively. Diverted Minnesota corn was routed into foreign markets via the ports in the Pacific northwest and Duluth.

Corn and Soybean Producer Revenues and Prices

As expected, corn and soybean prices and revenues in regions dependent on River transportation were unfavorably affected by higher traffic levels and associated higher barge costs, whereas prices and revenues in other regions modestly increased. Traffic increases of 50 percent were projected to reduce combined annual revenues of corn and soybean producers about $45 million, while 100 and 150 percent increases in traffic were projected to reduce annual revenues approximately $97 and $150 million, respectively. Declines in corn revenues accounted for about 90 percent of the total decline in all revenues. Corn/soybean producers in Minnesota and Iowa were more unfavorably affected than producers in other states; on average, producers in these states accounted for about three-fourths of the total decline in all revenues (Table 3).

State subregions most unfavorably impacted by the increase in traffic and associated higher barge costs were located near the upper reaches of the Mississippi River. For example, in northeast and north central Iowa, and southeast, central, and south central Minnesota, corn prices were projected to decline from $1.50-$2.00 per metric ton when traffic increases 100 percent, whereas in the remaining portions of these states, prices decline $0.33 to $0.75 per metric ton.

Conclusions

A recent study indicates the demand for transportation on the upper Mississippi and Illinois Rivers will nearly double by 2050. Inadequate trust fund resources to rehabilitate and expand locks in combination with the backlog of structures which require attention has generated concern regarding future transportation. Agricultural interests in the Midwest are particularly concerned regarding the upper Mississippi and Illinois Rivers since these arteries originate and carry about one-half of U.S. corn exports and one-third of U.S. soybean exports to lower Mississippi River ports. Spatial, intertemporal models of the international corn and soybean sectors in combination with an estimated lock delay equation and a barge cost model are used to explore the implications of a 25, 50, 75, 100, 125, and 150 percent increase in traffic levels on these Rivers.

The spatial models include regional demand and supply structures and transportation rates/costs representative of the 1992-94 period, whereas estimated barge costs reflect the heightened congestion and delay associated with the 25, 50, 75, 100, 125, and 150 percent increase in traffic. Accordingly, the results reflect the changes in producer prices and revenues, and flows that would occur if the anticipated congestion, delay, and associated barge costs were imposed on current production and transportation systems.

Results show increasing quantities of corn/soybeans diverted from the upper Mississippi River as traffic levels, congestion, tow delay, and ultimately barge costs increase. For example, if traffic levels were to increase 50 percent, about 30 percent of the corn would be diverted from the upper Mississippi and a doubling of traffic would divert about 58 percent of the corn. Corn supply regions at comparatively distant locations from the River would initially divert at increasing traffic levels whereas sites near the River would not be diverted at any traffic level. For example, southeast Minnesota and east Iowa corn were not diverted at any analyzed traffic level while west Iowa corn was diverted with a 50 percent increase in traffic and central Iowa and southcentral Minnesota corn at a 100 percent increase in traffic. The diverted grain was typically rerouted to an alternative domestic market or port area via railroad or, in some cases, to the same port area via railroad. As expected, regional corn/soybean prices and revenues declined as traffic levels and barge costs increased; based on 1992-1994 production levels and prices, a 50 percent increase in traffic would reduce annual producer revenues $45 million and a 100 percent increase in traffic would lower annual revenues $97 million. Producers in Minnesota and Iowa incur about three-fourths of the decline in producer revenues. Total U.S. exports declined modestly at higher traffic levels; this was the result of the short-run excess demand and supply relationships included in the models. Finally, the analysis shows important interwaterway affects, i.e., growing congestion on one waterway system can influence commodity flows on other systems, thus the need for planners to be cognizant of these potential affects when making infrastructure decisions. In summary, the projected doubling in demand for waterway transportation on the upper Mississippi and Illinois Rivers will have an important influence on tow delay and barging costs, and based on this analysis, it seems unlikely that the analyzed Rivers would carry the projected increase in tonnage since economic forces would divert much of this traffic prior to reaching the projected traffic level.

Table 3. Estimated Statewide Reductions in U.S. Corn and Soybean Prices and Revenues Resulting From a 25, 50, 75, 100, 125, and 150 Percent Increase in Traffic Levels on Upper Mississippi and Illinois Rivers

	Corn					Soybean			
	Minnesota	Iowa	Nebraska	Other	Total	Iowa	Minnesota	Other	Total
25%									
Price ($/ton)	0.27	0.20	0.10	0.19		0.10	0.21	0.04	
Revenue ($/million)	5.5	8.0	2.5	2.4	18.4	1.1	0.6	0.1	1.8
50%									
Price ($/ton)	0.71	0.38	0.22	0.44		0.22	0.56	0.08	
Revenue ($/million)	14.4	15.3	5.7	5.6	41.0	2.1	1.7	0.2	4.0
75%									
Price ($/ton)	1.12	0.55	0.28	0.71		0.36	0.88	0.08	
Revenue ($/million)	22.8	22.1	7.2	9.0	61.1	3.5	2.7	0.2	6.4
100%									
Price ($/ton)	1.54	0.86	0.33	1.05		0.52	1.24	0.12	
Revenue ($/million)	31.40	34.50	8.4	13.31	87.60	5.1	3.8	0.3	9.2
125%									
Price ($/ton)	1.83	1.13	0.42	1.30		0.69	1.55	0.16	
Revenue ($/million)	37.3	45.4	10.7	16.4	109.8	6.8	4.8	0.4	12.0
150%									
Price ($/ton)	2.27	1.38	0.48	1.54		1.12	1.43	0.20	
Revenue ($/million)	46.2	55.5	12.3	19.5	133.5	11.0	4.4	0.5	15.9

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