Economic Evaluation of Commercially Navigable Ohio River Waterway System: Phase I and Phase II
(Replaces prior Phase I draft)

Prepared for the Nick J. Rahall, II Appalachian Transportation Institute
Marshall University

By the Center for Transportation Research
University of Tennessee

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Definitions and Acronyms

This document reports regional economic impacts attributable to a commercially navigable Ohio River waterway, measured by five primary variables:

Employment: Employment comprises estimates of the number of jobs, full-time plus part-time, by place of work. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included.

Gross Regional Product (GRP): Gross Regional Product, as a value added concept, is analogous to the national concept of Gross Domestic Product. It is equal to output, excluding the intermediate inputs, and represents compensation and profits. GRP, as a final demand concept, is equal to consumption + investment + government + (exports – imports).

Output: Output is the amount of production, including all intermediate goods purchased as well as value added (compensation and profit). It can also be described as sales or supply.

Population: For a region, its residents, as defined by the U.S. Census Bureau.

Personal Income: Personal income is a Bureau of Economic Analysis (BEA) quantity reported by place of residence. It is the sum of wage and salary disbursements, other labor income, proprietors' income, rental income, personal dividend income, personal interest income, and transfer payments, less personal contributions for social insurance.

Also referenced are the following acronyms:

BEA: U.S. Bureau of Economic Analysis.

BTS: Barge transportation savings, when used, refers to the shipping cost difference between barge and the lowest cost alternative transport mode.

CTR: University of Tennessee Center for Transportation Research.

EIA: Energy Information Administration.

FERC: Federal Energy Regulatory Commission.

FIPS: Federal Information Processing Standards.

MRS: The Mississippi River System, consisting of the Mississippi River, its tributaries, and the surrounding basin.

MRSR: The Mississippi River System Region, as defined in this study and used in the REMI Model for economic impact analysis—an area consisting of counties, roughly two-deep around the Mississippi River and its tributaries (shown in Figure 4 in this report).

MW: Megawatts.

MWH: Megawatt hours.

ORS: The Ohio River System, consisting of the Ohio River, its tributaries, and the surrounding basin. Where the context is clear, as in various tables and figures, it is sometimes used to refer to the ORSR (see below).

ORMSS: Ohio River Main Stem Study.

ORSM: The Ohio River System (REMI) Model.

ORSR: The Ohio River System Region, as defined in this study and used in the REMI Model for economic impact analysis—an area consisting of counties, roughly two-deep around the Ohio River and its tributaries (shown in Figure 4 in this report).

PSA: Electric utility distributor power service area.

REMI: Regional Economic Model Inc., the company name used to refer to the economic simulation model employed in the study.

RoN: Rest of the nation.

SIP: System Investment Plan.

TVA: Tennessee Valley Authority.

USACE: U.S. Army Corps of Engineers.

Executive Summary

The study by the Center for Transportation Research (CTR) finds that the economic value of commercially navigable water on the Ohio River System (ORS) to a region encompassing the ORS waterways (ORSR), to a region encompassing the Mississippi River System (MRSR), and to the Rest of the Nation (RoN) registers in the tens of billions of dollars of goods and services produced and tens of thousands of annual jobs and population. Employing a modeling approach based primarily on barge freight cost savings to industries, with special consideration of advantages to electric power utilities from access to navigable water that manifest as electric rate reductions within the ORSR, the Phase I study estimates economic impacts attributable to a navigable ORS. Phase II extends the electric rate impacts to the power service areas (PSAs) for distributors of electric power generated by plants on the ORS. The final and most appropriate impact tabulations, taken from Phase II of the study, are shown below and include impacts for the base case and for an additional case that includes the impact from the Boeing/Lockheed Martin (ULA-United Launch Alliance) rocket booster plant having located in Decatur, Alabama, because of the ORS commercial barge channel.

		Present Value of Impact Stream to 2050* (Billions of 2006 $)	
Region	Parameter	Base Case (Electric Rate Model)	Electric Rate Model Plus Boeing
ORSR	Output	$268.9	$283.3
MRSR	Output	85.5	85.6
RoN	Output	148.3	128.3
USA	Output	502.8	497.2
ORSR	GRP	153.1	160.0
MRSR	GRP	47.5	47.5
RoN	GRP	61.9	52.1
USA	GRP	262.4	259.6
ORSR	Personal Income	138.6	142.3
MRSR	Personal Income	43.5	43.5
RoN	Personal Income	163.2	159.3
USA	Personal Income	345.3	345.1

* fixed 2006$ stream from 2006 to 2050 @ 3%

		2050 Jobs & Residents	
Region	Parameter	Base Case (Electric Rate Model)	Electric Rate Model Plus Boeing
ORSR	Total Employment	75,670	78,100
MRSR	Total Employment	20,930	20,950
RoN	Total Employment	-16,030	-19,000
USA	Total Employment	80,560	80,050
ORSR	Population	133,000	136,200
MRSR	Population	15,530	15,620
RoN	Population	-158,300	-161,900
USA	Population	-9,770	-10,080

The study appraises the regional economic value of commercial transportation on the ORS using a 70-sector REMI model customized for the ORSR with economic linkages to the

MRSR and to the RoN. Incorporating the value of barge shipments on the Ohio River and tributaries into the REMI model requires ORS barge movement cost savings, which are tabulated by comparison of the transport costs for ORS barge shipments with the next least costly mode. This is done in the study for some 1,500 ORS 2006 movements, totaling over $3 billion of savings and comprising approximately 82% of total ORS 2006 traffic. It is believed the remaining movements have transportation savings values generally greater than typically found in the 1,500 movement set, and, therefore, economic impacts are likely underestimated by 20% or more in the study. The transportation savings for each barged commodity movement is linked with a model region and one of the 70 model industry sectors.[1] Shipping costs for non-agricultural goods increase the cost of the goods to the purchasing industry in most instances. For example, steel coils might be transported from one site for input into a fabricated metals producing firm at a distant site, with the latter paying the freight. For export agriculture product shipments, transportation costs are more appropriately accounted for at the shipment source rather than at the receiving end.

Early in Phase I of the study, waterway effects were first evaluated using transportation savings for all industries. In this exercise, the loss of transportation savings when commercial barge transportation is unavailable gives rise to regional changes in production costs (or in certain cases, income or revenues) for all affected industries including electric utilities. After examining the results, further reflection on the effects for the electric utility industry led to consideration of a second approach that models waterway effects for that industry by way of changes in electric rates in the ORSR.

With the electric-rate approach, the non-utility sector loses the advantage of transportation savings, but the loss of the cost advantage from water transport to electric utilities manifests itself as an increase in ORSR electric rates. The basis for the increase is derived from linear regression analysis of an electric rate advantage enjoyed by U.S. waterway plants. The result for the ORSR is specified in the REMI model as a change in policy variables that reflect the price of electricity to ORSR electricity customers.

The study team expected that the electric-rate model scenario would yield greater economic impacts than the all-transportation savings scenario, as utilities likely gain from navigable water in ways additional to coal transport savings. CTR found, however, the electric rate approach produced quite similar impacts. This finding resulted in additional consideration of the electric rates methodology used in the study. The fact that the focus of this study is on a fairly narrow band of counties surrounding the ORS waterways, but the impacted utilities have power service areas that extend well beyond those counties, suggests an explanation. Phase II of the study, therefore, incorporates an extension of the electric power effects into the rest of the nation through a delineation of power service areas, resulting in the impacts for the regions and the nation shown above.

Finally, the study takes an additional step: the major REMI results for the ORSR are allocated to counties so that county aggregations of impacts can be performed. Apportioned to state pieces, the largest impacts are felt in Ohio, followed closely by Kentucky and then Tennessee, Pennsylvania, and Indiana. The county estimates are then used as a partial basis for estimating impacts by waterway pools. The five largest pool impacts are: Markland, McAlpine, Newburgh, Meldahl, and Pike Island.

[1] Mr. Chrisman (Chris) Dager of the Tennessee Valley Authority identified the commodity-industrial sector linkages for the study based on information obtained from field interviews of shippers, undertaken by TVA in support of the U.S. Army Corps of Engineers.

Introduction

The primary purpose of this study is to estimate the economic value attributable to the availability of commercial barge transportation on the Ohio River System (ORS) waterways. This work supports of the Ohio River Mainstem Study (ORMSS) with the goal of developing the best plan for maintaining a reliable navigation system on the main stem of the Ohio River.

The ORMSS will evaluate maintenance, rehabilitation, and new lock construction investment needs for 19 navigation locks and dams, and will identify the optimal plan for meeting those needs. The ORMSS will produce a System Investment Plan (SIP). The ORMSS is a regional approach to modernize and upgrade navigation structures from Pittsburgh to Cairo, Illinois. The intent is to use the best science available to prioritize upgrades in order to maintain a reliable and efficient Ohio River transportation system. Prioritization is essential, as funding for navigation construction and maintenance is limited.

For each alternative evaluated in the ORMSS, the U.S. Army Corps of Engineers (USACE) has estimated the net benefits, which are the transportation cost savings that would accrue to each improved navigation infrastructure option as compared to the cost of making the improvements. The U.S. Water Resources Council set forth the methodology in 1983.[2] The USACE considers the magnitude of the net benefits and benefit-cost ratios in determining the recommended alternatives in the SIP.

Regional benefits are not considered in the estimation of net benefits, but these benefits are certainly germane to the decision making process at the local, state, and congressional levels of government. Local, regional and state economies would be impacted by increases in transportation costs occurring in the absence of an efficient river transportation system. In a public meeting concerning the construction of a new lock at Chickamauga Dam, the owner of a railroad contended that all of the commodities moving in and out of the upper Tennessee region could be hauled by rail carriers and, thus, there was no need for a new navigation lock. This proposition is probably true, but the delivered price of each commodity would be higher. The purpose of this study is to estimate the economic impacts that could be expected to result from increases in these delivered prices in the ORS region.

Economic Model for Navigation Impacts

The *REMI Policy Insight* v.9.5 model used in this study was built specifically for the purpose of evaluating the economic value of having a navigable Ohio River waterway. REMI's *Policy Insight* v.9.5 models include disaggregated industry data for 23, 70, or 169 sectors. The model for this study is a 70-sector model.

The REMI Model

REMI models combine years of economic experience into a software product with a graphical interface. REMI's model-building system employs numerous programs developed over the past two decades to build customized models, using data from the *U.S. Bureau of Economic Analysis*, the U.S. Bureau of Labor Statistics, the U.S. Department of Energy, the U.S. Census Bureau, and other public sources.

A major feature of REMI is that it is a dynamic simulation model that forecasts how changes in the economy and adjustments to those changes will manifest on a year-by-year basis. The

[2] "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies," U.S. Water Resources Council, March 1983.

model is sensitive to a very wide range of policy and project alternatives and to interactions among regional and national economies.

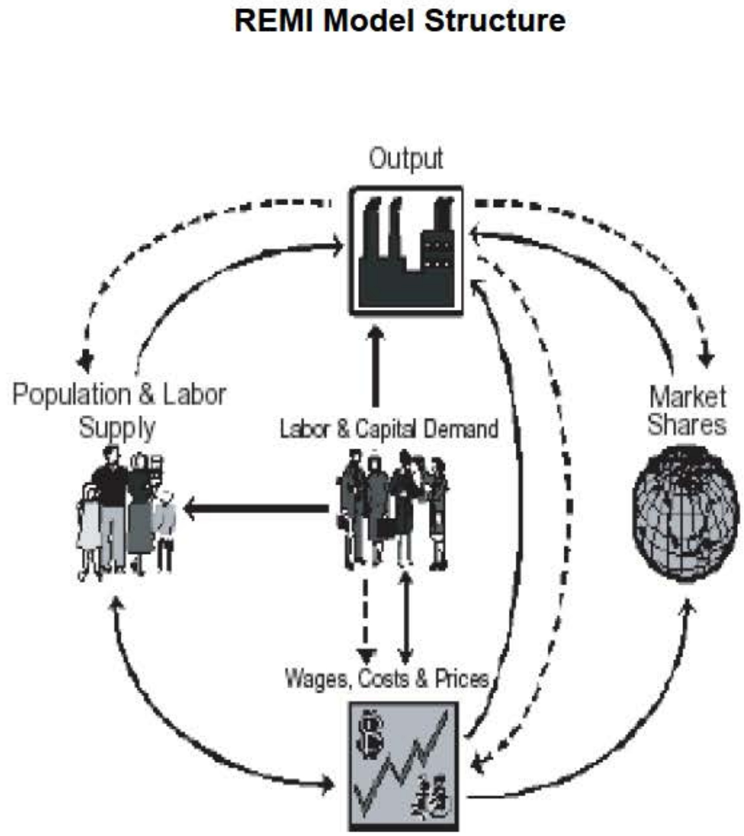
REMI embeds an econometric structure, in addition to input-output relationships, into their models in order to capture cause-and-effect relationships. Changes to five broad drivers are model inputs. These drivers constitute the major endogenous linkages in the REMI model: output; population and labor supply; labor and capital demand; market shares; and wages prices and profit. The model builds on two key underlying assumptions that guide economic theory: households maximize utility and producers maximize profits. Interested lay people, as well as trained economists, can understand the basic REMI model because these assumptions make sense.

In the model, businesses produce goods to sell to other firms, consumers, investors, governments, and purchasers outside their region. Output is produced using labor, capital, fuel and intermediate inputs. The demand for labor, capital and fuel per unit of output depends on their relative costs; an increase in the price of any input leads to substitution of that input for other inputs. The supply of labor in the model depends on the number of people in the population and the proportion of those people who participate in the labor force. Economic migration, whereby people respond to relative regional conditions, affects population size. People will move into an area if the real after-tax wage rates, the likelihood of being employed, and the access to consumer goods increase in a region. They will also move into an area if the attractiveness of the area improves due to changes in amenities.

Supply and demand for labor in the model determine the wage rates. These wage rates, along with other prices and productivity, determine the cost of doing business for every industry in the model. An increase in the cost of doing business causes an increase in production costs and the price of the goods or service, which would decrease the share of the domestic and foreign markets supplied by local firms. This market share, combined with the demand described above, determines the amount of local output. The model has many other feedbacks. For example, regional changes in wages and employment affect income and consumption, while economic expansion alters investment patterns and population growth affects government spending.

Figure 1 is a pictorial overview of the model. The Output block shows a factory that sells to all the sectors of final demand as well as to other industries. The Labor & Capital Demand block shows labor and capital requirements, depending on both output and relative cost. The Population & Labor Supply block is shown as contributing to demand and to wage determination in the product and labor markets. The feedback from this market shows that economic migrants respond to labor market conditions. Demand and supply interact in the Wages, Costs, & Prices block. Once costs and prices are established, they determine market shares, which along with components of demand, determine output.

Figure 1: REMI Model Structure



Source: *REMI Policy Insight v. 9.5: User Guide*

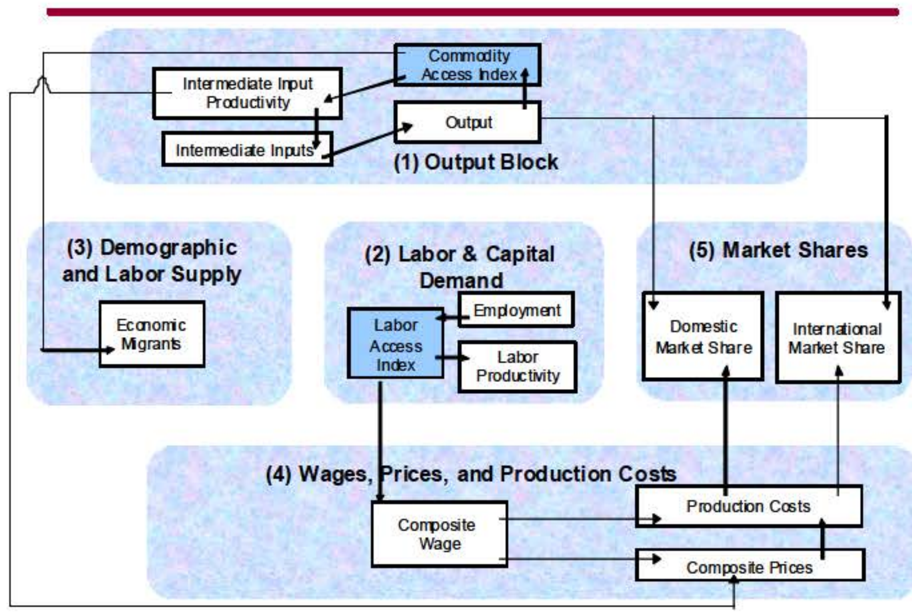
Linkages indicated by the dashed arrows depict effects of agglomeration in both the labor and product markets. These effects are crucial to accurately capture the key to why certain areas with a concentration of similar businesses can prosper despite high wages and real estate costs. By having a choice of suppliers and workers, firms can obtain specialized labor and input that best fulfills their needs to increase productivity and efficiency.

The dashed arrow from the Output block to the Cost block reflects the situation where more suppliers increase the efficiency of inputs, which can then reduce production costs and increase regional competitiveness. The dashed arrow from the Labor block implies that more labor will increase the productivity of labor, again making a region more competitive. The arrow from the OutputbBlock to the Population and Labor Supply block suggests that greater output may provide greater consumer choices, enhancing consumer satisfaction and resulting in a larger in-migration. The arrow from the Output block to the Market Shares block shows that a region with some industry concentration, by offering more to purchasers, can affect market share in addition to the price advantages through the Wages, Costs & Prices block.

The REMI model has strong dynamic properties, which means that it forecasts what can reasonably be expected to happen in the regional economies and when such occurrences will happen. The REMI model brings together all of the above elements to determine the value of each of the variables in the model for each year in the baseline forecast. Inter-industry relationships contained in typical input-output models are captured within the REMI Output block, but REMI goes well beyond typical input-output models by including the relationships among all of the other blocks shown in Figure 1.

The REMI economic geography module in Figure 2 details the dispersion and agglomeration effects among competing regions through two indexes in the model—the Commodity Access Index and the Labor Access Index.

Figure 2: REMI Economic Geography Diagram



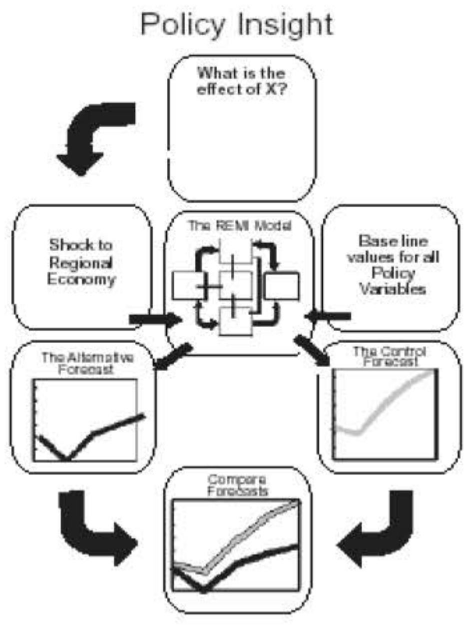
Source: *REMI Policy Insight v. 9.5: User Guide*

The Commodity Access Index assesses the impact of increased access to intermediate inputs on increased productivity and thus a reduction in production cost. Consumers benefit as well, due to the increased access to goods and services. The Labor Index captures the positive impact on labor productivity and cost as access to labor with a variety of skills expands. As land price rises and congestion sets in, economic activities tend to disperse.

The REMI model is designed to compute the effects of regional economic changes to regional economies arising from the five economic drivers. The baseline forecast uses the baseline assumptions for national and regional economic variables. Alternative forecasts are generated with user-specified input values for variables (referred to as 'policy variables') in the five drivers that measure the direct effects of potential changes in alternative scenarios.

Figure 3 illustrates how a problem is analyzed using the REMI model.

Figure 3: How REMI Analyzes a Problem



Source: *REMI Policy Insight 9.5: User Guide*

The ORS REMI model (ORSM) for this study comes with default baseline economic forecasts for three regions: an Ohio River System Region (ORSR), a Mississippi River System Region (MRSR), and a Rest of Nation (RoN) region. These baselines are the "control forecasts." The CTR found the ORSM's baseline forecast, as originally configured, did not sufficiently account for the level of water transportation demand in the ORSR, as determined in the course of the study to be actually taking place. The CTR made adjustments to the ORSM baseline forecast that more accurately reflects this demand.

Transportation savings to industries benefiting from barge transportation and changes in the transportation industry due to modal shifts are primary direct effects, or model 'shocks.' Once these changes to the directly affected economic sectors are introduced into the model, a simulation is run to produce a new forecast incorporating the economic impacts for the specific set of project costs and transportation savings. Total impacts result as the initial shocks work their way throughout the regional economies with multiplied effects, resulting in differences between the new forecast and the control forecast for policy variables of interest. For example, waterway changes that affect farm export shipping costs would affect local farm income and resulting spending. The REMI model tracks these effects throughout the regional economies as changes in all associated industries. Using the ORSM, this study reports regional total economic impacts, that is, the differences in the values of economic variables between the baseline forecast, which assumes the existence of an ORS navigable waterway, and an alternative which assumes no navigable ORS waterway.

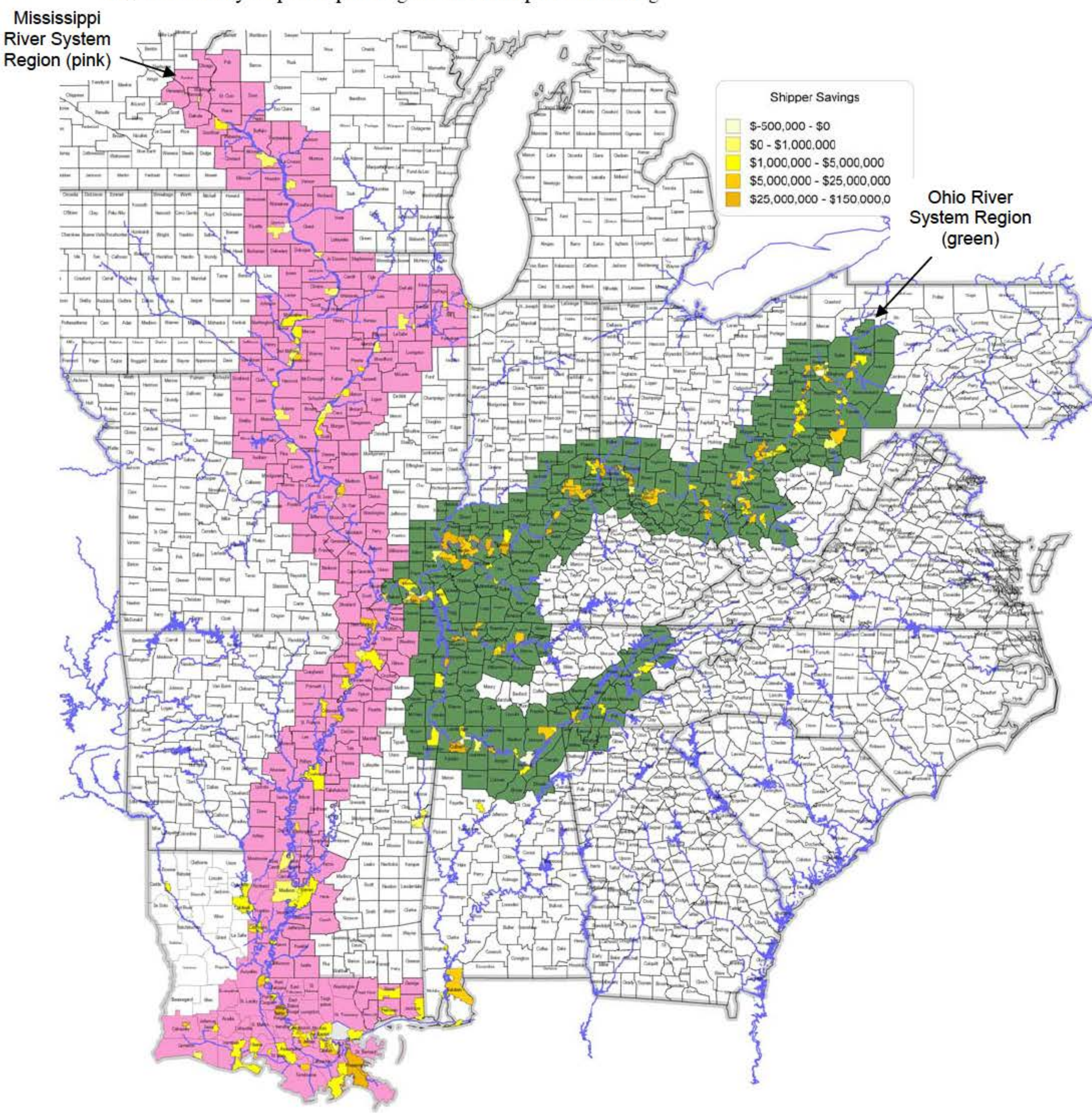
Definition of Model Regions for This Study

The ORS consists of the watersheds of the Ohio, Monongahela, Kanawha, Green, Cumberland, and Tennessee Rivers and their navigable streams. The primarily affected states are Alabama, Kentucky, Illinois, Indiana, Ohio, Pennsylvania, Tennessee, and West Virginia.

Figure 4 shows the delineation of the primary regions on which ORSM is constructed—the ORSR and the MRSR (a third model region is RoN). Each one is a composite of county aggregates, as the regions are generally defined so as to include an approximate two-county deep band around the navigable waterways. The CTR submitted the regional grid to the

Huntington District for their insight and comments. Mr. Chrisman (Chris) Dager of the Tennessee Valley Authority was also consulted as to the effectiveness of the "two-county" delineation. The consensus of opinion is that most economic activity tied to the river is located within this region. The county map is shown in Figure 4.

Figure 4: County Map of Impact Regions and Transportation Savings



The map in Figure 4 (County Map of Impact Regions and Transportation Savings) shows the two primary regions of interest in the study—the ORSR and the MSRS. The RoN includes those counties not included the ORSR and the MSRS. The regions are defined for the purposes of the study as, approximately, a two- deep county aggregation around each of the river systems of interest[3]. The sizes of the two regional economies are reflected in the basic economic statistics from the REMI Model for the two regions, shown in Table 1.

Table 1: 2006 ORSR and MRSR - Basic Economic Statistics (REMI Model)

Dollars are in 2006 billions; population and employment are in thousands.

Output	$1,001.7	$1,899.3
Gross Regional Product (GRP)	$608.8	$1,192.5
Personal Income	$542.4	$916.1
Population	15,323	23,761
Employment	8,967	14,598

Also shown on the map are the locations of the transportation savings, as determined and assigned in this study; the yellow-orange tinted patches depict ranges of shipper saving for 3-digit ZIP code areas (5-digit data have been aggregated to make the locations sufficiently visible on the map). In a few instances, transportation savings are negative, indicating a less costly transport mode is available for a movement. In some cases, transportation savings accrue to areas outside the two regions, and those data are ORSM inputs for the model's RoN region.

Methodologies Used to Evaluate ORS Commercial Navigation

Overview

The Ohio River navigation system has proven to be an efficient and cost-effective means of transporting a variety of goods. The locks and dams allow waterway traffic to move from one pool to another and constitute integral parts of a regional, national, and international transport network.

Coal is the principal commodity shipped on the Ohio River. There are over 50 coal-fired power plants in the ORS, providing 20% of the nation's coal-fired electric generating capacity (Platt's CoalDat Database). Electricity rates in the region are among the lowest in the nation; a primary reason is the relatively inexpensive transportation costs to deliver coal to the power plants via the waterway. Per weight of commodity, coal accounts for 50-60% of the ORS waterway shipments (U.S. Army Corps of Engineers, Waterborne Commerce Statistical Center).

This study provides estimates the regional total economic value of the commercial barge transportation, using a leased copy of the 70-sector REMI model (Regional Economic Models, Inc.) built for the ORS. As noted, the REMI model is customized for three regions, and built into each reach are economic linkages with the other two.

To integrate barged commodity shipments into the ORSM, some 1,500 movements on the Ohio River and tributaries in 2006 are linked with one of the model regions and one of its 70

[3] It is known that a two-deep county region captures all of the direct shipper savings effects and is believed, in Phase I, to account for most of the associated indirect effects, A three-deep region would have caused measurement problems at the confluence of the Ohio and Mississippi Rivers in that it that one river basin would impinge on the other. Thus, for presentation purposes the authors settled on a two-deep county region. In Phase II the study area was broadened as data became available.

industry sectors, according to who bears the burden of the shipping cost.[4] Shipping costs for non-agricultural goods generally increase the cost of the goods to the purchasing industry. For example, steel coils might be input into fabricated metals production. For export agriculture product shipments, transportation costs are assumed to be borne at the shipment source rather than at the receiving end, where world market prices prevail. After developing the direct effects, data are input to the REMI model to simulate and forecast impacts for two model scenarios.

The forfeiture of freight savings, resulting from an unavailability of commercial barge transportation, causes a rise in production costs in the appropriate industry sectors. It is assumed that no firm or industry ceases operation without the availability of barge transportation; rather, shipments are assumed to switch to the next least costly mode, thus eliminating the waterway transportation savings for movements. In the resulting model simulation, competition among firms, industries, and regions effects alterations in production, income, and resource allocation over time.

For the electric utility sector, changes in residential, commercial, and industrial electric rates are imposed on the model. The economic consequences from a loss of navigable water to water-sited electric utilities are accounted for by increases in their electric rates to residents and businesses. These cost increases are estimated using results rooted in the linear regression analysis of U.S. electric generating plants, configured and applied to the ORSM. The results are incorporated into the ORSM so as to account for changes in the price of electricity. As will be discussed in more detail below, in the first phase, the electric rate effect is accounted for only in the ORSR, while a second phase extends that effect into the rest of the nation.

Additionally, a loss of navigable water alters the transportation demand structure among transportation industries. Barged freight must now be moved by rail or truck. These demand shifts and the transfer of resources required to move the same freight by less efficient, more labor intensive, transport modes are inputs into the REMI model.

The second model scenario simply adds an additional direct effect to those in the first scenario by including the impacts arising from the absence of the Boeing/Lockheed Martin plant that located in the ORSR because of the commercial barge channel, assuming it would have located, instead, somewhere in the model's RoN region.

Waterway Transportation Savings

In modeling barge transport savings, as noted above, industry production costs (or other policy variables, depending on the benefiting industry) in the appropriate industry sectors will rise as transportation savings from the ORS navigable waterway are eliminated, and no firm or industry will cease operation due to unavailability of barge transportation, but instead will switch to the next least costly transport mode.

The transportation savings data underlying the input into the REMI model were developed by Mr. Chrisman (Chris) Dager at the TVA in his large and detailed study of shipping on the Ohio and Mississippi River systems, which was undertaken in 2006. The detailed data for the approximately 82% of ORS shipment tons were provided to the CTR, which aggregated shipments to commodity and origin-destination pairs. The movements were assigned 5-digit

[4] Mr. Chrisman (Chris) Dager of the Tennessee Valley Authority identified the commodity-industrial sector linkages for the study based on information obtained from field interviews of shippers, undertaken by TVA in support of the USACE. These movements comprise approximately 82% of ORS total tons shipped in 2006. Mr. Dager believes the remaining movements have transportation savings values that are generally greater than those found in the 1,500 movement set. Thus, it is likely that the economic impacts determined in this study are underestimates.

ZIP codes, which were used to assign the shipments to the appropriate benefiting region (origin or destination according to the commodity type and destination) by cross-referencing with county Federal Information Processing Standards (FIPS) codes. Figure 4 shows the locations of the transportation savings totals by ranges of magnitude, using 3-digit ZIP code boundaries for visibility. The transportation savings aggregated by model region and industry group are given in Table 2.

Table 2: Transportation Savings for Three Regions by Major REMI Industry Sectors (2006 $)

Benefiting Industry	ORS	MRS	Rest Of Nation
Air Transportation	$7,969,500	$ —	$ —
Chemicals	213,176,924	7,899,608	24,472,932
Construction	321,595,629	175,347,007	33,252,381
Electrical Equip. Mfg.	1,632,668	—	—
Fabricated Metals	10,236,993	1,761,925	3,021,792
Farms - Animal (Destination)	855,900	15,941,750	—
Farms - Crop (Destination)	30,268,712	1,494,183	—
Farms - Crop (Origin-Exported)	63,875,058	22,428,188	477,151
Food Mfg.	2,969,370	6,353,352	—
Government	27,785,312	—	—
Misc. Mfg.	8,936,751	24,997	-38,214
Nonmetallic Mineral Product Mfg.	53,242,166	6,156,555	7,097,175
Paper	766,505	—	—
Petroleum Mfg.	15,726,178	1,108,167	—
Plastics and Rubber	23,973,850	—	—
Primary Metals	426,173,412	35,729,246	29,505,160
Wholesale Trade	163,042,943	19,734,239	1,365,703
Wood Products Mfg.	15,358,659	3,340,927	—
Utilities	1,138,731,592	153,234,348	6,708,739
Region Total	2,526,318,121	450,554,494	105,862,818
Grand Total, All Regions = $3,082,735,433			

Source: TVA.

For model purposes, these transportation savings are forecast based on the ORSM baseline growth patterns and are input into the ORSM for impact simulation as changes in the appropriate REMI policy variables for the region and industry—production costs, in most instances, but farm income for export agricultural products and state and local government spending for government. Additionally, the demand changes for the transportation industry resulting from a loss of the ORS navigable waterway and shifts to alternative transport modes are forecast and input into the model. These adjustments are shown in Table 3. As these net demand changes require additional resources from the economy, due to their being less efficient, the net changes are adjusted in the rest of the economy to account for the transfer of resources.

Table 3: Transportation Industry Demand Changes (2000 $)

Industry	2006
ORS Water Transportation	-$2,694.000
ORS Rail	3,108.390
ORS Truck	1,714.097
MRS Water Transportation	-595.445
MRS Rail	952.682
MRS Truck	78.428
RoN Water Transportation	-115.153
RoN Rail	187.262
RoN Truck	11.554

Electric Rate Effects

There are good reasons to believe commercial transportation savings for coal shipments to electric power generating plants may not adequately capture the full direct effects of a navigable waterway on the facilities; for example, the waterway may also facilitate plant maintenance and affect plant design with respect to cooling water. Therefore, transportation savings direct effects for electric power utilities in the ORS are not input into the model, but instead, direct effects of the waterway on the utilities are entered through policy variables reflecting electric rate changes. This approach necessitates additional preparation of data inputs amenable to the model's capabilities.

Specifically, the model requires percentage changes in regional electric rates due to loss of navigable water. In Phase I these effects are accounted for only in the ORSR. The resulting impacts, however, displayed very little differences from using only transportation savings as a direct effect on utility production costs. This prompted CTR to consider that the electric rate effects should be extended beyond the ORSR, reflecting a more realistic distribution of electricity effects by Power Service Area (PSA), extending well beyond the ORS region. This is done in Phase II of the study.

Electric Utility Impacts Example: TVA Electric Power Plants

The TVA is a heavy user of barge transportation on the Tennessee, Cumberland, Green, Ohio, and Mississippi Rivers. The TVA has coal steam plants on the Cumberland (Gallatin), Tennessee (New Johnsonville, Colbert, Widows Creek, and Kingston), Green (Paradise), and Mississippi (Allen) that either receive coal or are serviced from the water side of the plants. The Kingston and Bull Run coal steam plants, located on the upper Tennessee and Clinch Rivers respectively, receive coal via rail transportation. Cranes are barged to the plants to do maintenance, and about 18 million tons of coal are barged annually to the above-mentioned coal steam plants. Both the coal and nuclear plants were built and designed to be serviced from the water side, due to the economies of water transportation. Barge mounted cranes are used to move and service items such as rotors and generators and to clean out trash racks. Pollution control equipment was also barged to the plants for installation.

As a result of being on navigable water, TVA and similar utilities gain significant cost advantages. The advantages ensue from lower equipment usage costs for servicing and maintaining steam plants, lower coal transportation rates—whether by barge or 'water-compelled' rail freight rates (wherein the rail carriers adjust their freight rates downward to match those of barge transportation)—and, possibly, access to lower cost cooling water in impoundments built and maintained for navigation.

Unfortunately, it is not feasible with available data to completely isolate the non-coal barge cost components of these advantages. Instead, in a prior study of the value of navigable water to TVA plants[5], that benefit was approximated by estimating total savings for plants on the waterway and subtracting the savings accruing to delivery of coal by barge transportation. The results showed a significant utility cost savings above and beyond the barge shipping savings. Based on that finding, the economic impacts estimated using electric rates can be expected to be greater than those captured solely by the calculated transportation savings.

Electric Utility Cost Regression Model[6]

A cross-sectional regression model is used to estimate electric utility production cost differentials for U.S. plants sited on inland navigable water (excluding the Great Lakes). These estimates are the direct effects that are input to the REMI model.

It is well known that generating plant size and the rate at which a plant is utilized are important determinates of the unit cost to operate a plant. The TVA study's cost function uses variables for these parameters whose values can be obtained from available secondary data. Additionally, a major shift in plant technology is posited with a (0,1) dummy variable for the year the plant's generating capacity was installed (1989 being the year for major change). The presence or absence of cooling towers is another potential production cost factor, and the function includes a dummy variable for it. The variable needed for the waterway impact estimation, a waterway dummy variable, is included to test and measure the effect of a navigable stream on plant costs. The components of steam power production costs (expenses), as defined by FERC (Federal Energy Regulatory Commission), are shown in Table 4.

Table 4: Steam Plant Production Expenses

Operation expenses	Maintenance expenses
Supervisions and engineering	Supervision and engineering
Fuel	Structures
Steam expenses	Boiler plant
Electric expenses	Electric plants
Miscellaneous steam power expenses	Miscellaneous steam plant
Rents	

Electric utility plant production costs per megawatt, then, are modeled as follows:

$$\ln(TCOST) = a_1 + a_2 * \ln(NETGEN) + a_3 * \ln(CAPFAC) + a_4 * WDUM + a_5 * CDUM + a_6 * YRDUM + \varepsilon,$$

where

TCOST = total generating production costs per megawatt

NETGEN = net generation in megawatts

CAPFAC = capacity factor or percent of plant capacity

WDUM = presence of a navigable stream (yes = 1)

CDUM = cooling tower dummy (yes = 1)

[5] *Large-Load and Special-Use Barge Movements on the Inland Waterway System: Their Economic Impacts in the Tennessee and Cumberland River Valleys*, a Tennessee Valley Authority study, prepared for the USACE, October 2005.

[6] This section is based on the TVA report noted above. The regression model and results used in this study are those for one of the models estimated in the TVA report.

YRDUM	=	year of installation dummy variable (1989 and forward = 1)
ε	=	standard OLS random error term

The waterway dummy variable, a_4, is expected to have a negative sign in the cost equation.

From this model, the direct effects of navigable waterways on electric rates are derived. By assumption, an increase in plants' production costs results in the need for additional revenues, and, thereby, eventuates in a rise in electric rates to close the revenue gap. Given the market structure of electric utility plants and an inelastic demand for electricity, this appears to be a reasonable assumption. Further, cost/rate issues can be viewed in light of the *Economic and Environmental Principles and Guides for Water and Related Land Resources Implementation Projects*, which states that any increase in transportation costs is passed along to the user as a proportionate rate increase. While the Guidelines focus on transportation rates, the same concept can be considered applicable to the present study; that is, cost changes can reasonably be directly translated into rate changes.

Appendix B: Electric Utility Waterway Effects Regression details the regression analyses and statistics.

Electric Rate Effect Estimation for Loss of Navigable Water Access

An electric power plant cost increase due to a loss of navigable water is estimated from the value of the regression coefficient for the waterway dummy variable discussed above. Using the plants in the FERC database that are located on waterways, their production expenses per megawatt hours (MWH) at the log mean are computed. Another estimate is similarly calculated wherein the waterway dummy variable is turned off. The difference in the per MWH expenses yields a point estimate of the MWH savings due to having plants located on a navigable stream.

Table 5 shows the calculation of the percentage increase per MWH to be attributed to navigable water. The average logarithm of production cost per MWH across all plants in the regression dataset is $3.00, which converts to $20.17 in non-logarithmic form. If the navigable waterway were unavailable, the mean plant's production costs would rise to $23.50, or a 16.6% increase.

Table 5: Coal Plant Regression - Estimated Production Cost Effect

Parameter	Value
Avg. Ln Production Cost. Per MWH	$3.00
Avg. Production Cost Per MWH	$20.17
Waterway Dummy Coefficient	-0.153
No-Waterway Cost	$23.50
Cost Per MWH Attributed To Navigable Water	$3.34
% Cost Increase Per MWH	16.6%

Navigable Water Captive Firm Effect: The Decatur Boeing Plant

In October of 2000, Boeing Company employees at their plant in Decatur, Alabama, completed the assembly of the first Delta IV common booster core (CBC), which is the largest element of the Boeing rocket. Boeing chose the site on the commercially navigable Tennessee River for a variety of reasons, including the fact that the CBCs are too large for transport by land-based trucks or aircraft. Thus, these rockets, if constructed away from the launch site, must have easy access to commercial water transportation. The CBCs measure

150 feet (45 meters) long and 16 feet (five meters) wide. At the Decatur plant, transportation of these huge booster cores is made possible by Foss Maritime's Delta Mariner, a vessel that can carry three CBCs in its main cargo hold.[7] The Delta Mariner sails from Decatur down the Tennessee River and ultimately to the launch pad.

In 2006, the Boeing Corporation and Lockheed Martin merged their operations to create the United Launch Alliance (ULA). There are three families of launch vehicles produced by the ULA plant: Delta II, Delta IV, and Atlas V. It is predicted that the current employment at the Decatur plant, about 637, will increase to between 700 and 800.[8]

In the simulation of ULA's impact on the ORS, it is assumed that the rocket plant is captive to the river. The regional direct benefit of the plant is its employment, thus entailing an increase in employment in the REMI sector "transportation, excluding motor vehicles." Through 2010, the employment level is set at 650. After 2010, the number rises to 750.

Phase I Methodologies

Methodology I: Industry Cost Savings from Barge Transportation

In this initial modeling effort, the loss of barge transportation cost savings for most industries is entered into the REMI model as increases in production costs for the recipient industry. Utilities are treated like other industries, with direct effects entered as production cost changes. For export agriculture, the losses are entered as decreases in farm income, while for government, expenditures are increased. Transport industry demand shifts are adjusted for modal shifting.

Methodology II: ORSR Electric Rate Analysis

CTR suggested to Marshall University that the power cost increase approach be included in the scope of work as a way to gain some degree of validation and possible improvement in the impact estimations that result from the first approach, which relies solely on the direct translation of transportation savings into the REMI model's industry cost changes. A prior study undertaken at the TVA in 2005 found significant additional savings to electric power plants beyond the calculated savings from coal transportation.[9]

As a result of being on navigable water, TVA and similar utilities likely gain a cost advantage from several sources. One is lower equipment usage costs for servicing and maintaining steam plants. Cranes are barged to the plants to do maintenance. Both coal and nuclear plants have been built and designed to be serviced from the water side, due to the economies of water transportation. Barge mounted cranes are used to move and service certain items such as rotors and generators and to clean out trash racks. Pollution control equipment was also barged to the plants for installation. Additionally, some plants may benefit from access to lower cost cooling water in impoundments built and maintained for navigation. Finally, transportation savings as calculated (that is, by comparison of barge costs with the next cheapest mode) may underestimate the true impact as a result of 'water-compelled' rail freight rates, wherein rail carriers adjust their freight rates downward to match those of barge transportation. For all these reasons, the impacts obtained from the sole use of transportation savings direct effects may not sufficiently account for all the economic advantages accruing to power plants sited on navigable water.

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[7] www.space.com/missionlaunches/launches/delta_mariner_010705-1 html. Web site was accessed May 6, 2009.

[8] Fleischauer, Eric. "Boeing, Lockheed tie the knot-ULA merger's official OK means more jobs for Morgan County," The Decatur Daily, Saturday, December 2, 2006.

[9] *Large-Load and Special-Use Barge Movements on the Inland Waterway System: their Economic Impacts in the Tennessee and Cumberland River Valleys*, a Tennessee Valley Authority study, prepared for the USACE, October 2005.

To simulate an increase in price of commercial and industrial electricity consumption, an ORSR electric rate change is calculated by applying the regression result for the percentage increase in utility cost per MWH to ORS electric plants and calculating a megawatt (MW) company-wide capacity-weighted change.

The steps of the first phase steps in implementing the study's methodology for estimating ORSR and MRSR impacts due to ORSR rate changes derived the regression analysis are as follows:

- From log regressions of U.S. electric plant data, use the percentage savings at plant generating costs (log) mean due to location on navigable water (16.6%).
- Identify companies with plants on ORS navigable water (using multiple sources to cross-validate).
- Determine overall percent of MW (megawatt) capacity for plants on ORS navigable water for these companies.
- Calculate weighted average cost increase with loss of navigable water; input into REMI commercial and industrial electricity fuel cost shares.
- Estimate increases in prices of residential energy consumption. To incorporate in the ORSM, increase the model's cost-of-living as follows:
    - Obtain the latest (December 2008) CPI weights for components of REMI's Consumer Price (Share): Household Operation policy variable, consisting of the following:
        - electricity
        - gas
        - telephone
        - water and sanitary services
        - domestic services and other household operations (not elsewhere classified)
    - Calculate the total electricity percentage of household operations
    - Enter electricity percent into REMI policy variable for Consumer Price (Share): Housing Operations.

The resulting changes in ORSR electric rates are shown in Table 6.

Table 6: ORSR Electric Rate Direct Effects

REMI Policy Variable	Input Value
Electricity Fuel Cost (share) - Industrial	7.89%
Electricity Fuel Cost (share) - Commercial	7.89%
Consumer Price (share) - Household Operations	2.85%

For Phase I impact simulation, these electric utility rate changes are input into the ORSM for this scenario, along with the production cost changes for the other industries and the transport industry demand changes. The value, 7.89%, is input into the ORSM policy variable: Electric Fuel Costs Share - Industrial and Commercial. The Electricity Fuel Cost Share policy variable changes the relative fuel costs of electricity by the percentage entered, resulting in substitution among power sources. In REMI, this variable does not alter employment in the public utility sector through a price elasticity response.

To simulate an increase in price of residential electricity consumption in the ORSR, an increase in the CPI for housing operations (of which electricity spending is a component) is entered in the REMI model. The change to the residential electricity rate direct effect is prepared by adjusting the utility percentage increase per MWH by the proportion that electricity bears to total household operations in the CPI: the result is 2.85%. The REMI Consumer Price (Share) for Housing Operations policy variable changes the housing component price by the percentage entered. The amount is the change in consumer purchasing power (opposite in sign).

Shortcomings in Phase I ORSR Electric Rates Analysis

In Phase I, the CTR initially undertook to evaluate the ORS regional impacts resulting from transportation savings effects on industry cost structures from barging commodities, including coal to electric power plants. The focus was on a region consisting of a fairly narrow band of counties encompassing the ORS waterways, with a similar secondary band around the Mississippi River. Initially, direct effects to a REMI model constructed for these regions consisted of (1) industry transport cost savings, as they impinge upon industry production costs and (2) inter-industry demand changes resulting from transport industry modal shifts from barge to rail and truck, taking into consideration the transfer of resources to the less efficient, more labor-intensive modes.

As Phase I progressed, the treatment of the utility sector was modified in realization that the REMI model alone does not contain the necessary economic apparatus to fully account for how changes in utility cost structures affect regional electric rates and how those rate changes affect energy consumers in all the regional economies. A more complete picture of potential electric rate impacts requires additional analysis and data preparation external to the model. The method employed to account for changes resulting from ORS electric utility use of navigable water is rooted in a prior TVA study's regression analysis of electric plant cost differentials attributable to waterway siting, using a sample of U.S. electric plants, both on and off navigable water. With this approach, residential and non-residential electric utility rate effects are entered into the REMI model for the ORSR.

Contrary to CTR's expectation, simulation results from this electric rate approach, however, yielded very little difference from the production cost approach for the impacts. Further reflection on the limitations of the analysis and the particular use of the ORS REMI model has led the CTR to propose and undertake a broader approach to evaluating the value of the waterway in light of its particular significance to electric power facilities that extends to the rest of the nation.

Phase II: Extending Electric Rate Effects beyond the ORSR

In this extended approach, the CTR takes into account the fact that utilities relying on power from generating plants operating on the ORS waterways have power service areas (PSAs) extending well beyond the model-defined ORSR. To implement this for impact analysis in Phase II, the non-electric utility sector in each region is again shocked with both the transportation industry modal shift demand adjustments and with the loss of ORS transportation savings to industries (excluding electric utilities) through the model's mechanism of production cost changes (or revenue or income changes, depending on the benefiting industry) in the industries affected. The effects in the electric utility industry due to cost structure changes in this extended study, however, go beyond the ORSR and are accounted for by exogenous estimates of the changes in electric rates in all affected ORS generating plant distributors' PSAs. As generating companies are expected to price their electricity on a system-wide basis, major tasks in this phase are to quantify their electric rate impacts attributable to one or more of their plants being on navigable water and to identify the applicable portions of distributor power service areas by county, ultimately quantifying those rate changes for all model regions and inputting them as appropriately formulated direct effects into the REMI model for impact simulation.

The following sections summarize the data sources relied upon and the major analytical components involved in this more comprehensive investigation into ORS electric rate impacts.

Electric Power Industry Data Sources

Platts is the primary source for the power utility generation and distribution data used in the study, supplemented as needed, with information from EIA, FERC, company reports and other reports found on the Web. Both the *Platts Directory of Electric Power Producers and Distributors* and a map of distributors purchased from Platts were extensively employed. Generator-owner-distributor relationships are sometimes complex, dynamic, and elusive; the CTR made reasonable efforts to get them as complete and correct as the available resources would allow.

Components of Extended Electric Analysis

Power Generation Cost Savings

All power plants owned by utility companies owning electric power plants on ORS waterways are identified. The ORS and non-ORS plants are separated, and ORS megawatt (MW) percentages are calculated for each generating company. From this company-wide rate effect, weighting factors are calculated on the assumption electric rates are set at the company level.

ORS Plant Owners and Distributors

Over 140 distributors—generation and distribution companies, independent distributors, municipals, and co-ops—for the 18 generating companies are identified, making full use of Platts data and drawing upon any other available sources when needed. Excluding Allegheny Energy (due to not being able to precisely identify a portion of the service population) these distributors served nearly 14 million residences.

Generators and Distributors Rates

Using Platts data, electric rates are averaged over the distributors for each generating company for each type of rate: residential, commercial, and industrial.

Power Distributor's Power Service Areas County Percentages

By state, the percentage of every county served by each distributor (for each of 829 counties) is estimated primarily from a visual inspection of the 2007/2008 Platts power service areas map, taking into consideration customer agglomerations in cities over 10,000 and in municipal utilities.

Population and Employment Totals

The 2006 Bureau of Economic Analysis (BEA) population and total employment is summed for the power service area encompassed by the 829 counties and for the generating companies over their distributors' power service areas, applying the county power service area percentages to each county.

Electric Rate Effect Calculations

Table 7 shows ORS generating companies and their ORS MW percentages and average rates, along with the rate weights.

Table 7: ORS Electric Generating Companies

Company	ORS MW %	Avg. Rate Cents per kWh	Rate Weight
Allegheny Energy Supply Co. LLC	24.8%	7.01	0.90
Appalachian Power Co.	69.0%	5.85	0.75
Cardinal Power Generation	65.4%	8.62	1.11
Cincinnati Gas & Electric (Duke Energy Ohio Inc.)	50.3%	9.33	1.20
Dayton Power & Light Co.	77.7%	9.40	1.21
Duquesne (Orion Power Midwest LP)	38.2%	9.21	1.19
East Kentucky Power Co-op, Inc.	6.8%	9.41	1.21
FirstEnergy Generation Corp (Ohio & PA only)	56.0%	9.68	1.25
Indiana Michigan Power Co.	61.6%	6.73	0.87
Kentucky Utilities Co.	55.4%	6.03	0.78
Louisville Gas & Electric Co.	92.7%	6.76	0.87
Monongahela Power Co.	77.9%	7.25	0.93
Ohio Power Co.	75.8%	7.53	0.97
PSI Energy Inc. (Duke Energy Indiana Inc.)	7.2%	8.19	1.05
Southern Indiana Gas & Electric Co.	86.8%	8.97	1.15
Tennessee Valley Authority	45.0%	7.12	0.92
Union Light Heat & Power (Duke Energy Kentucky Inc.)	57.8%	6.48	0.83
Western Kentucky Energy Corp	78.5%	6.24	0.80
Average		7.77	

Table 8 gives the estimated 2006 population for the PSAs.

Table 8: Distributor PSA Population by Region

Company	ORS PSA Pop.	MSR PSA Pop.	RoN PSA Pop.
Allegheny Energy Supply Co. LLC	1,107,766	—	1,695,918
Appalachian Power Co.	575,880	—	1,229,783
Cardinal Power Generation	346,487	—	1,500,441
Cincinnati Gas & Electric (Duke Energy Ohio Inc)	1,452,216	—	—
Dayton Power & Light Co.	42,834	—	1,006,311
Duquesne (Orion Power Midwest LP)	1,163,059	—	—
East Kentucky Power Co-op, Inc	423,328	—	760,495
FirstEnergy Generation Corp. (Ohio & PA only)	716,741	—	12,145,116
Indiana Michigan Power Co.	—	—	920,450
Kentucky Utilities Co.	234,189	1,519	446,069
Louisville Gas & Electric Co.	768,703	—	—
Monongahela Power Co.	539,828	—	216,416
Ohio Power Co.	254,787	—	1,025,478
PSI Energy Inc. (Duke Energy Indiana Inc)	344,144	—	1,105,146
Southern Indiana Gas & Electric Co.	278,659	—	—
Tennessee Valley Authority	5,270,493	1,349,800	2,261,569
Union Light Heat & Power (Duke Energy Kentucky Inc)	303,811	—	—
Western Kentucky Energy Corp.	200,141	—	—
Total of Distributors	14,023,066	1,351,319	24,313,192
Region Population	15,323,469	23,367,216	256,243,909
PSA % of Region	91.5%	5.8%	9.5%

Previous research[10] identified an average 16.6% increase in electric generating plant costs if they were to lose access to navigable water. Putting it all together yields the following residential rate changes for input into the ORS REMI model:

Table 9: Distributor Residential Rate Changes by Region

Company	ORS Rate Change	MSR Rate Change	RoN Rate Change
Allegheny Energy Supply Co. LLC	0.26%	—	0.02%
Appalachian Power Co.	0.31%	—	0.04%
Cardinal Power Generation	0.26%	—	0.07%
Cincinnati Gas & Electric (Duke Energy Ohio Inc)	0.92%	—	—
Dayton Power & Light Co.	0.04%	—	0.06%
Duquesne (Orion Power Midwest LP)	0.55%	—	—
East Kentucky Power Co-op, Inc	0.04%	—	0.00%
FirstEnergy Generation Corp (Ohio & PA only)	0.52%	—	0.53%
Indiana Michigan Power Co.	—	—	0.03%
Kentucky Utilities Co.	0.11%	0.00%	0.01%
Louisville Gas & Electric Co.	0.65%	—	—
Monongahela Power Co.	0.41%	—	0.01%
Ohio Power Co.	0.20%	—	0.05%
PSI Energy Inc. (Duke Energy Indiana Inc)	0.03%	—	0.01%
Southern Indiana Gas & Electric Co.	0.29%	—	—
Tennessee Valley Authority	2.27%	0.38%	0.06%
Union Light Heat & Power (Duke Energy Kentucky Inc)	0.15%	—	—
Western Kentucky Energy Corp	0.13%	—	—
Total Rate Change	7.134%	0.382%	0.887%
x 0.361 Residential Adjustment Factor			
= REMI CPI Household Operations Effects	2.575%	0.138%	0.320%

Similar calculations, but this time using employment for the PSA allocations, yield the following rate changes for commercial rates:

[10] *Large-Load and Special-Use Barge Movements on the Inland Waterway System: their Economic Impacts in the Tennessee and Cumberland River Valleys*, a Tennessee Valley Authority study, prepared for the USACE, October 2005.

Table 10: Distributor Commercial Rate Changes by Region

Company	ORS Rate Change	MSR Rate Change	RoN Rate Change
Allegheny Energy Supply Co. LLC	0.26%	—	0.03%
Appalachian Power Co.	0.31%	—	0.03%
Cardinal Power Generation	0.22%	—	0.07%
Cincinnati Gas & Electric (Duke Energy Ohio Inc)	1.03%	—	—
Dayton Power & Light Co.	0.05%	—	0.05%
Duquesne (Orion Power Midwest LP)	0.33%	—	—
East Kentucky Power Coop, Inc	0.03%	—	0.00%
FirstEnergy Generation Corp (Ohio & PA only)	0.51%	—	0.58%
Indiana Michigan Power Co.	—	—	0.03%
Kentucky Utilities Co.	0.11%	0.00%	0.01%
Louisville Gas & Electric Co.	0.86%	—	—
Monongahela Power Co.	0.35%	—	0.01%
Ohio Power Co.	0.14%	—	0.04%
PSI Energy Inc. (Duke Energy Indiana Inc)	0.03%	—	—
Southern Indiana Gas & Electric Co.	0.30%	—	—
Tennessee Valley Authority	2.80%	0.46%	0.06%
Union Light Heat & Power (Duke Energy Kentucky Inc)	0.15%	—	—
Western Kentucky Energy Corp	0.13%	—	—
REMI Commercial Rate Effects	7.598%	0.459%	0.927%

Finally, the following input values are for industrial rates:

Table 11: Distributor Industrial Rate Changes by Region

Company	ORS Rate Change	MSR Rate Change	RoN Rate Change
Allegheny Energy Supply Co. LLC	0.25%	—	0.03%
Appalachian Power Co.	0.28%	—	0.03%
Cardinal Power Generation	0.20%	—	0.06%
Cincinnati Gas & Electric (Duke Energy Ohio Inc)	0.99%	—	—
Dayton Power & Light Co.	0.03%	—	0.03%
Duquesne (Orion Power Midwest LP)	0.51%	—	—
East Kentucky Power Co-op, Inc	0.06%	—	0.01%
FirstEnergy Generation Corp (Ohio & PA only)	0.47%	—	0.54%
Indiana Michigan Power Co.	—	—	0.05%
Kentucky Utilities Co.	0.10%	—	0.01%
Louisville Gas & Electric Co.	0.80%	—	0.00%
Monongahela Power Co.	0.33%	—	0.01%
Ohio Power Co.	0.12%	—	0.04%
PSI Energy Inc. (Duke Energy Indiana Inc)	0.02%	—	—
Southern Indiana Gas & Electric Co.	0.28%	—	—
Tennessee Valley Authority	2.79%	0.46%	0.06%
Union Light Heat & Power (Duke Energy Kentucky Inc)	0.17%	—	—
Western Kentucky Energy Corp	0.07%	—	—
REMI Industrial Rate Effects	7.485%	0.458%	0.857%

Economic Impacts Attributable to ORS Navigable Water

This section contains the impact results obtained from the application of the methods discussed above. The focus in Phase I is primarily on economic impacts on the ORSR, and electric rate effects are prepared only for the ORSR. Phase II extends the results, incorporating electric rate effects into the rest of the nation by exogenous determination of rate changes in the PSAs for distributors of electricity generated by plants on the ORS.

The tables in this section report the total impacts attributable to the ORS waterway in each of the two phases. In the first, the analysis is limited to ORSR electric rate effects, and in the second, the analysis extends the electric rate effects beyond the ORSR. Impacts are provided for two models in each of the two phases: first, a model that employs the electric utility effects, the non-electric utility transportation production cost savings effects, and the modal shift effects adjusted to compensate for the employment of additional resources into less efficient transport modes; and, second, a model that adds the impact from shifting the Decatur Boeing plant out of the ORSR, under the assumption that it would have located elsewhere in the rest of the nation had navigable water not been available in the ORS.

With the REMI model, effects do not fully work out instantaneously, as might be the case in non-dynamic input-output models, but, more realistically, they work out over a forecast period from 2006 to 2050, where adjustments by regions and firms are allowed to take place over time according to econometrically-specified relationships.

Phase I Models: Economic Impacts

Table 12 shows 2050 resulting impacts for the Phase I model simulations employing: (1) only production cost effects, (2) the non-utility production cost effects plus the ORSR electric rate effect changes, and (3) the non-utility production cost effects plus the ORSR rate effect changes plus the Boeing impact.

Table 12: Phase I Impact Results

Region	Parameter	Present Value of Impact Stream to 2050* (Billions 2006 $) Production Cost Model	Electric Rate Model	Electric Rate Model + Boeing
ORSR	Output	$272.6	$273.1	$287.5
MRSR	Output	75.9	75.7	75.7
RoN	Output	-89.7	-95.8	-116.4
USA	Output	258.8	252.9	246.7
ORSR	GRP	157.2	156.7	163.5
MRSR	GRP	42.8	42.6	42.6
RoN	GRP	-$74.4	-78.7	-88.8
USA	GRP	125.6	120.6	117.4
ORSR	Personal Income	130.5	144.3	148.1
MRSR	Personal Income	39.5	38.5	38.6
RoN	Personal Income	32.0	16.8	11.9
USA	Personal Income	202.0	199.6	198.5

* fixed 2006$ stream from 2006 to 2050 @ 3%

Region	Parameter	2050 Jobs & Residents Production Cost Model	Electric Rate Model	Electric Rate Model + Boeing
ORSR	Total Employment	90,200	79,180	81,610
MRSR	Total Employment	22,400	21,810	21,830
RoN	Total Employment	-32,810	-40,810	-43,980
USA	Total Employment	79,780	60,170	59,450
ORSR	Population	148,400	145,500	148,800
MRSR	Population	20,860	21,610	21,710
RoN	Population	-179,000	-178,100	-181,700
USA	Population	-9,781	-10,940	-11,160

Phase II PSA Electric Rate Models: Economic Impacts

Table 13 shows the second phase results that expand the electric rate analysis beyond the ORSR. Here, electric rate direct effects are extended into the rest of the nation for the ORS generating plants distributor PSAs.

Table 13: Phase II Electric Rate PSA Model Impact Results

Region	Parameter	Present Value of Impact Stream to 2050* (Billions 2006 $) Electric Rate Model	Electric Rate Model Plus Boeing
ORSR	Output	$268.9	$283.3
MRSR	Output	85.5	85.6
RoN	Output	148.3	128.3
USA	Output	502.8	497.2
ORSR	GRP	153.1	160.0
MRSR	GRP	47.5	47.5
RoN	GRP	61.9	52.1
USA	GRP	262.4	259.6
ORSR	Personal Income	138.6	142.3
MRSR	Personal Income	43.5	43.5
RoN	Personal Income	163.2	159.3
USA	Personal Income	345.3	345.1

* fixed 2006$ stream from 2006 to 2050 @ 3%

Region	Parameter	2050 Jobs & Residents Electric Rate Model	Electric Rate Model Plus Boeing
ORSR	Total Employment	75,670	78,100
MRSR	Total Employment	20,930	20,950
RoN	Total Employment	-16,030	-19,000
USA	Total Employment	80,560	80,050
ORSR	Population	133,000	136,200
MRSR	Population	15,530	15,620
RoN	Population	-158,300	-161,900
USA	Population	-9,770	-10,080

The negative impacts (that is, gains due to loss of ORS barge transport) for the RoN jobs and population is due to the shift from more labor intensive barge transportation to rail and truck, which, in this region, are not offset by industry production cost impacts sufficiently to overcome the positive impacts (losses), even though there are net product and income losses.

ORS County-State and Pool Impact Allocations

The ORSM provides total impact results for the entire ORSR. (see Figure 4: County Map of Impact Regions and Transportation Savings for the delineation of the counties in the region). In order to add flexibility to using the impact results from the REMI model to approximate any desired county-aggregated ORS areas, a final step undertakes allocating the ORSR impacts to the individual counties and to pools. The methodology to accomplish this is, of necessity, somewhat imprecise. The following is a reasonable attempt.

The methodology employed is based on the notion that, on average, indirect output effects are typically about equal to direct output effects, that is, the multipliers usually hover around 2.0. This implies for a large region that leakage from nonlocal spending plus increased tax payments and savings average about one-half of a change in final demand. The allocation process begins by taking one-half of the 2050 macro-impacts (output, GRP, personal income, employment, and population) and allocating to the counties directly impacted (that is, where the transportation savings actually occur), apportioning based on their percentages of total transportation savings. Then, taking the other half (that is, the more diffuse indirect effect portion) and apportioning it using manufacturing earnings as a proxy for a generic export base sector in all the ORS counties, the two parts are combined to obtain total county impacts.

Table 14 provides the results of aggregating ORS county data to states for the transportation savings plus Boeing scenario.

Table 14: 2050 State ORS Impacts by Major Policy Variables (PSA Model with Boeing)

State	Output Millions 2006 $	GRP Millions 2006 $	Pers. Inc. Millions 2006 $	Population	Employment
AL	$28,530	$15,540	$12,701	11,970	7,144
GA	4,194	2,368	2,107	2,018	1,156
IL	1,908	1,084	977	937	534
IN	28,664	16,247	14,580	13,975	7,980
KY	57,112	32,393	29,112	27,904	15,928
MS	833	471	420	402	231
OH	62,296	35,349	31,798	30,493	17,394
PA	35,210	19,938	17,854	17,103	9,777
TN	45,375	25,682	22,975	22,004	12,584
WV	19,174	10,884	9,798	9,396	5,355

Table 15 gives the impact results aggregated by waterway pool.

Table 15: 2050 ORS Pool Impacts by Major Policy Variables (PSA Model with Boeing)

Pool	Output06$M	GRP06$M	PersInc06$M	Pop	Emp
Allegheny	$1,994	$1,127	$1,006	963	552
Belleville	4,964	2,807	2,507	2,401	1,374
Cannelton	2,945	1,664	1,482	1,419	812
Cheatham	14,515	8,215	7,347	7,037	4,025
Chickamauga	1,562	883	787	753	432
E-D-M	11,085	6,276	5,617	5,381	3,076
Fort Loudoun	3,745	2,115	1,883	1,802	1,033
Green-1	3,620	2,046	1,826	1,748	1,001
Green-2	824	466	417	399	228
Greenup	9,199	5,207	4,658	4,461	2,552
Guntersville	3,738	2,053	1,712	1,620	957
Hannibal	11,242	6,365	5,699	5,460	3,121
J.T. Myers	13,613	7,707	6,898	6,608	3,779
KY-Barkley	9,402	5,310	4,728	4,524	2,594
L&D No. 52	4,395	2,485	2,218	2,123	1,216
L&D No. 53	2,356	1,334	1,192	1,142	653
London	128	73	65	63	36
Markland	30,109	17,025	15,196	14,551	8,331
Marmet	2,072	1,173	1,051	1,007	575
McAlpine	25,703	14,531	12,964	12,412	7,107
Meldahl	16,739	9,478	8,486	8,130	4,648
M-G-P	3,912	2,217	1,988	1,905	1,088
M-H-O	482	272	242	232	133
Monongahela	8,318	4,713	4,226	4,049	2,313
N. Cumberland	12,773	7,222	6,447	6,173	3,534
Newburgh	17,782	10,061	8,992	8,612	4,928
Nickajack	4,696	2,653	2,364	2,263	1,297
Old Hickory	6,041	3,420	3,059	2,930	1,676
Pickwick	3,502	1,977	1,760	1,684	965
Pike Island	16,274	9,201	8,212	7,863	4,502
R.C. Byrd	7,098	4,013	3,581	3,429	1,963
Racine	3,185	1,803	1,613	1,546	884
Smithland	1,091	619	557	533	304
Watts Bar	854	483	430	412	236
Wheeler	10,272	5,687	4,836	4,592	2,689
Willow Island	3,130	1,776	1,598	1,533	874
Wilson	5,838	3,182	2,606	2,457	1,465
Winfield	3,946	2,232	1,994	1,909	1,093

Note: E-D-M: Emsworth-Dashields-Montgomery
M-G-P: Maxwell-Gray's Landing-Point Marion
M-H-O: Morgantown-Hilderbrand-Opekiska

The five largest pool impacts are Markland, McAlpine, Newburgh, Meldahl, and Pike Island.

Conclusions

Transportation savings provide a sound basis for estimating economic impacts that would result from the loss of the navigable ORS waterway. While not all transportation savings are accounted for in the study (perhaps 20% or so are not included), appropriate assignment of the transportation savings to industries and regions, proved feasible. The REMI model, a widely used tool to incorporate the direct effects on industry cost structures, for this study is customized for three study regions. While there is leeway in the definition of appropriate impact regions, the two-county deep band around the waterways defined for the study appears to yield reasonable results for production cost savings direct effects in all but the electric power industry. However, to more fully account for the ORS navigable water impacts, it is necessary to exogenously analyze and prepare data formatted differently for input to REMI as electric rate effects. Some adjustment to the base REMI model was also found to be necessary to make it consistent with known ORS water transport demand.

A shortcoming of the REMI model in conjunction with production cost changes alone is a lack of a mechanism to fully account for the linkage between electric utility navigable water savings and the effect on electric rates. The CTR incorporated results from a regression analysis in an attempt to better capture the electric rate effect within REMI model. In Phase I, however, where rate changes are developed only for the ORSR, the CTR found the electric rate approach did not change the results as expected. Consideration of the electric rate methodology suggested additional work to extend electric rate effects beyond the ORSR might yield improved impact estimations. This was implemented in Phase II and proved to significantly enhance results.

The study also considered possible impacts on industries captive to water, using the Boeing/Lockheed Decatur rocket booster plant as an example. Significant additional benefits to the ORSR result.

Whether estimated by available transportation savings alone or in combination with electric rate effects, the total economic impacts on the ORSR register, over time, in the tens of billions of dollars of goods and services produced and tens of thousands of annual jobs and population. The CTR developed a method to allocate the regional economic impacts to county levels and applied it to the major impact results, so those interested can aggregate counties to various area and obtain reasonable impact estimations. The county-based ORSR results, aggregated to states show the seven states that are most impacted, by magnitude of impact, are Ohio, Kentucky, Tennessee, Pennsylvania, Indiana, West Virginia, and Alabama. The CTR also made allocations to pools. The five largest pool impacts are Markland, McAlpine, Newburgh, Meldahl, and Pike Island.

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Appendix A: ORS Electric Utility Plants and Capacities on the Waterway

Table 16: ORS Electric Utility Plants

Company	ORV Plant	MW
Allegheny Energy Supply Co LLC.	Hatfields Ferry Power Station	1,728.0
Appalachian Power Co.	John E Amos	2,932.6
	Kanawha River	439.2
	Mountaineer	1,300.0
	Philip Sporn	1,105.5
Cardinal Operating Co.	Cardinal	1,880.4
Dayton Power & Light Co.	J M Stuart	2,451.6
	Killen Station	686.5
Duke Energy Indiana Inc.	R Gallagher	600.0
Duke Energy Kentucky Inc.	East Bend	669.3
Duke Energy Ohio Inc.	Miami Fort	1,444.0
	W H Zimmer	1,425.6
	Walter C Beckjord	1,432.9
Duquesne (Orion Power Midwest LP)	Cheswick Power Plant	637.0
	Elrama Power Plant	510.0
East Kentucky Power Co-op, Inc.	H L Spurlock	1,279.1
Electric Energy Inc.	Joppa Steam	1,099.8
FirstEnergy Generation Corp.	Bruce Mansfield	2,741.1
	R E Burger	423.3
	W H Sammis	2,468.1
Indiana Michigan Power Co.	Rockport	2,600.0
	Tanners Creek	1,100.1
Indiana-Kentucky Electric Corp.	Clifty Creek	1,303.2
Kentucky Utilities Co.	Ghent	2,225.9
	Green River	188.6
Louisville Gas & Electric Co.	Cane Run	660.9
	Mill Creek	1,717.2
	Trimble County	1,760.1
Monongahela Power Co.	Fort Martin Power Station	1,152.0
	Willow Island	213.2
Ohio Power Co.	General James M Gavin	2,600.0
	Kammer	712.5
	Mitchell	1,632.6
Ohio Valley Electric Corp.	Kyger Creek	1,086.0
Southern Indiana Gas & Elec Co.	A B Brown	706.8
	F B Culley	368.9
Tennessee Valley Authority	Colbert	1,826.0
	Cumberland	2,600.0
	Gallatin	1,918.4
	Johnsonville	2,911.2
	Paradise	2,558.2
	Shawnee	1,750.0
	Widows Creek	1,968.6
Western Kentucky Energy Corp.	HMP&L Station Two Henderson	365.0
	Kenneth C Coleman	521.2
	R D Green	528.0
	Robert A Reid	194.8

Appendix B: Electric Utility Waterway Effects Regression Analysis

The Regression Model

For regression analysis, total plant production costs per megawatt are modeled as follows:

$$\ln(\text{TCOST}) = a_1 + a_2{*}\ln(\text{NETGEN}) + a_3{*}\ln(\text{CAPFAC}) + a_4{*}\text{WDUM} + a_5{*}\text{CDUM} + a_6{*}\text{YRDUM} + \varepsilon$$

where

TCOST = total generating production costs per megawatt

NETGEN = net generation in megawatts

CAPFAC = capacity factor or percent of plant capacity

WDUM = presence of a navigable stream (yes = 1)

CDUM = cooling tower dummy (yes = 1)

YRDUM = year of installation dummy variable (1989 and forward = 1)

ε = standard OLS random error term

The coefficient, a_2, should reflect long run economies of scale enjoyed by larger generating plants and, therefore, is expected to have a negative sign in the cost equation.

It is expected that, as generation in a plant moves toward design capacity, total unit costs will fall over most of the normal capacity factor range. Plants would not normally be operated for long periods at levels well outside of optimum capacity. The coefficient of the capacity factor, a_3, should therefore be negative.

The waterway dummy variable, a_4, should enter the equation with a negative sign.

Cooling towers may lower costs, so the cooling tower dummy variable, a_5, is expected to enter the equation with a negative sign.

The dummy variable for 1989 is intended to capture a change in cost structure whereby steam-electric power plants generally used lower cost wet cooling systems from this point in time.[11] Thus, the expected sign of a_6 is positive.

The equation is estimated with a cross-section of coal-fired power plant data. The data preparation for the analyses consisted of the following primary activities:

- obtaining 2003 FERC Form 1 plant operations and cost data for 25MW and greater steam plants
- collecting EIA fuel cost data
- restricting the FERC data to coal-fired plants using EIA Form 860 fuel source data
- applying transportation expertise to further qualify the data by identifying inland coal-fired plants (that is plants not using either the Great Lakes or ocean vessels for transporting fuel to their plant site) and designating whether or not they are on a navigable inland waterway and receive coal by barge

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[11] Micheletti, Wayne C., and John M. Burns. "Emerging Issues and Needs in Power Plant Cooling Systems," paper presented at the 2002 National Energy Technology Laboratory (NETL) Conference-Electric Utilities and Water: Emerging Issues and R&D Needs, 2002.

While the data collection process is not conceptually complex, matching plants between datasets, investigating possible data errors, and otherwise cleaning the data is challenging. Plants with mixed barge and other fuel transportation are excluded, as are Great Lakes & coastal plants. In some cases plants were simply excluded from analysis because of missing pieces of information, uncertainty in the validity of data values, or difficulties in identifying or matching plant data. The original set of records for several hundred FERC plants was eventually qualified to a little over one hundred plants, constituting the input dataset available for regression analysis. TVA is not regulated by FERC and, therefore, is not included in the FERC database or the regressions.

Regression Analysis: Steam Electric Plant Production Costs

Table 17 presents the regression results.

Table 17: Regression Statistics for Steam Plant Production Cost Model

Regression Statistics	
Multiple R	0.796
R^2	0.634
Adjusted R^2	0.616
Standard Error	0.234
Observations	109

ANOVA	*df*	*BTS*	*MS*	*F*	*Signif. F*
Regression	5	9.808	1.962	35.720	0.000
Residual	103	5.656	0.055		
Total	108	15.464			

	Coefficients	*Std Err*	*t Stat*	*P-value*
Intercept	4.921	0.544	9.045	0.000**
Ln Net Generation (kWh)	-0.101	0.024	-4.139	0.000**
Ln Generation, % Of Capacity	-0.858	0.096	-8.954	0.000**
Waterway Dummy	-0.153	0.048	-3.210	0.002**
Cooling Tower Dummy	-0.081	0.047	-1.712	0.090*
Installation Year Dummy (1989)	0.315	0.101	3.133	0.002**

**significant at 95% level
*significant at 90% level

Multicollinearity Analysis

Inflated standard errors due to mulicollinearity appear to be of little concern, given the strong significance of all the independent variables. Regressing each independent variable on all the others to obtain the R^2s, as shown in Table 18, seems to confirm little multicollinearity exists among the independent variables.

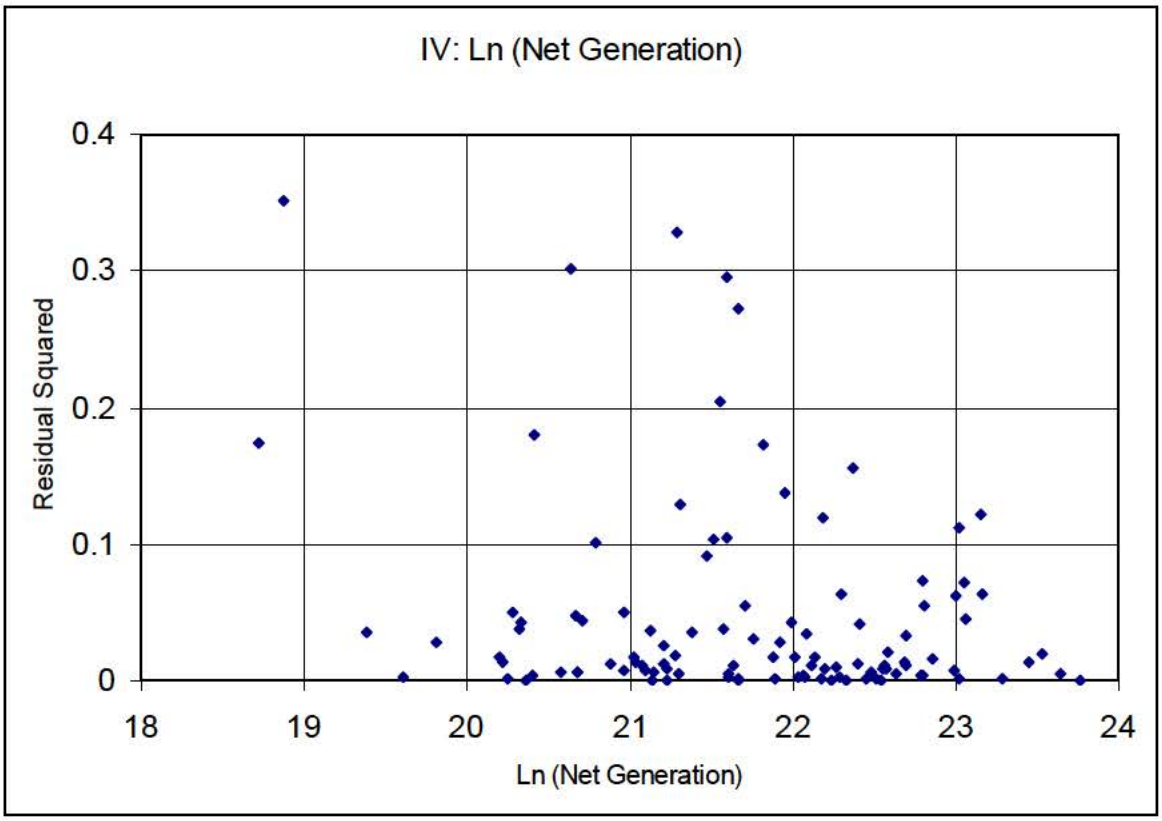
Table 18: Independent Variable Regression R^2s

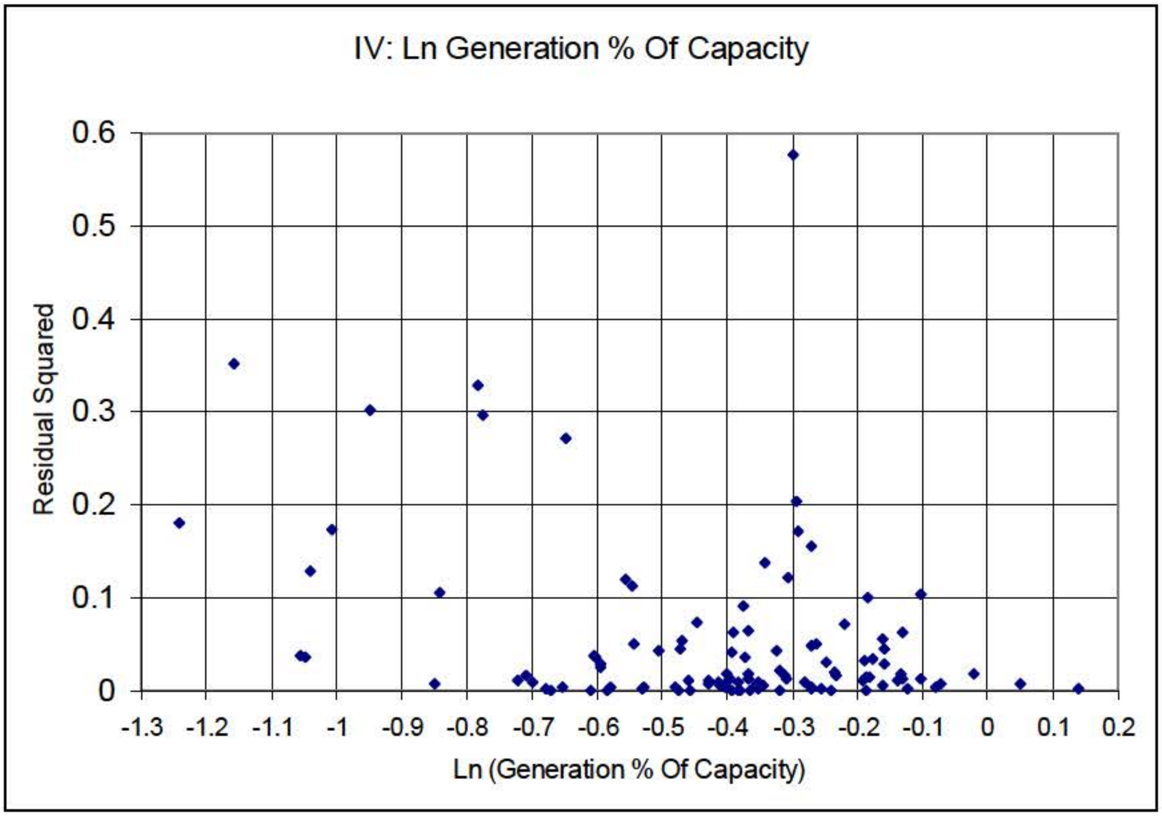
Variable	R^2
Ln (Net Generation) (kWh)	0.20
Ln (Generation, Percentage of Capacity)	0.16
Waterway Dummy	0.08
Cooling Tower Dummy	0.09
Installation Year Dummy (1989)	0.04

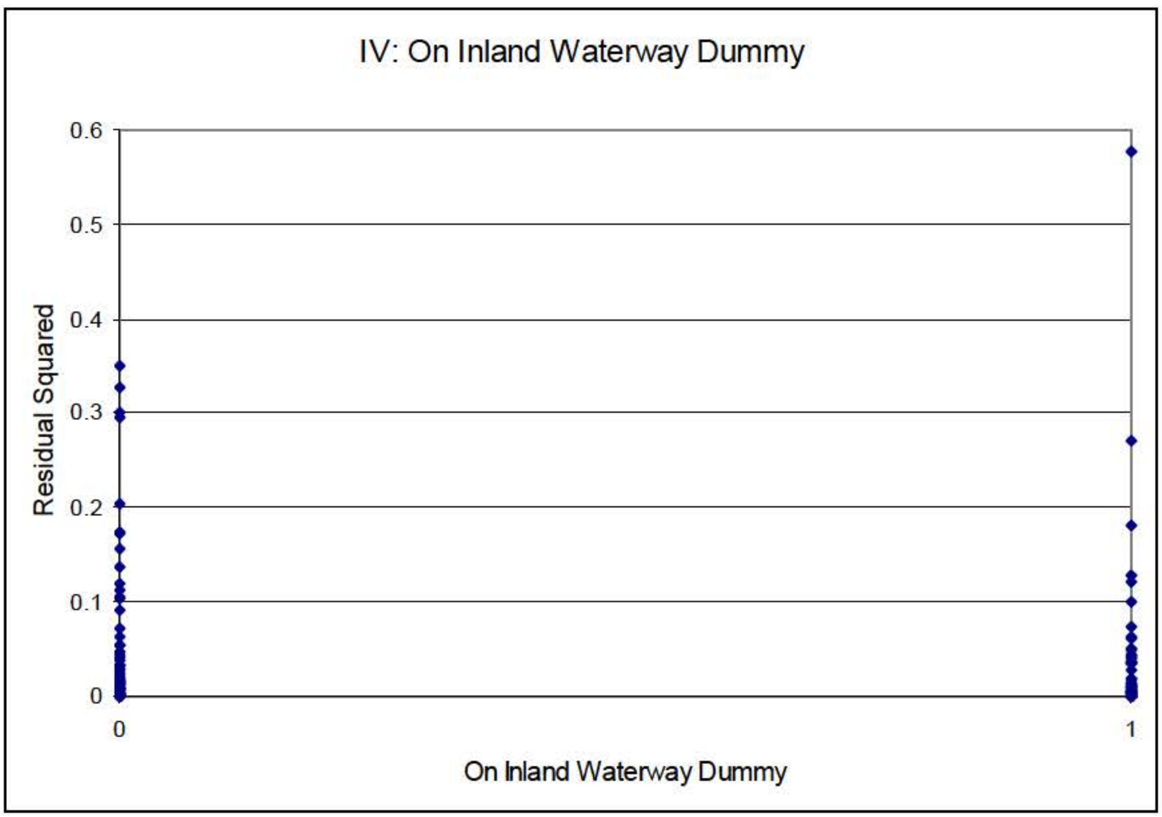
Residuals Analysis

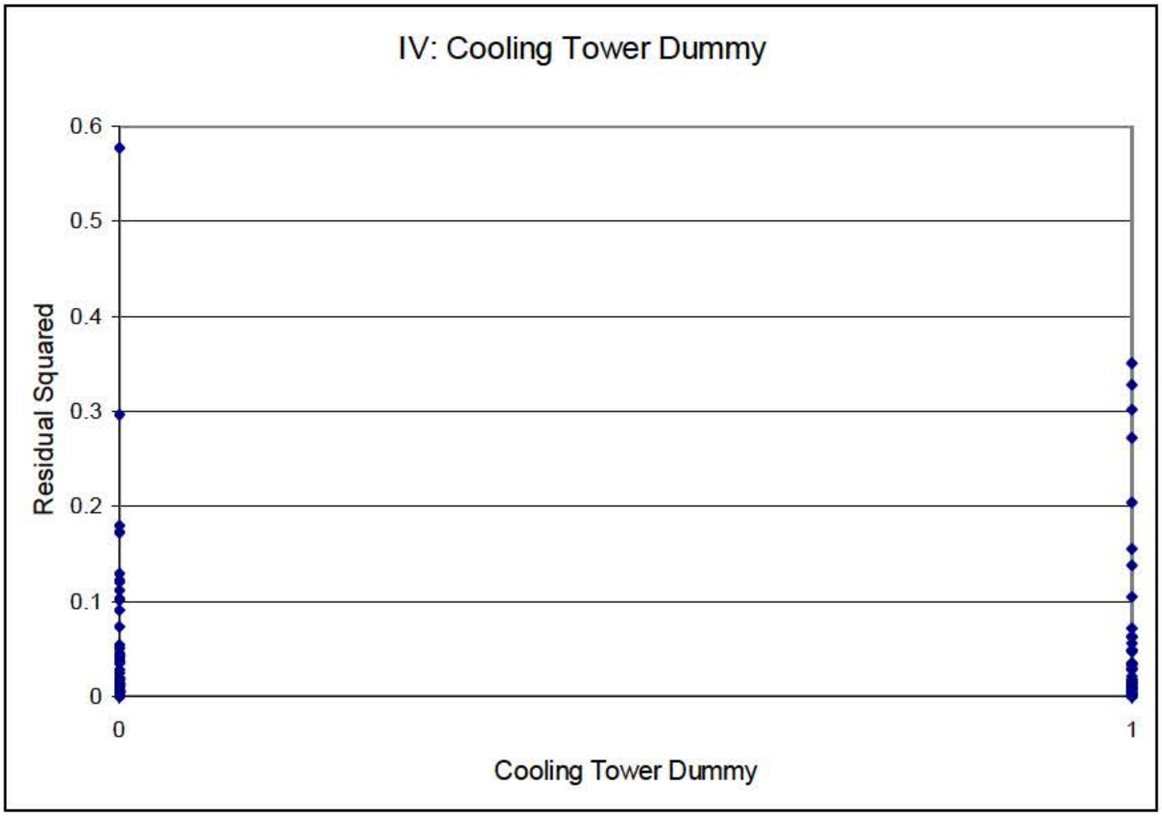
The regression results are further examined to consider the possibility of heteroskedasticity, which could bias standard errors.

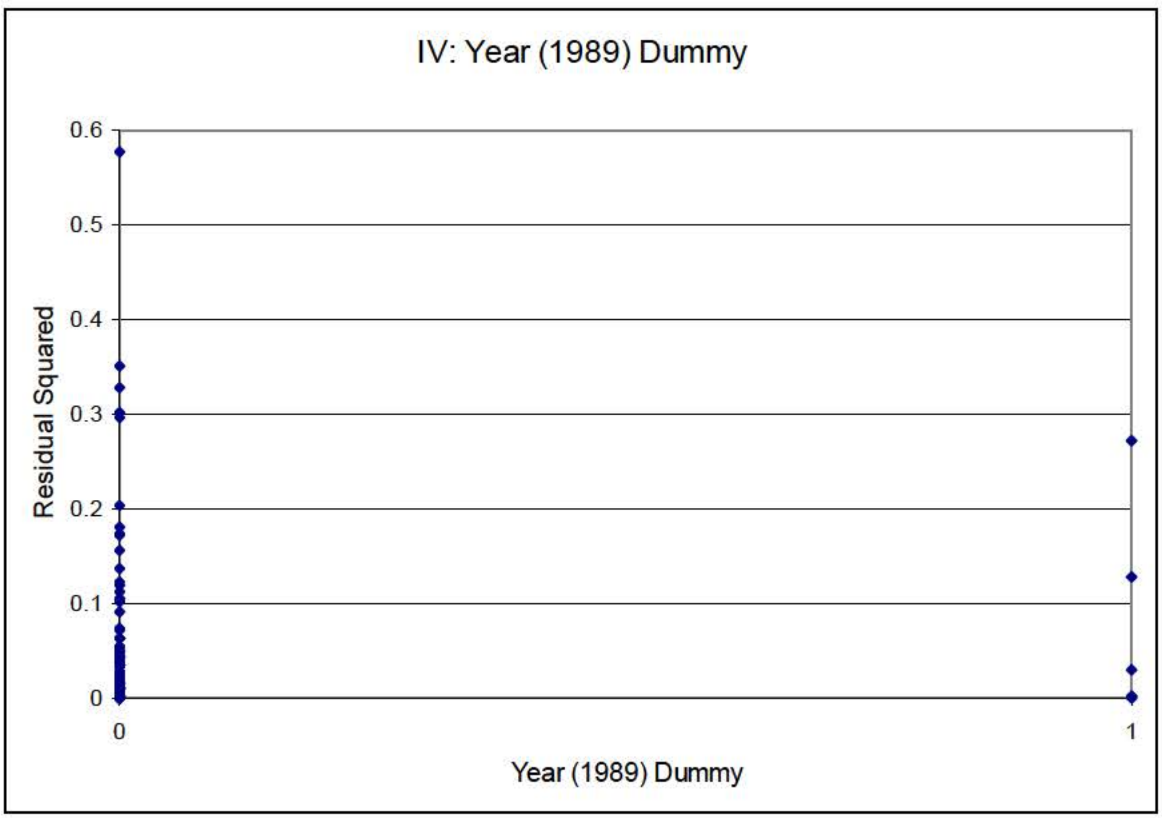
Figure 5: Graphs of Residuals Versus Independent Variables (IVs)




IV: Ln Generation % Of Capacity
Residual Squared
0.6
0.5
0.4
0.3
0.2
0.1
0
-1.3
-1.2
-1.1
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Ln (Generation % Of Capacity)


IV: On Inland Waterway Dummy
Residual Squared
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
On Inland Waterway Dummy





Visual inspection of the residuals in the graphs seems to indicate some potential concern for mild heteroskedasticity (as would be evidenced by non-zero slopes). A more sophisticated analysis, however, is beyond the scope of this study. If heteroskedasticity is mild, however, Long and Ervin have shown in their article "Using Heteroskedasticity Consistent Standard

Errors in the Linear Regression Model" in T*he American Statistician* 54:217-224, 2000, that OLS errors behave quite well.

Appendix C: Implicit ORS REMI Model National I-O Multipliers

The following total effect multipliers are derived by calculation of the Leontif inverse from the 2006 national input-output matrix embedded in the ORS REMI model used for this study. While these multipliers are dynamic within the context of the REMI model, they nevertheless indicate the general impact magnitude on macro-variables that may be expected from a simple, static direct effect shock; therefore, they are useful for supporting the proximate disaggregation of regional impacts to finer geographies, as is done in this report.

Table 19: Implicit REMI I-O Multipliers

Industry	*Multiplier*
Forestry et al.	2.123
Agriculture	1.878
Oil, gas extraction	1.925
Mining (except oil, gas)	1.933
Support activities for mining	1.910
Utilities	1.790
Construction	1.917
Wood product mfg.	2.391
Nonmetallic mineral product mfg.	1.940
Primary metal mfg.	2.333
Fabricated metal product mfg.	2.025
Machinery mfg.	2.183
Computer, electronic product mfg.	2.121
Electrical equip., appliance mfg	2.080
Motor vehicle mfg.	2.618
Transp. equip. mfg., exc. motor vehicle	2.239
Furniture, related product mfg.	2.101
Miscellaneous mfg.	1.955
Food mfg.	2.569
Beverage, tobacco product mfg.	2.238
Textile mills	2.403
Textile product mills	2.166
Apparel mfg.	2.067
Leather, allied product mfg.	2.329
Paper mfg.	2.300
Printing, related support activities	2.027
Petroleum, coal product mfg.	2.791
Chemical mfg.	2.153
Plastics, rubber product mfg.	2.177
Wholesale trade	1.519
Retail trade	1.543
Air transportation	1.850
Rail transportation	1.819
Water transportation	2.038
Truck transp.; couriers, messengers	1.900
Transit, ground passenger transport	1.946
Pipeline transportation	2.429
Scenic, sightseeing transport; support	1.815
Warehousing, storage	1.474
Publishing, exc. Internet	1.851
Motion picture, sound recording	2.037
Internet service, data processing, other	1.671
Broadcasting, exc. Internet; Telecomm	1.709
Monetary authorities, et al.	1.700
Securities, commodity contracts et al.	1.635

Industry	*Multiplier*
Insurance carriers, related activities	1.698
Real estate	1.466
Rental, leasing services	1.519
Professional, technical services	1.488
Management of companies, enterprises	1.641
Administrative, support services	1.553
Waste management, remedial services	1.998
Educational services	1.715
Ambulatory health care services	1.509
Hospitals	1.797
Nursing, residential care facilities	1.641
Social assistance	1.705
Performing arts, spectator sports	1.657
Museums et al.	1.873
Amusement, gambling, recreation	1.668
Accommodation	1.553
Food services, drinking places	1.975
Repair, maintenance	1.849
Personal, laundry services	1.709
Membership assocs., orgs.	1.713
Farm	2.231
Federal government	1.662
State and local government	1.627