TRANSPORTATION RATE ANALYSIS: UPPER MISSISSIPPI RIVER NAVIGATION FEASIBILITY STUDY

(VOLUME I)

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I. SUMMARY

Based on a 1,331 movement survey of barge shipping, users of the Upper Mississippi River navigation system are estimated to have saved as much as $13 per ton in transportation and handling charges for the movement of 137 million tons of cargo when available barge costs are compared to the next-best, all-land transportation alternative. These savings are calculated across eight commodity groups including over 100 separate commodities and range between a high $12.03 per ton for chemicals and $1.61 per ton for metallic ores, iron and steel scrap, and slag. A full reporting of all rate calculations is provided through a combination of spreadsheets and worksheets in Volume II.

II. INTRODUCTION

This study is conducted by the Tennessee Valley Authority (TVA) under contract with the Rock Island District of the U.S. Army Corps of Engineers (Corps) in order to facilitate the calculations of the National Economic Development (NED) benefits attributable to upper Mississippi River navigation. Toward this objective, the study provides a full range of transportation rates and supplemental costs for a sampling of over thirteen hundred 1991, waterborne commodity movements which, in total or in part, were routed over the upper reaches of the Mississippi River Navigation System.

Freight rates for each sample movement are calculated based on the actual water-inclusive routing, as well as for a competing all-land alternative. All computations reflect those rates and fees which were in effect on September 30, 1994. Results are documented on a movement-by-movement basis, including a separate worksheet for each observation. These disaggregated data are also integrated into individual spreadsheets for each of the eight commodity groupings. A full description of the study's scope and guidelines, TVA's methods of rate research and construction, and supporting assumptions is provided below.

III. STUDY PARAMETERS

A sample of 1,331 movements was identified for inclusion in this analysis. Dock-to-dock tonnage over included origin destination pairs ranges between 38 tons and 5.02 million tons annually, representing 109 individual commodities. The origin-destination stratification for the sample movements represents each river segment of the Inland Waterway System, each commodity group, and each quarter of the calendar year. Reported rates for both the water movement and the all-land alternative are based on the actual location of shipment origins and destinations.

1. *Water Routings*

Because many of the sample movements have off-river origins and or destinations, a full accounting of *all* transportation costs for waterborne movements also requires the calculation of railroad and/or motor carrier rates for movement to or from the nearest appropriate port facility. Additionally, all calculations reflect the loading and unloading costs at origin and destination, all transfer costs to or from barge, and any probable incidental costs. Finally, though it was rarely a concern, all waterborne routings were constrained to include, at least, partial use of the upper Mississippi Navigation System.

2. *Land Routes*

With the exception of over-sized shipments and intraport sand dredging, rail or truck rates are calculated for all movements (See Section VI for a discussion of exceptions.). Additionally, pipeline alternatives are calculated for anhydrous ammonia and petroleum products when both the origin and destination are pipeline served. As in the case of the barge-inclusive routings, many all-land routes require the use of more than one transport mode. Therefore, when appropriate, calculations include all requisite transfer charges and/or storage charges.

3. *Seasonality and Market Anomalies*

To accurately reflect NED benefits, it is necessary to develop rates which portray the normal market conditions which are anticipated over the project life. For this reason, every attempt was made to purge the data of anomalous or transitory influences. As a part of all shipper surveys and interviews, respondents were directed to ignore te*mporary market disruptions and provide information reflective of "normal" operating conditions. However, because of the recurring nature, seasonal patterns are incorporated into the analysis where they are observed to be significant.

IV. Worksheet Explanation

Volume II contains the individual worksheets for each of the 1,331 movements. Each worksheet consists of 1 - 6 pages and catalogues basic shipment information including:

1) Corps assigned shipment reference number
2) Individual commodity description
3) Commodity group description
4) River origin
5) River origin waterway mile
6) Off-river origin (if applicable)
7) WCSG number
8) Shipment tonnage
9) River destination
10) River destination waterway mile
11) Off-river destination (if applicable)

Section I of the worksheet contains the analysis of the barge-inclusive routing from origin to destination via the upper Mississippi River Navigation System. Section II contains information describing the best available all land alternative. Section III contains an analysis of the intermodal movement via the St. Louis port area and Sections IV, V, VI VII, and VIII provide an analysis of routings and rates to alternative destination points for grain and fertilizers where appropriate.[1]

Authorities or sources for all calculations are reported in footnotes to the appropriate worksheet items. All rates and supplemental costs are expressed on a per net ton basis in third quarter 1994 U.S. dollars. When the river port town name and the railroad station name are different, the railroad station name is indicated as an off-river origin or destination with no cost to and/or from the river.

V. JUDGMENTS AND ASSUMPTIONS

Based on information collected from shippers, receivers, carriers, river terminal operators, stevedores, federal agencies, and private trade associations, TVA was able to identify probable origins and destinations for the majority of those movements that originated or terminated at off-river locations. In the absence of specific shipper/receiver information, it is assumed that the river origin and destination are the originating and terminating points for both the river and alternative modes of transportation. In every case, an attempt was made to gather information from all shipping ports. However, in some instances, 1991 logistical data are not available from these ports. In other cases, port representatives declined to provide the requested information.

Specific commodity groups are discussed in more detail later in this section. However, for those movements that originate or terminate at a river port location, it is assumed that rail service could also be utilized by the shipper or receiver if that port is rail served. Exceptions to this

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[1] The St. Louis alternative is included to reflect the possibility that navigation might become impractical only

assumption are noted on individual worksheets. When the shipper or receiver is served by truck only, a railroad team track or transfer facility at the station nearest the off-river shipper or receiver is used for the land alternative. Only those shippers who ship more than 100,000 tons annually and who are already adjacent to rail trackage would be assumed to undertake the significant capital expenditures necessary to acquire direct rail service. No consideration is given to private car leasing costs and mileage allowances made by carriers to shippers for the use of private equipment are, similarly, ignored.

In all cases, it is assumed that the alternative modes of transportation would have the physical capacity to accommodate the additional tonnage represented by each commodity movement. Commodity specific judgments and assumptions include:

Coal (Group 1)

A number of assumptions are made for land haul rates on the movements of coal to utility destinations that are not rail served. Volumes to these destination are, in many cases, substantial, so that long-haul truck transportation cannot be considered a viable option. In the absence of water transportation, receiving utilities would have to carefully evaluate those available options which might insure their ability to continue to receive large volumes of coal. These considerations might include the replacement cost of transfer and handling facilities, the construction cost of switch or main line rail trackage, the cost of new or improved highway access, the economies of buying or leasing rail equipment, and the possibility of shifting origins to assure adequate coal supply. For their part, we may assume that rail carriers would be willing to construct additional trackage if volumes are sufficient. However, these construction costs would very probably be passed on to the shipper via higher rates.

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on the upper-most reaches of the upper Mississippi.

To accommodate those instances in which sample barge movements are to non-rail served utilities, we have incorporated the following judgments and assumptions.

- If the receiving utility is not rail served, rates are applied to the nearest railhead and trucking costs from the railroad to the destination are applied. If the shipping point is not rail served, a motor carrier charge is applied from the mine origin to the nearest railhead. It is assumed that transfer facilities would be available at both origin and destination for transfer between rail and truck.
- In some instances, movements involve a truck haul from multiple origins to a concentration or preparation point for loading to rail. In these instances, where shipments originate at several mines within the same general area, a representative rail origin is selected as the transfer location.

Aggregates (Group 2)

Land haul rates on limestone and sand and gravel reflect the modes necessary to transport the shipments from actual origins to actual destinations. If origins or destinations are not rail served, a trucking charge is applied from the nearest rail station. For those movements where both rail and truck transportation are an option, truck hauls are limited to a distance of 100 miles. This, on occasion results in slightly higher rates. However it was deemed impractical, in the absence of water transportation, to transport large volumes of these commodities for long distances by truck. Limiting factors include lower cargo carrying capacity, the inability to round-trip more than two times per day, and the absence of loaded back-haul opportunities.

With regard to waterway improvement materials, we assume that movements would require a truck haul at the destination for delivery to river bank work locations. These truck movements would likely average ten miles each. It should be noted that a significant amount of channel improvement and bank stabilization work is conducted off shore or at locations without highway access, so that land transportation would often be impractical.

Grain (Group 4)

The computation of rates for grain is based upon the survey responses of the shippers and receivers. Specifically, if a country elevator gathers grain then ships it to the river terminal, we assume a 20 mile truck haul from the farmer's field to the country elevator. If the grain moves for export, a unit train movement is assumed, and land rates are computed from a unit train capacity elevator to the original Gulf port location, as well as Gulf port, Pacific Northwest, Great Lakes and domestic market alternatives. For domestic shipments, the computation of rail rates is based on the track capacity of the country elevator or domestic receiver. We assume that the grain shipper would maximize the use of his facilities and utilize gathering rates to reach the track capacity of the receiver.

Notable within the computational method is our use of both rail costing models and tariff rates depending on which value is the lowest.[2] Since the rail tariff rates are generally based on the short line miles, tariff miles were computed for both the cost model and grain tariff rates. No consideration is given to the Burlington Northern's Certificate of Transportation (COT) program, OT-5 authority decisions by rail carriers or the C6-X covered hopper car rate structure on grain.[3]

The rail rating of feed ingredients follows assumptions similar to those used for the rating of grain - namely, unit trains for export, rates constrained by track capacity, and the use of the lower of either tariff rates or rates estimated via the costing model. Rail and barge transit programs for meals were not considered.

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[2] Use of contract rates for the movement of grains appears to have peaked in 1986 when approximates 40% of all grain moved under contract. Since that time, a number of Class I carriers have returned to the use of traditional tariffs as the basis for rate calculations.

[3] C6-X cars are the over-sized covered hoppers, holding up to 115 tons of grain each which were introduced by some carriers in 1994.

VI METHODS AND PROCEDURES

As a result of the flexibility created by surface transportation deregulation, it is sometimes difficult to determine the exact rate charged by a carrier on shipments moving under contract. Barge rates are a matter of negotiation between shipper and barge line operator, and these rates are not published in tariff form. Each carrier's rates are based on individual costs and specific market conditions, so that these rates will vary considerably between regions, across time, and from one barge line to another.

Contract rates are also common in pipeline, rail and motor carrier transportation and, like barge rates, may be maintained in complete confidentiality. In other cases (particularly grain), tariff rates are still applied. However, there is rarely any dependable means for determining whether a contract rate or a tariff rate should be used to price a particular movement.

For the purposes of this study, actual rates, as provided by shippers, receivers, or river port operators, are used whenever possible. Sources for these rates are identified by footnotes within the worksheets for the individual movements. All other rates were obtained from published sources or, when this was not possible, estimated by TVA based on the mode of transportation, the tonnage, and other shipment characteristics. All rates, whether actual or estimated, are based on those which were in effect September 30, 1994. However, when necessary, reported rates have been refined to eliminate seasonal impacts or the effects of abnormal market conditions. The methodologies employed in the estimation of unobservable rates were developed through extensive contacts with shippers, railroads, motor carriers, and the barge industry. This information was often integrated with confidential federal data and/or the output of computerized simulation and costing models. This process was both guided and augmented by in-house TVA rating and costing expertise developed through decades of experience as a major shipper of coal and other bulk commodities and through the implementation of navigation-based economic development programs throughout the Tennessee River Basin.

Barge Rates

With the exception of grain and feed ingredients (Group 4) unobservable barge rates are calculated through the application of a computerized barge costing model developed by the Tennessee Valley Authority. The TVA model has been refined to include 1994 fixed and variable cost information obtained directly from the towing industry and from 1994 data published within the Corps' annual *Estimated Towboat and Barge Line-Haul Cost of Operating on the Mississippi River System*. These data are provided in Appendix 3, while an explanation of barge model parameters is provided in Appendix 4.

The TVA model contains three costing modules - a one-way, general towing service module, a round-trip dedicated towing service module, and a round-trip general towing service module. The one-way module calculates rates by simulating the use of general towing conditions between origin and destination, including the potential for a loaded return. The dedicated towing service module calculates costs based on a loaded outbound movement and the return movement of empty barges to the origin dock. The round-trip general towing service module is similar to the one-way, except that it provides for the return of empty barges to the point of origin. This module does not calculate costs for towboat standby time during the terminal process but does include barge ownership costs for both the terminal and fleeting functions.. It does not require that the empty barges be returned with the use of the same towboat. Depending on the module in use, inputs may include towboat class, barge type shipment tonnage, the interchange of barges between two or more carriers, switching or fleeting costs at interchange points or river junctions, and barge ownership costs accruing at origin and destination terminals, fuel taxes, barge investment costs, time contingency factors, return on investment, and applicable interest rates. Because there is neither statistical nor anecdotal evidence suggesting the presence of significant seasonal rate patterns for non-grain-related barge rates, none of the TVA model modules contain a seasonal component.

Barge rates on dry commodities are calculated with the use of the general towing service round-trip costing module. Inputs, based on information from carriers and the Corps' Performance Monitoring System (PMS) database were programmed into the module to simulate average towboat size (horsepower) and corresponding tow size (barges) for each segment of the Inland Waterway System. Other inputs include barge types, waterway speeds, horsepower ratios and empty return ratios. These inputs are documented by Appendix 4.

An example of a typical shipment cost in this analysis would be a dry bulk commodity (sea shells) originating on the Mobile River at Mobile, Alabama and terminating on the Missouri River at Omaha, Nebraska. Based on the modeling process, this shipment would be assumed to move in an eight barge tow from Mobile to the Mississippi River at New Orleans, a thirty barge tow from New Orleans to St. Louis, and an eight barge tow from St. Louis to Omaha. At each interchange point, appropriate fleeting charges would be calculated. Empty return (back haul) factors would also be included for each segment of the movement.

With the exception of movements involving Northbound and tributary rivers, barge rates for grain and feed ingredients are estimated on the basis of a percentage of rates formerly published in Waterway Freight Bureau Tariff 7.[4] For movements with origins in the Upper Mississippi River Basin, the five the year quarterly average percent of base for the Lower Mississippi, Mid Mississippi, Upper Mississippi, Illinois, and Missouri Rivers is used (See appendix 5). For movements on the Tennessee, Gulf Inter Coastal Waterway, an arbitrary is added to the New Orleans rate. Rates for

[4] The expression of barge rates for agricultural commodities as a percentage of waterway Freight Bureau Tariff 7 is consistent with industry standards.

those movements that traversed the Tennessee - Tom Bigbee Waterway are calculated through the use of the TVA general towing service costing module.[5]

Barge rates for asphalt, heavy fuel oils, and light petroleum products are calculated through the use of the dedicated service round-trip costing module. Twenty-four hours standby time is allocated at origin and destination for towboat terminal functions. Finally, rates for sodium hydroxide, vegetable oils, lubricating oils, liquid chemicals, and molasses are calculated through the use of the general service round-trip costing module. As a result of comparable barge sizes, these commodities normally move in the same tow with dry commodities.

Barge rates calculated by the use of the TVA model reflect charges that would be assessed in a period of traditional demand for waterway service. It should be noted that the model does not explicitly consider market factors such as intra or inter modal competitive influences, favorable back haul conditions created by the traffic patterns of specific shippers, or the supply and demand factors which affect the availability of barge equipment. These and other factors can influence rate levels negotiated by waterway users. The model does, however, calculate rates based on the overall industry's fully allocated fixed and variable cost factors, including a reasonable rate of return on assets. It is TVA's judgment that the rates are representative of the industry and provide a reasonable basis for the calculation of NED benefits.

Railroad Rates

As in the case of barge, reported rail rates are used in every case for which they are available. However, in the face of incomplete information, most movements requires the calculation of probable railroad rates. For grain and feed ingredients, two methods are used. First, the appropriate tariff rate is identified. Next, the Rebee Rail Costing Model is used to generate an

[5] There is no basis for rates via the Tenn-Tom in Waterway Freight Bureau Tariff 7.

estimate of rail movement cost. This cost was then inflated to reflect rail carrier market power in order to produce a final estimate of the most likely rail rate. For those cases in which the published tariff is lower than the estimated rate, the tariff rate is selected for use. Conversely, when the estimated rate is lower than the tariff rate, it is the estimated rate which is retained for inclusion in the surface and alternative rate analysis. Estimated full and variable railroad costs based on the Uniform Rail Costing System are included for each movement.[6]

In developing revenue and cost information for this analysis, we have observed modest seasonality in actual rail rates for the movement of some agricultural commodities. We have, nonetheless, chosen to exclude these influence from our analysis. There are several reasons for this decision. First, while sometimes statistically significant, the magnitude of these seasonal variations is relatively small.[7] No seasonal component is evident at all for rail rates of wheat. For corn and soybeans, there is an estimated fourth quarter premium of perhaps three mills per ton-mile or roughly seven to ten percent. Moreover, no seasonal components are ubiquitously observable in the tariff rates which for the basis of a considerable amount of the grain rate analysis. Finally, we strongly suspect that the seasonality which was observed was the product of specific and somewhat unusual market conditions, rather than any sort of perennial pattern.

Rates for all other commodities are calculated based on the Rebee cost estimates plus an appropriate mark-up. Market-up factors and shipment characteristics were determined through a variety of means, with shipper information being the preferred source. However, in the absence of a superior source information from the Interstate Commerce Commission's annual Carload Waybill Sample was used.[8] Appendix 6 details the parameters used to compute the Rebee estimates. For

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[6] Rebee is an URCS based model.

[7] This is in contrast to barge rates for grain and grain products which can more than double during the peak shipping season.

shipments originating in Canada, the rail rates are converted to U.S. currency through the exchange rate and surcharge published for September 15-30, 1994.

Motor Carrier Rates

Actual truck rates for off-river movements are used whenever possible. All other rates are estimated based on published motor carrier tariffs or regional rate quotations from truck brokers and contract motor carriers.

Handling Charges

Handling charges between modes of transportation are estimated on the basis of information obtained from shippers, receivers, stevedores, and terminal operators. Handling charges for transfer of commodities from or to ocean-going vessels are on the basis of information obtained from ocean ports or stevedoring companies. For import or export movements that involved mid-stream transfer operations, handling costs to or from land modes at a competing port with rail access are applied.

Except as noted within individual worksheets, it is assumed that movements of bulk products (for example, grain or fertilizer) would be handled through elevators or storage facilities. It was also assumed that liquid commodities transferred between modes would require tank storage. Additional costs are incurred at both river and inland locations if shipments remain in storage past the free-time period allocated by the facilities involved. Storage charges are usually assessed on a monthly basis.

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[8] In addition to shipper information and the Carload Waybill Sample, shipment characteristics were also identified from Association of American Railroads publications.

Loading and Unloading Costs

Because loading and unloading costs are not usually documented by shippers and receivers, they are particularly difficult to obtain.[9] Moreover, these costs can vary considerably across firms. In an attempt to provide the best possible estimates of these costs we use available shipper and receiver information in combination with data from Corps studies performed by other researchers, as well as previous TVA studies. These data are revised to reflect 1994 conditions then averaged as required. In those cases where varying sources produced disparate estimates, we relied most heavily on shipper and receiver estimates. A table of handling and transfer costs is included in Appendix 7.

VII SAVINGS TO USERS

Based on the third quarter 1994 cost levels, those users of the upper Mississippi River represented by the 1,331 sampled movements saved, on average, about $9.00 per ton over the best possible all-land routing alternative. Savings for each of the eight commodity groupings identified for this analysis are summarized bow.[10]

During the preparation of this study, we observed that in a very few instance, the selection of barge transportation is more costly than the land alternative. There are any number of scenarios which work individually or in combination to explain this phenomenon. First, in some cases, the sample may occasionally captured a transitory use of barge which occurs when pipelines lack capacity or when rail cars are in short supply. That is to say, for some particular shipper/receiver barge is only the mode of choice when other transportation markets are unusually active. Secondly, long term contracts and large capital investments may lead to discontinuities in the relationship between relative rates and modal choice. While this is a short-run situation, it may, nonetheless help

[9] Loading and unloading costs are often considered a part of through-put or production costs.
[10] All rates and rate differentials are unweighted.

Table 7.1

Group	Commodities	*Average Per-Ton Barge Rate*	*Average Per-Ton All-Land Rate*	*Average Per-Ton NED Saving*
1	Corn	18.93	28.51	9.58
2	Soybeans and Meal	16.25	27.75	11.50
3	Wheat	19.70	25.59	5.88
4	Barley, Oats, Sorghum, Hay	22.11	33.19	11.08
5	Coal	17.17	21.60	4.42
6	Petroleum Products	14.85	24.46	9.61
7	Chemicals	19.49	31.52	13.88[11]
8	Fertilizers	29.77	37.80	8.03
9	WWIM, Ores, I&S Scrap, Slag	26.67	28.28	10.35
10	Stone, Sand, Cement	12.52	21.26	8.47
11	Processed Products[12]	18.03	29.63	11.60
AVERAGE ALL COMMODITIES		19.59	28.14	9.49

to explain what appears to be perverse behavior. Next, the analysis superimposes 1994 transport market conditions on set of 1991 modal choice decisions. In the vast majority of cases, this dichotomy is of little import. However, in a few isolated cases, transportation rates may have changed sufficiently, so that in 1994, barge would no longer have been the mode of choice. Finally, regulatory constraints on the new construction of coal and hazardous materials handling facilities may preclude the development of facilities necessary for some shippers to take advantage of changes in the vector of available transportation rates.

[11] For commodity groups 7 and 9, the average per-ton benefit does not equal the difference between the average per-ton land cost and the average per-ton barge cost. This is because there were several movements within each group for which no rail routing was possible.

[12] Includes iron and steel products, foods, feeds, shell, processed oils, etc.

VIII Risk and Uncertainty

Motivation

While analysts exercise every caution in the calculation of project benefits and costs, the imposition of a fifty year time horizon leads to considerable "risk" of error. In the past the uncertainty associated with necessary parameter projections was largely ignored as policy makers focused, instead, on the relative values of point estimates. This pattern, however, seems to be giving way to a more comprehensive analytical approach which requires that point estimates of project benefits and costs be considered in association with the confidence bounds which portray the relative likelihood of these outcomes. While no formal mechanism has been prescribed in the evaluation of navigation projects, we have been asked to provide those additional parameters which may be necessary in the event that the above described "risk analysis" is extended to calculations based on TVA supplied rates.

As detailed above, the transportation rates within the TVA analysis are gathered directly from shippers and from carriers whenever possible. In those instances where survey information is unavailable, non-stochastic rate models are used to develop proxy measures. As a consequence, there is very little cross-sectional variability inherent within these transportation rates. Moreover, the fact that they are produced for some pre-specified point in time eliminates *any* possibility of intertemporal variation. Therefore, we have found it necessary to develop a secondary or alternative approach to the question of relative risk.

The basic element of interest is the difference between the total shipment cost via the observed water routing and the shipment cost if a land or land-water route is used instead. This difference measures the National Economic Development (NED) benefit attributable to barge transportation and is summarized by:

$$NED_{ijt} = A_{ijt} - B_{ijt} \quad (1)$$

where ***NED*** is the NED benefit to navigation, ***A*** is the alternative land-route rate, ***B*** is the observed water-route rate and where the subscripts *i, j,* and *t* represent the i^{th} shipment over the j^{th} origin-destination pair in the t^{th} time period. Again, the TVA rate analysis measures this difference through non-stochastic methods and for a unique point in time. Therefore, alternative data are substituted in Equation (1) in order to determine the cross-sectional and intertemporal variability of projected NED benefits. In all cases, records from the annual Carload Waybill Sample (CWS) were used to measure A_{ijt}. However, a paucity of available barge data required that we develop a variety of methods for the estimation of B_{ijt}. Even so, we are currently able to provide "risk" parameters for two commodity groups - grain (and grain products) and coal.

Grain and Grain Products

Barge rates for a variety of down-bound grain and grain product movements are available on a weekly basis from the U.S. Department of Agriculture (USDA).[13] These rates were used as a proxy for B_{ijt} in the calculations of NED variability. Appendix 8 provides the computational code used to combine available barge data with CWS records. The process, however, is reasonably straight forward.

The USDA rates are expressed as a percentage of the last barge tariffs published by the Waterway Freight Bureau in 1977. This "percent-of-tariff" rates are available for a number of river segments on a weekly basis from 1980 through the present and are included in Appendix 8. The first computational step involved the conversion of the percent-of-tariff rates to per ton-mile rates for

[13] These rates apply only to down-bound movements. The rates for up-bound grain are considerably different in magnitude. Nonetheless, because down-bound traffic flows are inexorably tied to up-bound rates, the variability of the unobserved rates for up-bound movements should mirror the variability evident in those rates which we can observe.

each eight river segments where rates are reported.[14] Next, these records were aggregated by month.

Rail rates for the movement of grain and grain products from the appropriate origin states to Louisiana destinations were, then, matched with the monthly barge rates based on origin and time period. Table 8.1 reflects the geographic pairings used in this process. Based on these merged data, we then calculated the mean rate differential and the standard deviation across all river segments for each monthly time period between 1980 and 1994.[15]

Table 8.1.

USDA Bare Rate Reporting Segment	*Corresponding Rail Movement Origins*
Upper Mississippi (Twin Cities)	Minnesota, Wisconsin
Mid Mississippi (Clinton, Iowa)	Iowa, Illinois
Lower Mississippi (St. Louis)	Missouri, Illinois
Lower Miss/Ohio (Cairo, Illinois)	Illinois, Kentucky
Lower Mississippi (Memphis)	Arkansas, Tennessee
Illinois River	Illinois
Lower Ohio (Owensboro, Kentucky)	Kentucky, Indiana
Lower Ohio (Cincinnati)	Ohio, Kentucky

Next, we attempted to model both the mean difference and its variability in order to provide projections of this variability throughout the fifty year project life.[16] Any number of factors affect the variability of observed prices, these include, but are not limited to the variability of the demand for the product in questions, variations in the availability of market information, the variability of

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[14] All rates are for grain and grain product movements to the Gulf of Mexico. Rates are reported for the Upper Mississippi (Twin Cities), the mid-Miss (Clinton, Iowa), the lower Mississippi (St. Louis), the lower Miss/Ohio (Cairo), the lower Mississippi (Memphis), the Illinois River, the lower Ohio (Owensboro), and the lower Ohio (Cincinnati).

[15] The end date was chosen to correspond with the period in which other economic parameters were measured.

prices for related products, the variability of aggregate price levels, and the variability of input costs. Consideration was given to a variety of independent variables which reflect these root causes, as well as a variety of model functional forms. After lengthy experimentation, the final forecasting models were selected.

$$(2)\ MEAN_t = \beta_0 + \beta_1(JUN_t) + \beta_1(TIME_t) + \beta_2(TIME2_t) + \beta_3(AGXPORT_t) + \beta_4(DFUEL_t) + \beta_5(UNFLLD_t) + \varepsilon_t$$

$$(3)\ ln(STD_t) = \beta_0 + \beta_1(APR_t) + \beta_2 ln(TIME_t) + \varepsilon_t$$

where $MEAN_t$ is the mean water-land rate difference in period t, STD_t is the standard deviation of that mean, JUN_t is a zero/one dichotomous variable indicating whether period t was, in fact, June, $TIME_t$ and $TIME2_t$ are a time trend variable and its square, $AGXPORT_t$ is the volume of agricultural exports, $UNFLLD_t$ is the percentage of unfilled orders for durable goods and APR_t is a zero zero/one dichotomous variable indicating whether period t was during the month of April. These model were estimated using Ordinary Least Squares.[17]

Estimated coefficients are reported in Appendix 8 along with other regression output. For the most part, these estimates display signs which are consistent with anecdotal information describing the formulation and variability of railroad and barge rates. These results do, however, provide information which is extremely useful in understanding and predicting the variability of the NED differential described by Equation (1). In particular, the regression results indicate that this variability is decreasing over time. This result, while not surprising, greatly enhances the usability of

[16] Strictly speaking, it was not necessary to model the mean differences themselves. However, we deemed this exercise to be useful to our understanding of the variability of the difference between land and water costs.

[17] Numerous missing observations precluded the use of a more appropriate Generalized Least Squares model designed to correct for autocorrelation.

the NED rate information provided herein.[18] The coefficient estimate for $\boldsymbol{APR_t}$ is positive and highly significant. This is also as expected. This relationship reflects the perturbation of barge rates associated with the Spring opening of the upper Mississippi River.

The final step in providing the information necessary to incorporate uncertainty into the NED rate analysis was to forecast this variability over the 50 project life envisioned for new lock construction. These monthly predictions are provided in Appendix 8.

Coal - Spot Market

Most coal shipments, whether by barge or by rail, move under contract rates. The CWS data have been shown to reliably reflect contract rates for rail movement of coal. Unfortunately, contract rates for the barge movement of this commodity are less readily available. This notwithstanding, barge rates for the roughly 20% of coal movements which are not governed by contract are maintained on a monthly basis for a variety of markets by Fieldston. These data were combined with rail rate data to perform an analysis similar to that just described for grain and grain products. The computational code used to prepare these data is included in Appendix 9.

Again, we attempted to model the variability of both the NED rate spread and the variability of that spread based on those factors which might reasonably affect these dependent variables. The final models are reported in Equations (4) and (5) below.

$$(4)\qquad MEAN_t = \beta_0 + \beta_1(JAN_t) + \beta_2(JUN_t) + \beta_3(SEP_t) + \beta_4(OCT_t) + \beta_5(NOV_t) + \beta_6 ln(TIME_t) + \varepsilon_t$$

$$(5)\qquad STD_t = \beta_0 + \beta_1(FEB_t) + \beta_2(NOV_t) + \beta_3 ln(TIME_t) + \varepsilon_t$$

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[18] The decrease in the variability of the rate spread between barge and rail very probably owes to the increased availability and declining cost of reliable market information.

Again, estimated coefficients are reported in Appendix 9. The results differ considerably from those attained in the estimation of Equations (2) and (3). First of all, unlike grain the spread between spot market barge rates and rail rates is increasing over time. This is particularly surprising given the well publicized fall in rail rates for coal movements. More important from the standpoint of this investigation, is the relationship between the variability of the rate spread and time. β_3 within Equation (5) is both positive and statistically significant. This indicates that the variability of the spread between rail rates and spot market barge rates for the movement of coal is an increasing function of time. Nonetheless, the functional form of this relationship indicates that the magnitude of intertemporal increases in variability falls considerably with each passing year. .A full set of estimated values for both the mean and variability of the rate spread between railroad rates and spot market barge rates over the fifty year project life is provided in Appendix 9.

Coal - Contract

As indicated above, nearly 80% of all barge movements of coal occur under contract rates. Unfortunately, there are only minimal data describing the terms of these contracts. The public-release version of the Coal Transportation Rate Data Base (CTRDB) published by the Department of Energy's Energy Information Administration does provide some information describing contract coal movements and these data were combined with corresponding CWS data based on the state of origin and the state of destination. However, the very nature of the barge contracts makes it nearly impossible to detect any intertemporal variations in the spread between rail rates and contract rates for the barge movement of coal. Each reported contract provides a barge line-haul rate which is to be in place over the life of the contract. Each record also contains the date of any subsequent contract modification. Still, in most cases, the barge rate does not vary over the contract life. It is possible to observe the pattern of barge rates signed in successive time periods, but because the records reflect only the year in which the contract is executed, the number of observations available for modeling purposes is too small to be meaningful.

Table X.X reports the mean rail-barge spread based on the CWS and CTRDB data for six years along the standard deviations. In the absence of more complete contract barge data, these summary statistics represent the best information we can provide about the variability of the spread between railroad rates and contract rates for the movement of coal.

Table 8.2

Year	*Mean Rate Difference*	*Standard Deviation*
1986	0.030309	0.023317
1987	0.029834	0.024027
1988	0.029767	0.022692
1989	0.028374	0.017007
1990	0.025305	0.019484
1991	0.029416	0.022756