Regional Economic Impact Study for the McClellan-Kerr Arkansas River Navigation System

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16 . ABSTRACT: The main objective of this study is to identify, evaluate, and measure—as comprehensively as possible—the full extent of regional economic benefits/impacts that are expected to accrue to the citizens of Oklahoma and Arkansas, as well as, other significantly affected areas of the country (e.g., the States of Kansas, Missouri, and Texas) from operational activities of the MKARNS (waterborne commerce, hydropower, and recreation). Evaluations are also made of the economic impacts of deepening the MKARNS navigation channel an additional three feet. Delays due to traffic interruptions (such as lock closures or natural events) can be costly to businesses that rely on the MKARNS. The economic impacts of delays are evaluated.

A second objective of this project is to undertake and implement two water resources impact modeling innovations. One, the multiregional variable input-output (MRVIO) model has been extended to address “transboundary” income generation and expenditure effects that provide more accurate economic impact estimates. Two, this project also updated, re-estimated, and extended a model of transportation infrastructure productivity that includes both highway and waterway investments. Previous models are based on dated highway and water resource capital investment information for which more recent data is now available and it only measures the productivity effects for navigation. The new infrastructure productivity model has been integrated with the enhanced MRVIO model.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^{o}F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^{o}C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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EXECUTIVE SUMMARY

The McClellan-Kerr Arkansas River Navigation System (MKARNS) was established in June 1971 as a 445 mile, 9-foot navigation channel. The Port of Catoosa is at the head of the system near Tulsa, OK on the Verdigris River, connects with the Arkansas River, and extends down-stream to its confluence with the Mississippi River. The MKARNS is basically a navigation channel in which waterborne cargo is shipped into and out of the states of Arkansas and Oklahoma. However, the economic functions that the MKARNS performs are generated by a complex and multi-faceted system of interrelated and highly integrated activities of businesses and public and private institutions. In terms of the water transportation-related function, public and private ports, shipping and barge companies, and the U.S. Army Corps of Engineers spend money to use, maintain, and operate the MKARNS. They also make vital investments to improve its functioning. For the goods being shipped, barges offer greater economic efficiencies and fewer economic damages relative to other methods of transport (rail and truck). In addition to the transportation function, electricity is produced at several hydroelectric facilities and the MKARNS offers many recreational opportunities for fishing, camping, hiking, boating, sightseeing, and hunting.

Public officials, business leaders, and other important local stakeholders have been interested for some time in the economic "benefits" that the MKARNS provides citizens of the region that surrounds the waterway (this would most directly include the States of Arkansas and Oklahoma, as well as, other nearby geographic areas).

The main objective of this study is to identify, evaluate, and measure—as comprehensively as possible—the full extent of regional economic benefits/impacts that are expected to accrue to the citizens of Oklahoma and Arkansas, as well as, other significantly affected areas of the country (e.g., the States of Kansas, Missouri, and Texas) from operational activities of the MKARNS (waterborne commerce, hydropower, and recreation). The economic impacts are measured and summarized in a variety of ways including industrial and regional sales, value added, income and employment. Evaluations are also made of the economic impacts of deepening the MKARNS navigation channel an additional three feet. Delays due to traffic interruptions (such as lock closures or natural events) can be costly to businesses that rely on the MKARNS. The economic impacts of delays are evaluated.

A second objective of this project is to undertake and implement several water resources impact modeling innovations. For example, the multiregional variable input-output (MRVIO) model has been extended to address "transboundary" income generation and expenditure effects that provide more accurate economic impact estimates. In addition, the enhanced version of the MRVIO model and to convert the existing, earlier version of the MRVIO models into a more user-accessible spreadsheet software format. This project also updated, re-estimated, and extended a model of transportation infrastructure productivity that includes both highway and waterway investments. Previous models are based on dated highway and water resource capital investment information for which more recent data is now available and it only measures the productivity effects for navigation. The model has also been extended across a broader, more sector-specific set of industrial sectors than the past models. The new infrastructure productivity model has been integrated with the enhanced MRVIO model.

ES.1 McClellan-Kerr Arkansas River Navigation System's Economic and Environmental Value

A study being completed by researchers at the Institute of Economic Advancement (IEA) with the assistance of Oklahoma State University and the University of Arkansas at Fayetteville has estimated the economic value of the Oklahoma portion of the MKARNS. They found that the economic influence of this portion of the MKARNS extends well beyond Oklahoma's borders into the surrounding region (Arkansas, Kansas, Missouri, and Texas) and to rest of the nation as well. It is important to note that these beneficial economic effects are expected to continue year after year as long the MKARNS is maintained and operated in good order.

The economic value of the McClellan-Kerr Arkansas River Navigation System is the sum total of all the economic losses due to closing the MKARNS. Closing the MKARNS is estimated to decrease the nation's business sales annually by $4.1 billion (in 2015 prices). The contribution to the nation's gross domestic product (GDP) is $2.0 billion and gross business operating surpluses of $807.0 million. Oklahoma's portion of the MKARNS is responsible for 22,760 of the nation's full and part-time jobs and for $931.8 million in employee compensation. Business taxes and license fees total $124.6 million. For Oklahoma and the surrounding region, the Oklahoma portion of the MKARNS provides $1.9 billion in business sales, $744.5 million in GDP, 11,840 full and part-time jobs, $375.2 million in employee compensation, $361.7 million in gross operating surplus, and $51.0 million in business taxes. The State of Oklahoma also shares in the economic value: $1.2 billion in business sales, $470.0 million in GDP, 6,620 full and part-time jobs, $216.6 million in employee compensation, $225.4 million in gross business operating surpluses, and $28.1 million in business taxes.

If commercial navigation on the MKARNS had to be diverted to alternative modes of transport, the authors estimate that both fuel usage and environmental damages (as measured by CO_2 emissions) would increase significantly in the region. It is estimated that moving the current waterway traffic to rail would increase both fuel usage and raise CO_2 emissions by nearly 40 percent. On the other hand, using trucks to haul the same traffic would increase fuel usage and CO_2 emissions by 270 percent.

ES.2 Water Resources and the Economy

Waterways are vital resources that have multiple functions. Foremost, waterways provide an attractive method of transporting goods. On a ton-mile basis, barge transportation is well known as the cheapest mode to haul commodities. In addition, waterways can provide a variety of other valuable services. For example, hydropower generating facilities are often included as part of the locks and dams built to enhance navigation on the waterways. Structures and flow regimes that are used to maintain and control channel depths for navigation can also help in lessening flooding events and, as a result, mitigating their damage effects on affected populations and properties. Waterways are an important source of water supply for drinking, for commercial and industrial uses, and for irrigation. Waterways and the reservoirs that are often built are attractive for many recreation opportunities—fishing, boating, camping, hunting, sight-seeing, hiking, etc. And, important environmental benefits can be gained when appropriate and effective mitigation facilities are put in place and actions are implemented such as improving fish and wildlife habitat or species protection.

Water resources are fundamental and critical to regional economic development. The availability of well integrated transportation networks often defines how that region can compete, what types of goods will be available as inputs for local industries, what types of goods and services will be reasonable for local sectors to produce. An improvement in the transportation system of a region can change the production costs of many goods and services produced in the region and can provide the benefited region with a competitive advantage in regional, national, and international markets. Transportation of goods on the inland waterway system occurs because this mode of transportation provides the lowest cost means of movement for such heavy and bulky goods as grain, grain mill products, lumber, paper products, chemicals, petroleum, coal, stone, iron, and steel. When a new waterway is opened, the reduction in transportation costs reduces the cost of producing other goods. Reductions in transport costs make indigenous industries more competitive, thereby leading to firm expansions. The firms are able to lower costs and participate in new markets. This helps to increase region output, employment, and income.

The unique feature of these functions is that their benefits are, in one form or another, valued in terms of efficiency gains or cost savings. The complicating factor in evaluating the regional economic effects of these cost savings is that improvements in these activities (i.e., reductions in transportation costs) affect both industrial producers and final consumers (i.e., households, governments and foreign residents). How one analyzes and computes the regional economic impacts of project functions that generate system-wide efficiencies is not as straightforward as for project-related spending. Much goes on between regions of an economic system, between firms within regions, and within the firms themselves. Some effects are compensating while others are complementary, however, they all occur approximately during the same timeframe.

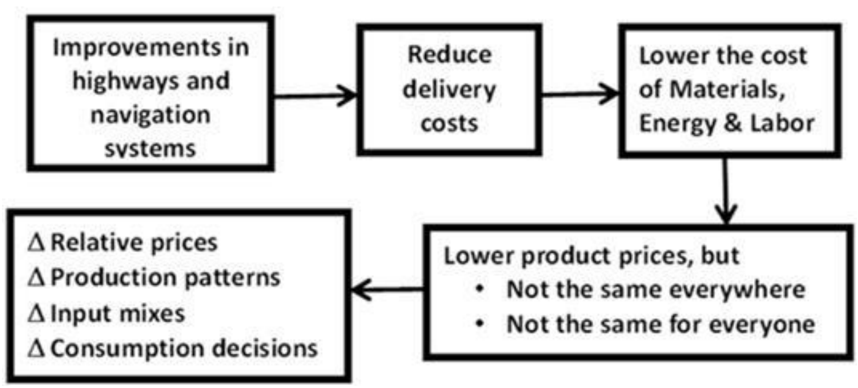

Figure ES 1 Effects of Transportation Improvements

The basic premise of transportation cost savings is that improvements in navigation systems reduce the delivery costs of capital, materials, and energy inputs used by firms, as well as, the transportation costs to deliver the products produced—that is, reduces the cost of the flow of goods and services between regions. Such delivery cost reductions, *ceteris paribus*, should be reflected in lower factor and product costs. In addition, one should also expect indirect systems interactions that will spread quite readily within and between regions depending on the competitiveness of the economic system. Factor cost reductions themselves should also lead to lower production costs. Lower production costs in some firms relative to others should lead, in a competitive industry, to relative price reductions for their goods and services. These changes in relative prices, in turn, should cause some goods and services to be consumed more, and others less. This chain of events is likely to change trading patterns among firms and, thus, between regions. It would also be expected to alter the factor mix in production processes within firms (i.e., technological change).

In addition, the effects of the transportation improvements are not often confined to a single region. In areas that experience transportation improvements, cost reductions not only reduce production costs for exported goods but also reduce the cost of imported products. When the price of imported goods declines consumers and producers will tend to substitute the imported products for the relatively more expensive domestically produced goods. Even in areas that do not directly benefit from transportation improvements, less expensive imported goods will cause local consumers and producers to use the more relatively inexpensive imported goods more intensively than more expensive domestic products.

Transportation cost reductions are further complicated by intermediate goods deliveries such as those hauled on inland waterways—goods that are used to produce other goods (e.g., the steel used to produce cars). Reductions in the transportation cost of the intermediate products will affect the prices of local goods and services and will alter the mix of goods and services used by producers. There will also be expansive effects on local production.

ES.3 Modeling the Regional Economic Effects of Water Resource Development

Water resources investments generate three basic types of regional economic impacts. First, some activities involve the direct expenditure of funds—like construction, operations, and recreation. For example, if improvements are made in navigation channel, like deepening the MKARNS, then we can expect that transporting commodities on the waterway will be cheaper and more efficient (lower transportation rates). Or, generating electricity by hydropower—because a lock and dam has a generating unit on-site—is often cheaper and environmentally "cleaner" than electricity produced from alternative fuel sources. These types of water resource-related activities create modeling complications that are incompatible with any of the standard and commercially available regional economic impact software programs. Third, recent innovations in the evaluation of national and regional economic effects of water resources infrastructure investments have focused on the effects the investments have on resource costs—i.e., the prices of labor, energy, and materials—that producers use in the economy.

ES.3.1 Effects of Project-Related Expenditure Changes

To understand how regional economic effects are generated and, in turn, estimated, it is important to review their economic context. The simplest economic context for the regional economic effects to be understood is in terms of an input-output accounting framework. We begin with a set of double-entry accounts of an economy, showing both the production and consumption of goods and services. All legal transactions that occur within the economy during an accounting period (normally a year) are found somewhere in the input-output accounts. The input-output accounts consist of three basic quadrants. The "processing" sector quadrant explicitly shows all transactions between and among the economy's firms and industries. Within this quadrant, the manufacturer of the economy's goods and services can be "traced" through all of the steps in the production process, from the sowing of wheat to the sale of a loaf of bread (for example). The "final demand" quadrant depicts sales of goods and services to final consumers. The final consumers are people (personal consumption spending), investors (inventory changes and gross private investment), governments (local, State and Federal expenditures) and foreign buyers (exports minus imports). The "value added" quadrant indicates the payments to the factors of production by firms: workers (employee compensation of wages and salaries), owners of capital (interest, rents, profits and capital consumption allowances) and business taxes (sales and excise taxes).

Following the input-output model development of Miller and Blair (2009), the input-output accounts can be easily restated and summarized in the form of a simple equation,

[ES.1] $$\boldsymbol{X} = \boldsymbol{A}\boldsymbol{X} + \boldsymbol{Y},$$

Where $\boldsymbol{X}$ is a vector of industrial output levels, $\boldsymbol{A}$ is a matrix of direct interindustry production requirements for goods and services (per dollar of output), and $\boldsymbol{Y}$ is a vector of industrial final demand levels. Assuming the direct production requirements are linear, fixed and constant, output levels can be solved for final demand levels by a simple manipulation of equation [ES.1]; i.e.,

[ES.2] $$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}}\boldsymbol{Y}.$$

The matrix $(\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}}$ is the table of direct and indirect (if households are included) requirements to meet industrial demand levels ($\boldsymbol{Y}$). The effects of changes in spending (either by the Corps—for construction, operations, maintenance, and major rehabilitation—or by people involved with recreational activities) are computed by posing a vector of changes in purchases ($\Delta\boldsymbol{Y}$) in equation [ES.2] to derive a vector of changes in industrial requirements necessary to meet the changes in purchases ($\Delta\boldsymbol{X}$), or

[ES.3] $$\Delta\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}}\Delta\boldsymbol{Y}.$$

Employment and income effects are simply computed by applying the appropriate industry-specific employment and income per output ratios to the industry-specific output changes ($\Delta\boldsymbol{X}$) of equation [ES.3].

ES.3.2 Effects of Transportation Cost Changes

The spending effects just discussed do not consider (by assumption) the effects that occur due to system efficiencies brought about by infrastructure investments such as Corps waterway developments. Nothing in the standard input-output accounts or the subsequent standard model solution (equations [ES.2] or [ES.3]) is able to address the economic expansion effects resulting from the efficiencies of improved water resources—i.e., transportation, water supply, hydropower, or flood protection benefits. For example, the standard input-output solution, above, is incapable of estimating the economic impacts that can occur because of reductions in transportation or production costs. A reduction in costs in the delivery or production of commodities creates a type of "substitution" effect which conventional regional economic impact models fail to capture. In fact, the effects of cost reductions are ruled out by assumption. This substitution effect plays a crucial role in determining the technical and trading patterns in an economy both temporally and spatially. These types of changes also have industrial repercussions that can be measured in terms of output (sales), employment, and income.

Much of the restrictive nature of the assumptions underlying the standard version of the input-output model can be overcome by totally differentiating equation [ES.1] and then solving for changes in output levels with respect to changes in technological and trading patterns and with respect to changes in final demand; i.e.,

$$\Delta \boldsymbol{X} = \Delta \boldsymbol{A}\boldsymbol{X} + \boldsymbol{A}\Delta \boldsymbol{X} + \Delta \boldsymbol{A}\Delta \boldsymbol{X} + \Delta \boldsymbol{Y}$$
$$\Delta \boldsymbol{X} - \boldsymbol{A}\Delta \boldsymbol{X} - \Delta \boldsymbol{A}\Delta \boldsymbol{X} = \Delta \boldsymbol{A}\boldsymbol{X} + \Delta \boldsymbol{Y}$$
$$(\boldsymbol{I} - \boldsymbol{A} - \Delta \boldsymbol{A})\Delta \boldsymbol{X} = \Delta \boldsymbol{A}\boldsymbol{X} + \Delta \boldsymbol{Y}$$

[ES.4] $$\Delta \boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A} - \Delta \boldsymbol{A})^{-1}\Delta \boldsymbol{A}\boldsymbol{X} + (\boldsymbol{I} - \boldsymbol{A} - \Delta \boldsymbol{A})^{-1}\Delta \boldsymbol{Y}.$$

Equation [ES.4] is the most general solution to the input-output model (in contrast to the more restrictive standard version, equation [ES.3], above). Not only does this solution account for those effects due to changes in project-related spending, but it also evaluates those effects resulting from reductions in transport costs.

Liew and Liew (1985) introduced a practical production function approach, called the multiregional variable input-output (MRVIO) model, that makes changes in the technical coefficients of input-output models depend on changes in such cost items as transportation costs, wage rates, and service price of capital, and the relative prices on inputs and outputs. This is accomplished by exploiting the duality between production and price frontiers. The price frontiers are solved and expressed in terms of input elasticities, wage rates, the service price of capital, transportation costs, tax rates, technical progress parameters, and quantities of commodities. These equilibrium prices then determine the equilibrium multiregional input-output technical, trade, and primary input coefficients. As a consequence, changes in such costs as transporting commodities induces price changes which, in turn, alters the purchasing patterns of commodities throughout the economic system. The methodology of the MRVIO model works based on maximizing "system-wide" profits (revenues minus business costs) which are constrained to be simultaneously consistent with technical production requirements (production functions) and with consumption balances. Price relationships with changes in factor costs (labor, financial, transportation costs, and technological conditions) are derived by solving the detailed and complex system of mathematical equations of the MRVIO model. Changes in multiregional technical coefficients expressed in terms of changes in output-to-input price ratios, the inverse of changes in transportation costs, and underlying technical factors. These are also derived directly from the model's mathematical optimization solution.

ES.3.3 Effects of Infrastructure Productivity Changes

Investments in transportation infrastructure, such as inland waterway improvements on the MKARNS, have general equilibrium effects that also generate widespread effects in a variety of sectors within and between regions (Rietveld, 1989). Improvements in transportation bring about further cost reductions by their effects on resource costs (such as labor, energy, and materials). Reductions in the resource costs will affect the prices of local goods and services and will alter the mix of goods and services used by producers in a process similar to the effects of transportation cost reductions.[1] In addition, firms will have an incentive to increase its production levels due to the reduced production costs. The great majority of studies analyzing the transportation infrastructure productivity effects have ignored these resource cost effects in their models and estimation procedures.[2] Kelejian and Robinson (2000) specifically analyzed the productivity effects of resource cost effects due to infrastructure investment, simultaneously, for both navigation and highway capital investments. One result of their investigation was the development of industry-specific navigation capital investment final demand elasticity estimates. An industrial final demand elasticity of navigation capital investment is the percentage change in final demand for a sector due to a one-percent (1%) change in navigation capital investment. They also evaluated the short- and long-run effects of navigation capital investments. The methodology employed by Kelejian and Robinson (2000) is to conjoin an econometrically estimated model of resource prices (for labor, energy, and materials) in relation to transportation infrastructure capital investments (i.e., highways and navigation) with a variable input-output (VIO) model of the U.S. economy. Kelejian and Robinson (2006) further refined their econometric resource price model to state economies, which can be then conjoined with a state-level MRVIO model.

ES.4 Economic Value of the McClellan-Kerr Arkansas River Navigation System

For the purpose of our study the economic value of the Oklahoma portion of the McClellan-Kerr Arkansas Navigation System, we define the Oklahoma portion of the MKARNS

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[1] Recent empirical evidence by Hillberry and Hummels (2005) suggest that intermediate demand helps explain the variation in industry expenditures across regions. For example, consumption varies considerably across regions and this is well predicted by the industrial structure and the demand for intermediate inputs.

[2] The resource cost effects of transportation infrastructure development and the consequences of ignoring them for infrastructure productivity modeling are further discussed by Dalenberg and Partridge (1997), Haughwout (1998), and Kelejian and Robinson (2000).

to consist of the navigation channel from the Port of Catoosa to where it flows into the State of Arkansas.[3] This includes the seven projects that are managed by the Tulsa District Office of the U.S. Army Corps of Engineers shown in the upper portion of Table ES 1.[4] In addition, we also consider in our economic value study of the MKARNS the supporting functions of those upstream Tulsa District projects shown in Table ES 2.

Table ES 1 McClellan-Kerr Arkansas River Navigation System and Related Corps-Managed Projects[5]

Tulsa District MKARNS Project	Navigation	Hydro Power	Water Supply	Flood Control	Recreat ion	Fish & Wildlife
Arkansas River Bank Stabilization and Channel Rectification, OK	X			X		
Chouteau Lock and Dam (#17)	X				X	X
Newt Graham Lock and Dam (#18)	X				X	X
Robert S. Kerr Lock and Dam (#15) and Reservoir	X	X			X	
Robert S. Kerr Marine Terminal	X					
Sans Bois Navigation Channel	X					
W. D. Mayo Lock and Dam (#14)	X					
Webbers Falls Lock and Dam (#16) and Reservoir	X	X				

ES.4.1 Economic Valuation Methodology

The economic value of an existing activity or project is commonly determined by evaluating the consequences of ceasing the activity or project. In the terms used by the Corps of Engineers the “with” condition is for the Corps of Engineers to continue maintaining the existing state of the MKARNS. The “without” condition is the hypothetical state of shutting down the McClellan-Kerr Arkansas Navigation System. This will mean that the functions performed by the MKARNS will no longer be continued. These functions include such activities as navigation, hydropower, recreation, water supply, and flood control. However, it is assumed that the Corps will continue the maintenance and operations of the functions performed at the projects shown in Table ES 2 (i.e., that formally supported the MKARNS). Specifically the navigation, hydropower, and recreation functions of the MKARNS will cease because it is expected that the navigation channel will be lowered to a “river” level by simply leaving the locks open. This will mean that the MKARNS’ reservoirs will also be lowered.

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[3] This includes the section of the Verdigris River that connects the Port of Catoosa to the Arkansas River.

[4] See Appendix E for descriptions of the MKARNS projects managed by the Tulsa District of the US Army Corps of Engineers.

[5] Source: Tulsa District. 2003. *Tulsa District Civil Works Projects Pertinent Data Sheets*. Tulsa, OK: Tulsa District, U.S. Army Corps of Engineers (November).

Table ES 2 MKARNS-Related Corps-Managed Projects[6]

Other Tulsa District Navigation Projects	Navigation	Hydro Power	Water Supply	Flood Control	Recreation	Fish & Wildlife
Big and Little Sallisaw Creeks Navigation Project, OK	X					
Poteau River Navigation Project, OK and AR	X					
Copan Lake (1)			X	X	X	X
Eufaula Lake	X	X	X	X		
Fort Gibson Lake		X		X		
Grand Lake O' the Cherokees (Pensacola Dam)		X		X		
Hulah Lake (2)			X	X		
Kaw Dam (3)		X	X	X	X	X
Keystone Lake	X	X	X	X		X
Lake Hudson (Markham Ferry Dam)		X		X		
Oologah Lake	X		X	X	X	X
Tenkiller Ferry Lake		X		X		
Wister Lake (4)			X	X		

Two water resource functions are not evaluated in this report. One, water supply is not an authorized function of the MKARNS. People are currently allowed to use the available water in the MKARNS for such purposes as irrigation (essentially by putting a pipe or hose in the waterway), however, if the water levels drop too low the Corps will not manage the MKARNS to maintain water supplies. As a result, because the MKARNS has no authorized water supply function we will not consider any economic effects of reduced water supplies due to the closure of the MKARNS. People will still be able to put hoses and pipes in the "Arkansas River". Water supply is an authorized function of the reservoirs upstream of the MKARNS and they will be maintained in the hypothetical event of closing the MKARNS. Two, flood control is a function that is also performed by the upstream reservoirs (projects in the lower portion of Table ES.1). This function is controlled by a river gage that measures water flow located at Fort Smith on the Arkansas side of the Oklahoma/Arkansas border. It is expected that this function will continue whether the MKARNS exists or not.

The regional economic impacts estimated and reported in this study stem from hydropower generation, waterway-related spending and investment, transportation savings due to navigation traffic, and recreational activities affected by the operations and maintenance of the MKARNS. The economic effects of the MKARNS are evaluated in one of three ways describe above: 1) MKARNS-related spending, 2) transportation savings generated by the MKARNS, and 3) induced productivity enhancements induced by public investments related to

[6] (1) Copan Lake has a water quality function, (2) Hulah Lake has water conservation and low-flow regulation functions, (3) Kaw Lake has a water quality function, and (4) Wister Lake also has low-flow augmentation, water conservation & sedimentation functions. Functions marked with a red X have MKARNS supporting purposes. Source: Tulsa District. 2003. *Tulsa District Civil Works Projects Pertinent Data Sheets*. Tulsa, OK: Tulsa District, U.S. Army Corps of Engineers (November).

the proposed navigation channel deepening for the MKARNS. The algorithms and procedures for each of the three types of economic effects analysis have been implemented in an "easy-to-use" spreadsheet program (called "***MKARNSCalculator_MRVIO_Final.xlsb***"). MKARNS-related spending impact calculations requires that a spreadsheet user enter the "direct" project spending effects as either set of industry- or commodity-specific expenditures for each region that is directly impacted by the project or activity (such as Corps operations and maintenance expenditures that occur in Oklahoma).

Transportation savings generated impacts requires a spreadsheet user to enter percentage changes in transportation costs between domestic locations (i.e., between regions of the model—Arkansas, Oklahoma, Kansas, Missouri, Texas, and the rest of the United States) for each affected commodity.[7] Waterborne commerce data from the Navigation Data Center (US Army Corps of Engineers) show foreign imports and exports occurring in coastal states that have ports and for states that have ports on the Great Lakes. This means that the Corps' waterborne commerce data do not report foreign exports or imports for the State of Oklahoma. However, a large portion of Oklahoma's outgoing traffic is shipped to buyers located in foreign destinations. Consequently, transportation savings for foreign exports are evaluated using a different procedure. The percentage reductions and increases in transportation savings of foreign exports are converted into changes in export demand by multiplying the percentage changes in transportation changes for each affected foreign exported commodity by their respective direct uses for each industry in Oklahoma.[8] These multiplications then multiplied by the respective industry output levels then provide estimates of industry-level demand changes to be used in the spreadsheet calculator.

Induced productivity enhancements by public investment impacts are computed by first estimating the reduction labor, materials, and energy costs by industry using the Model B version of the infrastructure productivity model given in Appendix C of this report. Multiplying the estimated labor, material, and energy cost reductions derived the infrastructure production model (in percentage terms) by their existing cost shares by industry will provide estimates of demand changes for goods and services in each region.[9] That is, even though the infrastructure investment (i.e., channel deepening) is being made on the MKARNS in Oklahoma the productivity effects will be felt throughout the nation.

ES.4.2 Economic Value of the McClellan-Kerr Arkansas River Navigation System

The economic value of the McClellan-Kerr Arkansas River Navigation System is summarized here as the sum of the net electricity effects of ceasing MKARNS hydropower

[7] Increases are shown as positive changes and decreases are shown as negative changes.

[8] The industry uses of commodities can be interpreted as the percentage change in industry output due to a one percent change in the cost of a commodity's use.

[9] This procedure is similar to that used to compute the demand changes due to percentage changes in transportation costs on foreign exports from Oklahoma.

operations at their sites and substituting a new natural gas electricity generating facility within Oklahoma to replace the lost power capacity. The analysis required calculating the negative effects of losing hydropower operations, the positive effects of a new natural gas electricity power facility, and the negative effects of the forgone income required to finance the new natural gas power generation facility.[10]

Table ES 3 Net Losses Due to Changes in Electricity Generation[11]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$93,945**	**655**	**$24,088**	**$23,177**	**$4,701**	**$51,967**
Arkansas	**$1,823**	**12**	**$435**	**$319**	**$57**	**$811**
Oklahoma	**$64,981**	**484**	**$17,036**	**$16,280**	**$3,462**	**$36,779**
Kansas	**$2,815**	**19**	**$701**	**$530**	**$89**	**$1,320**
Missouri	**$4,297**	**28**	**$1,171**	**$836**	**$158**	**$2,164**
Texas	**$20,029**	**113**	**$4,746**	**$5,212**	**$936**	**$10,893**
Rest of US	**$40,889**	**232**	**$10,929**	**$9,097**	**$1,592**	**$21,617**
US Total Impact	**$134,834**	**887**	**$35,017**	**$32,274**	**$6,293**	**$73,584**

The loss of hydropower generation capacity on the Oklahoma portion of the MKARNS is estimated to decrease the nation's business sales annually by $134.8 million (in 2015 prices): see Table ES 3. The loss in contribution to the nation's gross domestic product (GDP) is $73.6 million and gross business operating surplus is $32.3 million after all other expenses have been paid (i.e., rents, dividends, interest, and profits). Oklahoma's portion of the MKARNS is responsible for 890 of the nation's full and part-time jobs and for $35.0 million in employee compensation. Business taxes and license fees total $6.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $93.9 million in business sales, $52.0 million in GDP, 655 full and part-time jobs, $24.1 million in employee compensation, $23.2 million in gross business operating surplus, and $4.7 million in business taxes. The State of Oklahoma also shares in the economic value: $65.0 million in business sales, $36.8 million in GDP, 480 full and part-time jobs, $17.0 million in employee compensation, $16.3 million in gross business operating surpluses, and $3.5 million in business taxes.

[10] The economic effects of constructing the new natural gas electricity power generating facility were evaluated. However, the construction impacts are not included here because they will only occur while the construction activity is ongoing. After that, the construction impacts are expected to cease.

[11] All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

Table ES 4 Losses Due to Reductions in Private and Public Waterway Expenditures[12]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$1,615,700	8,888	$323,174	$309,131	$41,707	$674,012
Arkansas	$56,273	356	$13,887	$9,023	$1,503	$24,413
Oklahoma	$1,110,345	6,088	$197,581	$206,652	$24,131	$428,364
Kansas	$39,221	213	$9,211	$6,487	$1,083	$16,781
Missouri	$70,439	387	$17,508	$12,201	$2,071	$31,780
Texas	$339,423	1,845	$84,988	$74,768	$12,919	$172,675
Rest of US	$1,542,958	8,488	$418,560	$314,475	$51,628	$784,662
US Total Impact	$3,158,658	17,376	$741,734	$623,606	$93,335	$1,458,675

Closing the MKARNS will mean reductions in private and public waterway-related spending in Oklahoma. The US Army Corps of Engineers spends money annually to operate and maintain the MKARNS that will no longer be needed without the MKARNS. Private port and cargo shipping activities will cease if the MKARNS closes. In addition, private sector interests make substantial annual investments to enhance their infrastructure. The loss of the private and public expenditures on the Oklahoma portion of the MKARNS is estimated to decrease the nation's business sales annually by $3.2 billion (in 2015 prices): see Table ES 4. The loss in contribution to the nation's gross domestic product (GDP) is $1.5 billion and gross business operating surplus is $623.6 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 17,380 of the nation's full and part-time jobs and for $741.7 million in employee compensation. Business taxes and license fees total $93.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $1.6 billion in business sales, $674.0 million in GDP, 8,890 full and part-time jobs, $323.2 million in employee compensation, $309.1 million in gross business operating surplus, and $41.7 million in business taxes. The State of Oklahoma also shares in the economic value: $1.1 billion in business sales, $428.4 million in GDP, 6,090 full and part-time jobs, $197.6 million in employee compensation, $206.7 million in gross business operating surpluses, and $24.1 million in business taxes.

If the MKARNS closed it is expected that transportation costs will rise for those commodities currently hauled on the waterway having to switch to more expensive modes of transportation. Based on 2012 traffic data it is estimated that transportation costs will rise by $156.1 million (2015 prices): see Table ES 5.[13] Higher transportation costs are estimated to decrease the nation's business sales annually by $1.1 billion. The contribution to the nation's gross domestic product (GDP) is $569.0 million and gross business operating surpluses is $194.3 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 4,470 of the nation's full and part-time jobs and for $181.3 million in employee

[12] All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[13] Note that the increases in transportation costs due to closing the MKARNS are included

compensation. Business taxes and license fees total $37.5 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $693.4 million in business sales, $298.8 million in GDP, 3,270 full and part-time jobs, $125.2 million in employee compensation, $144.5 million in gross operating surplus, and $29.1 million in business taxes. The State of Oklahoma also shares in the economic value: $526.9 million in business sales, $218.2 million in GDP, 2,330 full and part-time jobs, $88.3 million in employee compensation, $106.8 million in gross business operating surpluses, and $23.1 million in business taxes.

Table ES 5 Losses Due to Increases in Transportation Rates[14]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$37,723	169	$8,080	$8,875	$1,519	$18,474
Arkansas	$3,800	19	$707	$684	$96	$1,488
Oklahoma	$9,897	49	$1,953	$2,429	$485	$4,867
Kansas	$866	3	$153	$162	$25	$340
Missouri	$2,907	14	$622	$703	$120	$1,445
Texas	$20,254	84	$4,645	$4,895	$793	$10,334
Rest of US	$483,575	2,205	$127,109	$121,755	$20,326	$269,190
US Total Impact	$521,298	2,374	$135,189	$130,629	$21,846	$287,664
Transport Savings	$156,139	0	$0	$0	$0	$156,139
US Impact + Savings	$677,437	2,374	$135,189	$130,629	$21,846	$443,803

Closing the MKARNS would reduce recreational visitation in Oklahoma. Subsequently, recreation spending in Oklahoma is expected to reduce business sales by $105.6 million, $43.5 million in GDP, 2,120 full and part-time jobs, $19.0 million in employee compensation, $20.5 million in gross business operating surpluses, and $3.1 million in business taxes (2015 prices): see Table ES 6.

Table ES 6 Losses Due to Reductions in Recreation Activities[15]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
Oklahoma	$105,589	2,123	$19,863	$20,524	$3,112	$43,498

The economic value of the McClellan-Kerr Arkansas River Navigation System is the sum total of all the economic losses due to closing the MKARNS. Closing the MKARNS is estimated to decrease the nation's business sales annually by $4.1 billion (in 2015 prices): see Table ES 7.[16] The contribution to the nation's gross domestic product (GDP) is $2.0 billion and gross

[14] All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[15] All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[16] Note that the business sales and value added reported here includes the loss of transportation savings generated by the MKARNS 9-foot navigation channel.

business operating surpluses of $807.0 million. Oklahoma's portion of the MKARNS is responsible for 22,760 of the nation's full and part-time jobs and for $931.8 million in employee compensation. Business taxes and license fees total $124.6 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $1.9 billion in business sales, $744.5 million in GDP, 11,840 full and part-time jobs, $375.2 million in employee compensation, $361.7 million in gross operating surplus, and $51.0 million in business taxes. The State of Oklahoma also shares in the economic value: $1.2 billion in business sales, $470.0 million in GDP, 6,600 full and part-time jobs, $216.6 million in employee compensation, $225.4 million in gross business operating surpluses, and $28.1 million in business taxes.

Table ES 7 Total Economic Losses Due to Closing the MKARNS[17]

Region	Sales	Employment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$1,852,957**	**11,836**	**$375,205**	**$361,707**	**$51,039**	**$744,452**
Arkansas	**$167,486**	**2,510**	**$34,892**	**$30,550**	**$4,768**	**$26,712**
Oklahoma	**$1,185,222**	**6,620**	**$216,569**	**$225,362**	**$28,078**	**$470,009**
Kansas	**$42,901**	**235**	**$10,065**	**$7,179**	**$1,196**	**$18,440**
Missouri	**$77,642**	**428**	**$19,300**	**$13,740**	**$2,349**	**$35,389**
Texas	**$379,706**	**2,042**	**$94,379**	**$84,875**	**$14,648**	**$193,902**
Rest of US	**$2,067,423**	**10,925**	**$556,598**	**$445,327**	**$73,546**	**$1,075,470**
US Total Impact	**$3,920,380**	**22,761**	**$931,803**	**$807,033**	**$124,585**	**$1,819,922**
Transport Savings	**$156,139**	**0**	**$0**	**$0**	**$0**	**$156,139**
US Impact + Savings	**$4,076,519**	**22,761**	**$931,803**	**$807,033**	**$124,585**	**$1,976,061**

ES.4.3 Environmental Effects of MKARNS

Two key indicators of the value the McClellan-Kerr Arkansas River Navigation System (MKARNS) are fuel savings and lower carbon dioxide (CO_2) emissions created by hauling commodities via the waterway (by barge) rather than by the competing rail and highway modes.[18] Barges are known to use fuel more efficiently than either rail or truck. Every gallon of fuel used by barges will haul a ton of cargo 576 miles, while rail will haul the same ton 413 miles and truck will haul the same ton 155 miles. In addition, barges also generate fewer CO2 emissions than either rail or trucks. For every million ton-miles, barges generate 19.3 metric tons of CO2 gases, while rail emits 26.9 metric tons and trucks generate 71.6 metric tons.[19]

[17] All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[18] C. James Kruse, Annie Protopapas, Leslie E. Olson, and David H. Bierlin. 2009. *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*. Houston, TX: Center for Ports and Waterways, Texas Transportation Institute. Prepared for the Maritime Administration, U.S. Department of Transportation and the National Waterways Foundation (March).

[19] A metric ton of carbon dioxide is more appropriately interpreted as a volume, not a weight.[19] The density of CO_2 in its pure form is 0.1234 pounds per cubic foot—so one pound of CO_2 fills about 8.1 cubic

The MKARNS provides significant fuel savings and reduces substantial environmental emissions (in terms of carbon dioxide) as compared with other possible modes of transportation. The Oklahoma portion of the MKARNS carried approximately 6.1 million short tons and 12.5 billion ton-miles of freight during 2012.[20] This required the use of about 21.7 million gallons of fuel and a little more than 241.4 thousands of metric tons of CO_2 were emitted during the transport on the MKARNS. We estimate that fuel use and CO_2 emissions would be 40 percent higher if the MKARNS waterway freight traffic were hauled by rail and 270 percent higher if trucks had been used. However, the latter comparison is a bit skewed in that truck transportation is not often the competing mode for barge traffic.

Table ES 8 MKARNS Waterway Traffic Modal Fuel Use and Emissions[21]

	Conversion Factors*		Based on 2012 MKARNS Traffic	
Mode	**Ton-miles per gallon**	**Metric tons of CO2 emissions per million ton-miles**	**Fuel Used (millions of gallons)**	**CO2 Emissions (metric tons)**
Barge	**576**	**19.3**	**21.7**	**241,396**
Rail	**413**	**26.9**	**30.3**	**336,453**
Truck	**155**	**71.6**	**80.7**	**895,541**

In addition, a standard barge on the MKARNS is estimated to be able to hold 1,500 short tons of dry-bulk commodities. It is estimated that 4,077 barges were required to transport the 6.1 million tons of waterborne traffic on the MKARNS during 2012. It is also estimated that it would take 13.7 rail cars and 60 trucks to hold the same volume of commodities as one barge. This would mean that approximately 55,915 rail cars and 2 trucks would be needed to haul the same cargo that was carried on the MKARNS during 2012 via barges (Table ES 9).

Table ES 9 Traffic Mode Equivalence[22]

Mode	**Capacity**	**2012 MKARNS Traffic**	**Number Required**
Barge	**1,500**	**6,116**	**4,077**
Rail Car	**109**	**6,116**	**55,915**
Truck	**25**	**6,116**	**244,629**

feet of space (approximately a cube that is 2 feet on each side). One ton (2,000 pounds) of CO_2 would fill about 16,200 cubic feet—a cube that is around 25.3 feet on each side or a weather balloon with a diameter of 31.4 feet.

[20] A ton of cargo hauled by barge travels approximately 2,045 miles, on average, per trip based on the US Federal Highway Administration's (2009) *Freight Analysis Framework 3* data for 2015.

[21] Note: Fuel use and CO2 emissions are based on 2012 MKARNS traffic for Oklahoma.

[22] Note: Capacity is the tons hauled by one barge, rail car, or truck. 2012 MKARNS traffic is in thousands of tons. Number required is the number of barges, rail cars, or truck needed to haul the 2012 MKARNS traffic.

ES.5 Other Analysis Covered in This Report

ES.5.1 Economic Effects of Deepening the McClellan-Kerr Arkansas River Navigation System

In August 2005 the U.S. Army Corps of Engineers Districts at Little Rock, Arkansas and Tulsa, Oklahoma completed two major studies that justified enhanced maintenance and improvements of the MKARNS and ensured compliance with national environmental regulations.[23] These maintenance activities and improvements have three features. One, continue ongoing operation and maintenance of the existing 9-foot navigation channel on the MKARNS. Some approved dredged material disposal sites have reached capacity and new disposal sites are required to continue channel maintenance activities. Additionally, the construction of new river training structures would facilitate the maintenance of the 9-foot navigation channel. Two, sustained high flows on the MKARNS have adversely influenced the safety and efficiency of commercial navigation operations and have resulted in flood damages along the river. The reliability and predictability of river flows affect navigation traffic utilization of the MKARNS. Three, commercial navigation is not at optimum productivity within the MKARNS since its 9-foot navigation channel limits towboat loads compared to the Lower Mississippi River's authorized 12-foot channel.

The 2005 MKARNS Feasibility Report indicated that total cost of the MKARNS project is $166.4 million and about half of that cost (approximately 44%) will occur from project activities in Oklahoma. The 2005 MKARNS Feasibility Report considers a combination of flow management, dredging, and training structures (dikes and jetties) in order to achieve and maintain a 12-foot navigation channel in the McClellan-Kerr Arkansas River Navigation System (MKARNS). The purpose of this report is to estimate Arkansas' portion of the costs of deepening the McClellan-Kerr Arkansas River Navigation System (MKARNS) to 12 feet by dredging alone. Note that the MKARNS project cost here is as was published in 2005 and does not reflect the most current cost estimate shown earlier ($183 million in 2013 and about $185 million in 2015 prices). Purpose here is to evaluate the cost of a "channel deepening".

There are three parts to estimating the economic impacts of deepening the MKARNS navigation channel an additional three feet. The first part is similar to computing the economic effects of the loss of transportation benefits of having the MKARNS. That is, the additional three feet of navigation channel adds to the existing transportation benefits created by the existing nine feet. The additional transportation savings created by the additional three feet of navigation channel (i.e., from 9 feet to 12 feet) is approximately $9.0 million shown in Table ES

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[23] Little Rock and Tulsa Districts. 2005. *Final Environmental Impact Statement: Arkansas River Navigation Study*. Little Rock, AR and Tulsa, OK: U.S. Army Corps of Engineers (August). Little Rock and Tulsa Districts. 2005. *Final Feasibility Study: Arkansas River Navigation Study Arkansas and Oklahoma McClellan-Kerr Arkansas River Navigation System*. Little Rock, AR and Tulsa, OK: U.S. Army Corps of Engineers (August).

10 (2015 prices). Second, it is estimated that an additional $1.6 million annually in operations and maintenance expenditures will be required to properly maintain the deeper navigation channel. Third, the money spent to deepen the MKARNS navigation channel represents a public investment in the nation's waterway infrastructure. The approximate cost of deepening the entire MKARNS navigation channel is about $185 million of which about 44% is Oklahoma's share (see the earlier discussion about the channel deepening costs).

Table ES 10 Total Impacts of Deepening the MKARNS Navigation Channel an Additional Three Feet[24]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$160,677**	**1,041**	**$45,403**	**$32,232**	**$5,702**	**$83,337**
Arkansas	**$4,414**	**23**	**$919**	**$702**	**$116**	**$1,737**
Oklahoma	**$109,628**	**783**	**$34,247**	**$20,920**	**$3,796**	**$58,964**
Kansas	**$5,186**	**27**	**$1,021**	**$975**	**$134**	**$2,130**
Missouri	**$6,134**	**34**	**$1,406**	**$1,176**	**$188**	**$2,770**
Texas	**$35,314**	**173**	**$7,810**	**$8,459**	**$1,468**	**$17,737**
Rest of US	**$95,409**	**474**	**$23,946**	**$21,390**	**$3,552**	**$48,888**
US Total Impact	**$256,086**	**1,516**	**$69,349**	**$53,622**	**$9,255**	**$132,225**
Transport Savings	**$9,006**	**0**	**$0**	**$0**	**$0**	**$9,006**
US Impact + Savings	**$265,092**	**1,516**	**$69,349**	**$53,622**	**$9,255**	**$141,231**

The economic value of deepening the McClellan-Kerr Arkansas River Navigation System navigation channel an additional 3 feet is estimated to increase the nation's business sales annually by $265.1 million (in 2015 prices): see Table ES 10.[25] The contribution to the nation's gross domestic product (GDP) is $141.2 million and gross business operating surpluses of $53.6 million. Oklahoma's portion of the MKARNS is responsible for 1,500 of the nation's full and part-time jobs and for $69.3 million in employee compensation. Business taxes and license fees total $9.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $160.7 million in business sales, $83.3 million in GDP, 1,040 full and part-time jobs, $45.4 million in employee compensation, $32.2 million in gross operating surplus, and $5.7 million in business taxes. The State of Oklahoma also shares in the economic value: $109.6 million in business sales, $59.0 million in GDP, 780 full and part-time jobs, $34.2 million in employee compensation, $20.9 million in gross business operating surpluses, and $3.8 million in business taxes.

[24] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[25] Note that the business sales and value added reported here includes the loss of transportation savings generated by the deepening the MKARNS navigation channel from 9 feet to 12 feet.

ES.5.2 Economic Effects of Disruptions of Waterborne Traffic on the McClellan-Kerr Arkansas River Navigation System

Inland waterway ports are vital to the U.S. economy since these ports serve as multimodal transport hub by connecting barge, train, and truck transportation modes (MacKenzie et al., 2012). In fact the Oklahoma Department of Transportation (ODOT) reported 12.1 million tons traveled the entire McClellan-Kerr Arkansas River Navigation System (about half of the tonnage traveled on the Oklahoma portion on the MKARNS). Disruptive events such as the closure of an inland port can significantly effects the flow of commodities, thus impacting the businesses that rely on the MKARNS for delivery of their cargo in a timely manner (Grier, 2009). When a traffic disruption occurs tow boats have several choices. A tow boat can either wait for the system to become operable or choose to use an alternative mode of transportation. If the tow boat decides to wait, there are two costs associated with that decision: a penalty cost and a holding cost. If another mode of transportation is chosen there is an extra transportation cost in addition to the penalty and holding costs. The commodity-specific delay costs per ton for different disruption durations are shown in Table ES 11.

Table ES 11 Average Delay Costs per Ton of Commodity Shipped for Varying Disruption Durations[26]

Commodity	1 day	2 days	3 days	2 weeks	2 months	6 months
Chemical Fertilizers	$0.01	$0.02	$0.04	$1.10	$11.25	$38.39
Coal and Coke	$0.00	$0.00	$0.01	$0.21	$5.23	$28.10
Food/Farm Products	$0.00	$0.01	$0.01	$0.29	$6.84	$30.13
Iron and Steel	$0.01	$0.03	$0.06	$1.70	$13.06	$43.29
Manufacturing Equipment and Machinery	$0.07	$0.21	$0.40	$3.74	$34.40	$109.63
Minerals and Building Materials	$0.00	$0.01	$0.03	$0.77	$10.07	$35.71
Miscellaneous Products	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other Chemicals	$0.00	$0.01	$0.03	$0.74	$10.01	$35.47
Petroleum Products	$0.01	$0.02	$0.03	$0.82	$10.31	$36.11
Sand, Gravel and Rock	$0.00	$0.00	$0.00	$0.02	$0.55	$5.50
Grain	$0.00	$0.01	$0.02	$0.35	$7.41	$30.92

Transportation cost estimates are computed by multiplying the per ton delay costs by the outgoing and incoming 2012 Waterborne Commerce traffic data for each commodity type: see Table ES 12. Note, delays that are 3 days or less have total delay costs that are less than $1 million. We do not expect that delay costs that are less than $1 million in total are likely to generate substantial regional economic impacts and, as a result, they are not reviewed in this

[26] Source: Calculations by Professor Heather Nachtmann, and Mssers. Furkan Oztanriseven and Othman Boudhaoum, University of Arkansas at Fayetteville.

executive summary. Below, we review the economic consequences of traffic disruptions lasting 2 weeks, 2 months, and 6 months.

Table ES 12 Traffic Delay Costs for Varying Disruptions[27]

		Disruption Costs					
Delay	**Traffic**	**AR**	**OK**	**MO**	**TX**	**RUS**	**Total**
1 Day	**From Oklahoma**	**$7**	**$0**	**$2**	**$4**	**$68**	**$82**
	To Oklahoma	**$1**	**$0**	**$5**	**$1**	**$44**	**$52**
	1 Day Delay Total	**$9**	**$0**	**$7**	**$5**	**$113**	**$133**
2 Days	**From Oklahoma**	**$22**	**$1**	**$5**	**$11**	**$212**	**$252**
	To Oklahoma	**$5**	**$1**	**$15**	**$2**	**$120**	**$143**
	2 Day Delay Total	**$27**	**$1**	**$20**	**$13**	**$332**	**$394**
3 Days	**From Oklahoma**	**$43**	**$3**	**$10**	**$19**	**$399**	**$474**
	To Oklahoma	**$9**	**$3**	**$29**	**$4**	**$230**	**$274**
	3 Day Delay Total	**$51**	**$3**	**$38**	**$23**	**$629**	**$745**
2 Weeks	**From Oklahoma**	**$399**	**$25**	**$92**	**$243**	**$4,363**	**$5,121**
	To Oklahoma	**$146**	**$25**	**$267**	**$33**	**$3,660**	**$4,131**
	2 Week Delay Total	**$544**	**$25**	**$359**	**$276**	**$8,023**	**$9,227**
2 Months	**From Oklahoma**	**$3,666**	**$232**	**$844**	**$2,550**	**$48,744**	**$56,036**
	To Oklahoma	**$1,405**	**$232**	**$2,459**	**$302**	**$36,045**	**$40,442**
	2 Month Delay Total	**$5,071**	**$232**	**$3,303**	**$2,852**	**$84,788**	**$96,246**
6 Months	**From Oklahoma**	**$11,684**	**$738**	**$2,691**	**$8,497**	**$172,808**	**$196,418**
	To Oklahoma	**$5,183**	**$738**	**$7,837**	**$962**	**$121,736**	**$136,456**
	6 Month Delay Total	**$16,867**	**$738**	**$10,528**	**$9,459**	**$294,543**	**$332,136**

The economic value of traffic disruptions on the MKARNS lasting 2 weeks is estimated to decrease the nation's business sales annually by $26.5 million (in 2015 prices): see Table ES 13. The contribution to the nation's gross domestic product (GDP) is $18.7 million and gross business operating surpluses of $4.3 million. Oklahoma's portion of the MKARNS is responsible for 80 of the nation's full and part-time jobs and for $4.5 million in employee compensation. Business taxes and license fees total $0.7 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $1.1 million in business sales, $550 thousand in GDP, 5 full and part-time jobs, $250 thousand in employee compensation, $250 thousand in gross operating surplus, and $40 thousand in business taxes. The State of Oklahoma also shares in the economic value: $220 thousand in business sales, $110 thousand in GDP, 1 full and part-time job, $50 thousand in employee compensation, $50 thousand in gross business operating surpluses, and $9 thousand in business taxes.

[27] Note: Monetary values in thousands of 2015 annualized net present value dollars. Savings for Oklahoma is both incoming and outgoing, the total only counts it once.

Table ES 13 Economic Effects of a 2-Week Delay in MKARNS Traffic[28]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$1,110**	**5**	**$254**	**$252**	**$39**	**$546**
Arkansas	**$109**	**1**	**$25**	**$20**	**$3**	**$48**
Oklahoma	**$222**	**1**	**$53**	**$52**	**$9**	**$113**
Kansas	**$22**	**0**	**$4**	**$4**	**$1**	**$9**
Missouri	**$64**	**0**	**$14**	**$15**	**$2**	**$32**
Texas	**$693**	**3**	**$158**	**$161**	**$25**	**$344**
Rest of US	**$16,181**	**74**	**$4,251**	**$4,027**	**$661**	**$8,939**
US Total Impact	**$17,291**	**79**	**$4,506**	**$4,279**	**$700**	**$9,485**
Transport Savings	**$9,227**	**0**	**$0**	**$0**	**$0**	**$9,227**
US Impact + Savings	**$26,518**	**79**	**$4,506**	**$4,279**	**$700**	**$18,712**

Table ES 14 Economic Effects of a 2-Month Delay in MKARNS Traffic[29]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$13,276**	**63**	**$2,949**	**$3,072**	**$493**	**$6,514**
Arkansas	**$1,332**	**8**	**$287**	**$244**	**$35**	**$566**
Oklahoma	**$2,854**	**18**	**$622**	**$684**	**$123**	**$1,429**
Kansas	**$280**	**1**	**$52**	**$55**	**$8**	**$114**
Missouri	**$896**	**4**	**$190**	**$220**	**$35**	**$445**
Texas	**$7,915**	**33**	**$1,799**	**$1,869**	**$292**	**$3,960**
Rest of US	**$185,637**	**841**	**$48,163**	**$46,772**	**$7,701**	**$102,637**
US Total Impact	**$198,913**	**904**	**$51,113**	**$49,844**	**$8,195**	**$109,151**
Transport Savings	**$96,246**	**0**	**$0**	**$0**	**$0**	**$96,246**
US Impact + Savings	**$295,159**	**904**	**$51,113**	**$49,844**	**$8,195**	**$205,397**

The economic value of traffic disruptions on the MKARNS lasting 2 months is estimated to decrease the nation's business sales annually by $295.2 million (in 2015 prices): see Table ES 14. The contribution to the nation's gross domestic product (GDP) is $205.4 million and gross business operating surpluses of $49.8 million. Oklahoma's portion of the MKARNS is responsible for 900 of the nation's full and part-time jobs and for $51.1 million in employee compensation. Business taxes and license fees total $8.2 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $13.3 million in business sales, $6.5 million in GDP, 60 full and part-time jobs, $2.9 million in employee compensation, $3.1 million in gross operating surplus, and $0.5 million in business taxes. The State of Oklahoma also shares in the economic value: $2.9 million in business sales, $1.4 million in

[28] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[29] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

GDP, 20 full and part-time jobs, $0.6 million in employee compensation, $0.7 million in gross business operating surpluses, and $120 thousand in business taxes.

Table ES 15 Economic Effects of a 6-Month Delay in MKARNS Traffic[30]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$48,770	229	$10,722	$11,352	$1,871	$23,944
Arkansas	$4,935	28	$1,039	$898	$129	$2,067
Oklahoma	$11,002	63	$2,309	$2,656	$505	$5,470
Kansas	$1,043	4	$191	$204	$30	$425
Missouri	$3,397	16	$719	$833	$136	$1,688
Texas	$28,393	117	$6,464	$6,760	$1,071	$14,295
Rest of US	$660,830	2,997	$171,549	$166,829	$27,544	$365,922
US Total Impact	$709,600	3,226	$182,271	$178,181	$29,415	$389,866
Transport Savings	$332,136	0	$0	$0	$0	$332,136
US Impact + Savings	$1,041,736	3,226	$182,271	$178,181	$29,415	$722,002

The economic value of traffic disruptions on the MKARNS lasting 6 months is estimated to decrease the nation's business sales annually by $1.0 billion (in 2015 prices): see Table ES 15. The contribution to the nation's gross domestic product (GDP) is $722.0 million and gross business operating surpluses of $178.2 million. Oklahoma's portion of the MKARNS is responsible for 3,230 of the nation's full and part-time jobs and for $182.3 million in employee compensation. Business taxes and license fees total $29.4 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $48.8 million in business sales, $23.9 million in GDP, 230 full and part-time jobs, $10.7 million in employee compensation, $11.4 million in gross operating surplus, and $1.9 million in business taxes. The State of Oklahoma also shares in the economic value: $11.0 million in business sales, $5.5 million in GDP, 60 full and part-time jobs, $2.3 million in employee compensation, $2.7 million in gross business operating surpluses, and $0.5 million in business taxes.

ES.5.3 MKARNS Survey, Key Industries, and Extended Reach of Oklahoma's Waterborne Commerce

One of the features of this study is that a survey of MKARNS users was undertaken by researchers at Oklahoma State University—Caneday and Soltani (2014). Three groups of users were surveyed: recreation users, waterway users, and port operators. The results for the waterway users and port operators are summarized here. Out of the 181 waterway users that responded to the survey a large majority (≈160) indicated more than 70% of their business relies on using the McClellan-Kerr Arkansas River Navigation System. A small portion of the respondents (39) have no facilities located at ports on the MKARNS. A large majority (≈160) reported that the MKARNS is vital to their business.

[30] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

Five port operators reported on the activities ongoing at their ports on the MKARNS. On average, the MKARNS ports contain 25 businesses that employ about 1,742 workers and require 896 acres to operate. Also on average over all five ports, each of the firms employed nearly 70 workers and required 36 acres to operate. A total of 748,515 tons of cargo were loaded, on average, at the MKARNS ports—dry bulk goods were the most common of the good loaded. According to the survey results, dry bulk goods are loaded and discharged most commonly at MKARNS ports in terms of tonnages: on average, there 481,356 tons discharged and 331,292 tons loaded. Liquid bulk goods are the second most commonly handled types of cargo at MKARNS ports (34,566 tons discharged and 226,403 tons loaded, on average). Break bulk goods are the third most commonly handled types of cargo at MKARNS ports (95,735 tons discharged and 15,220 tons loaded, on average). Finally, miscellaneous category of goods is the fourth most commonly handled types of cargo at MKARNS ports (8,800 tons discharged and 175,600 tons loaded, on average).

The five most common incoming commodities on the MKARNS (in terms of average tonnages) are fertilizers (498,679 tons), coal and petroleum products (290,265 tons), non-metallic minerals (243,537 tons), primary and semi-finished base metal forms (242,238 tons), , and base metal products (89,333 tons). The five most common outgoing commodities on the MKARNS (in terms of average tonnages) are cereal grains (535,000 tons), fuel oils (300,000 tons), coal and petroleum products (190,811 tons), waste and scrap (180,000 tons), and fertilizers (126,667 tons).

Waterborne commerce data for 2012 from the US Army Corps of Engineers indicates that Oklahoma has trading partners throughout the U.S. and beyond. During 2012 Oklahoma shipped out 3,478 thousand tons of cargo via the MKARNS. The five states receiving the larges shipments from Oklahoma are Louisiana (2,456 thousand tons), Alabama (179 thousand tons), Illinois (145 thousand tons), Texas (144 thousand tons), and Tennessee (106 thousand tons). Also during 2012 Oklahoma received 2,632 thousand tons of cargo on the MKARNS. The five states shipping waterborne cargo to Oklahoma are Louisiana (1,779 thousand tons), Arkansas (179 thousand tons), Alabama (149 thousand tons), Mississippi (92 thousand tons), and Tennessee (84 thousand tons).

Although the waterborne commerce statistics do not show any foreign exports or imports leaving or entering Oklahoma, it is suspected that a majority (if not a great portion) of outgoing traffic to the State of Louisiana is in fact represents foreign exports. Unfortunately, the official source for the waterborne commerce data (U.S. Army Corps of Engineers) does not contain the necessary information to make the distinction about how much of Oklahoma's traffic with Louisiana is export or import. For the purpose of analyzing the economic effects of the cost savings that the MKARNS provides we assume that the waterborne commodity traffic going to Louisiana from Oklahoma represents foreign exports.

ES.5.4 Potential Waterway Traffic

Identifying the sectors associated with the outgoing traffic is relatively simple. The industries that produced the commodities shipped out are identified by the commodity codes.[31] The first step in identifying industries that have potential for growth in waterborne commerce was to narrow those under consideration to ones that are not time sensitive or location specific; industries that can take advantage of the savings generated by shipping via the waterways. Prior examination of the commodities transported via water shows that extraction, agriculture, and some manufacturing are heavily represented. Manufacturing industries included are those that may acquire raw materials, ship finished goods, or some combination by water. Industries of particular interest exhibited greater concentrations of employment in the region than that of the nation, indicating that these industries are exporting the portion of production that is not consumed locally.

The second step is to consider those industries that have significant numbers of employees and recent growth (say from 2008 to 2014). Industries that have small levels of employment locally and nationally may show high measures for exporting, but still be insignificant to the local and national economies. Even industries with large numbers of employees may not be attractive candidates for growth if employment has been declining. In examining the employment data for both the 25 and 100 mile radiuses, it becomes apparent that many of the industries that are the largest or exhibit noteworthy growth in the entire 100 mile radius area are also leaders in the core counties surrounding the ports (25 mile radius).

Table ES 16 Potential MKARNS-Using Industries within a 25 Miles of the Ports of Catoosa and Muskogee[32]

NAICS Code	Description	2014 Employment	2008 - 2014 Employment Growth	Rank	2014 Export Percentage	Rank	Average Rank
2123	Boiler, Tank, and Shipping Container Manufacturing	453	36.0%	5	92.6%	1	3
3331	Steel Product Manufacturing from Purchased Steel	3,439	166.3%	1	72.6%	7	4
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	523	161.5%	2	75.8%	6	4
3312	Agriculture, Construction, and Mining Machinery Manufacturing	703	36.3%	4	75.9%	5	4.5

[31] On the other hand, identifying the industries associated with the commodities entering Oklahoma from other places is not easy. These shipments represent commodities that are used by industries that produce other goods. We do not have data necessary to directly identify the specific purchasers of the waterborne cargo by industry. Analytical techniques to identify new users of waterborne commodities and to measure their effective demands would require resources and time beyond those that were made available for this study. We recommend that such an analysis be undertaken.

[32] Note: Industrial order is based on the average ranking of the employment growth rates and export percentage.

NAICS Code	Description	2014 Employment	2008 - 2014 Employment Growth	Rank	2014 Export Percentage	Rank	Average Rank
3339	Cement and Concrete Product Manufacturing	5,475	46.3%	3	41.6%	10	6.5
3327	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	2,994	1.5%	10	82.7%	3	6.5
3328	Oil and Gas Extraction	1,091	1.7%	9	82.0%	4	6.5
3273	Other General Purpose Machinery Manufacturing	983	0.8%	11	84.2%	2	6.5
3334	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	2,410	30.7%	6	56.8%	9	7.5
2111	Coating, Engraving, Heat Treating, and Allied Activities	11,795	8.9%	8	57.9%	8	8
3324	Nonmetallic Mineral Mining and Quarrying	4,228	9.4%	7	16.9%	11	9

Table ES 17 Potential MKARNS-Using Industries within 100 Miles of the Ports of Catoosa and Muskogee

NAICS Code	Description	2014 Employment	2008 - 2014 Employment Growth	Rank	2014 Export Percentage	Rank	Average Rank
3324	Boiler, Tank, and Shipping Container Manufacturing	6,721	30.6%	4	82.9%	2	3
3312	Steel Product Manufacturing from Purchased Steel	2,196	83.0%	1	67.7%	6	3.5
2111	Oil and Gas Extraction	51,736	7.9%	8	84.9%	1	4.5
3331	Agriculture, Construction, and Mining Machinery Manufacturing	9,541	20.9%	5	68.1%	5	5
3111	Animal Food Manufacturing	2,868	8.2%	7	77.3%	3	5
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	908	66.3%	2	48.8%	8	5
3315	Foundries	2,860	50.9%	3	47.8%	9	6
3339	Other General Purpose Machinery Manufacturing	10,254	3.7%	10	68.9%	4	7
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	6,468	11.6%	6	26.3%	10	8
3271	Clay Product and Refractory Manufacturing	1,599	5.5%	9	62.6%	7	8
3328	Coating, Engraving, Heat Treating, and Allied Activities	2,053	3.4%	11	17.6%	11	11

ES.6 Recommendations

Based on the work conducted for this report it is recommended that the following suggestions should be considered for further study.

- **Potential Users of Incoming Commodities.** We were unable to identify potential users of commodities entering Oklahoma via the MKARNS due to the lack of relevant data and time. Data measuring industrial use of commodities that are transported via water do not separate inland waterway versus deep water transport.[33] We recommend that a special study be undertaken to investigate the possibility of remedying of this shortcoming.
- **Updating the MKARNS Multiregional Social Accounts Matrices.** Updating the MKARNS MRSAM model is time consuming and labor-intensive. This process takes from one to two full-time months to complete. We recommend that procedures be systematically extract the regional social accounts databases directly from IMPLAN. This could be in the form of a special spreadsheet program specifically designed for this purpose. Also, the procedures should be implemented to automatically balance both the interregional trade and commuter flows.
- **Enhance the Functionality of the MKARNS Spreadsheet Software Program.** The relationships between water resource development and economic development are complicated and unique for each water resource development function (e.g., hydropower, recreation, water transport, water supply, flood control, and environmental mitigation). We recommend that special water resource development scenario building templates be designed and constructed.
- **Enhance the Infrastructure Productivity Assessment Model.** The Infrastructure Productivity Assessment Model provided in Appendix C is still in a preliminary form. The new model advances the previously published version by expanding the number sectors covered and uses more recent transportation capital stock data to estimate the econometric relationships. The econometric estimation process has identified an interesting infrastructure productivity "story". A story in which increased highway construction appear to lead to "congestion" effects, while greater investments in water transportation are needed. We recommend that this line of inquiry be further investigated.
- **Arkansas Portion of the MKARNS.** We recommend that the analytical approach and techniques applied here should be implemented for the Arkansas portion of the McClellan-Kerr Arkansas River Navigation System.
- **Other Inland Waterway Systems.** Although it is beyond the responsibilities of public officials in Arkansas and Oklahoma, we recommend that similar analysis undertaken herein should be carried out for other inland waterway systems—for example, the Missouri River, the Ohio River, and the upper and lower portions of the Mississippi River.

[33] This data source is the Benchmark U.S. National Input-Output Accounts as published by the US Bureau of Economic Analysis.

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I INTRODUCTION

Rivers were our nation's first interstate highway system. Early in our nation's history, the only practical way to travel or to trade across long distances was to use waterways. Early exploration of North America identified large amounts of natural resources such as fisheries, forests, furs, and minerals. The historical developments of water-based transportation played a key role in the nation's domestic and international trade. Travel overland was difficult and time consuming. As a result, trade centers were established along coasts and rivers where goods could be gathered together to help transport them to markets in Europe and other foreign areas. Today, the United States has a complex network of connections between coastal ports, inland ports, rail, air, and truck routes. There are more than 17,700 kilometers of commercially important navigation channels within the continental United States. Inland and intra-coastal waterways directly serve 38 states throughout the nation's heartland as well as the states on the Atlantic seaboard, the Gulf Coast, and the Pacific Northwest.

Barges are well suited for the movement of large quantities of bulk commodities and raw materials (such as coal, minerals, chemicals, grain, aggregates, and petroleum) at relatively low cost. According to research by the Tennessee Valley Authority, moving cargo by barge is $10.67 per ton cheaper (on average) than shipping by alternative modes (e.g., rail or truck). It is not difficult to understand why this is important economically. Transportation facilitates the trade of goods and services. Moving goods by cheaper modes of travel or improving transportation systems (such as navigation routes) reduces delivery costs which, in turn, lowers the costs of materials and energy for businesses that use commodities that are hauled via the cheaper travel methods. With a competitive market environment, these lower transportation costs will create changes in relative prices, change production patterns and input mixes, and alter consumption decisions. Producers of the goods and services that can take advantages of these changes will see competitive advantages over their competitors and will experience market expansions compared with firms not so advantaged. Regions and their communities where the competitively advantaged firms are located, as consequence, will enjoy increases in employment and wealth producing opportunities.

Public officials, business leaders, and other important local stakeholders have been interested for some time in the economic "benefits" that the MKARNS provides citizens of the region that surrounds the waterway (this would most directly include the States of Arkansas and Oklahoma, as well as, other nearby geographic areas).

The main objective of this study is to identify, evaluate, and measure—as comprehensively as possible—the full extent of regional economic benefits/impacts that are expected to accrue to the citizens of Oklahoma and Arkansas, as well as, other significantly affected areas of the country (e.g., the States of Kansas, Missouri, and Texas) from operational activities of the MKARNS (waterborne commerce, hydropower, and recreation). The economic impacts are measured and summarized in a variety of ways including industrial and regional sales, value added, income and employment.

Evaluations are also made of the economic impacts of deepening the MKARNS navigation channel an additional three feet. Delays due to traffic interruptions (such as lock closures or natural events) can be costly to businesses that rely on the MKARNS. The economic impacts of delays are evaluated.

A second objective of this project is to undertake and implement several water resources impact modeling innovations. For example, the multiregional variable input-output (MRVIO) model has been extended to address "transboundary" income generation and expenditure effects that provide more accurate economic impact estimates. In addition, the enhanced version of the MRVIO model and to convert the existing, earlier version of the MRVIO models into a more user-accessible spreadsheet software format.

This project also updated, re-estimated, and extended a model of transportation infrastructure productivity that includes both highway and waterway investments. Previous models are based on dated highway and water resource capital investment information for which more recent data is now available and it only measures the productivity effects for navigation. The model has also been extended across a broader, more sector-specific set of industrial sectors than the past models. The new infrastructure productivity model has been integrated with the enhanced MRVIO model.

Section 2 describes the history and definition of the McClellan-Kerr Arkansas River Navigation System. The waterway traffic on the MKARNS is reviewed in total since the early 1970s and compared to national inland waterborne commerce. Current estimates of commodity-specific MKARNS traffic are also given. Oklahoma's public and private ports are described.

Section 3 presents the general economic setting ("profile") of the MKARNS region—defined here to be the States of Arkansas and Oklahoma as the immediate vicinity of the MKARNS and a "hinterland" area surrounding Arkansas and Oklahoma is defined as the States of Kansas, Missouri, and Texas. One of the major features of this study is that it required the construction of a "full set" of multiregional social accounting matrices (called the MKARNS MRSAM). There are six regions of this MRSAM are the States of Arkansas (AR), Oklahoma (OK), Kansas (KS), Missouri (MO), and Texas (TX) plus an aggregate region that includes the remaining states of the nation (RUS). The MKARNS MRSAM has an eighty-nine (89) sector configuration. Also included in section 3 of the report is the presentation of the MKARNS MRSAM multipliers. The MRSAM multipliers are similar to input-output (IO) multipliers in that they provide estimates of the direct, indirect, and induced effects of final demand changes. However, the MRSAM multipliers are more comprehensive than the simple IO multipliers because they include household income generation effects and they attribute the multiplier effects by region. The MKARNS MRSAM multipliers are even better because they also account for interregional income generation and expenditure effects.

Section 4 summarizes the results of several surveys of MKARNS users (transportation users, port operators, and recreation visitors). Key industrial users of the MKARNS are identified. The extended reach of Oklahoma's commercial waterway traffic is shown and the potential for new and future waterborne commerce is analyzed. Section 5 reviews various economic valuation issues and methodologies. The role that waterways play in the economy is explained and the way in which the economic effects of water resource developments should be evaluated is presented. A brief discussion of the use of the MKARNS MRVIO Excel spreadsheet program is given.

Section 6 provides the heart of this report—what is the economic value of the McClellan-Kerr Arkansas River Navigation System? We discuss the approach that is taken in this evaluation. The basis for the economic value of the MKARNS is determining the economic losses in the hypothetical event that the MKARNS were to close. First, there will be a loss of hydropower generating capacity, however, this would be mitigated somewhat by new capacity generated by an alternative source of power. We assume that the most likely alternative fuel source is natural gas. Second, there would be the loss of annual Corps of Engineers operations and maintenance (O&M) expenditures that help to maintain and operate the MKARNS. Third, there would be the loss of transportation services provided by the ports and the shippers—their services would no longer be needed if there was no navigation channel. Fourth, there would be the loss of transportation benefits (i.e., savings) that the MKARNS provides. Fifth, there would be the loss of recreation opportunities as the MKARNS reservoirs are drained. And sixth, there would be environmental damages due to current barge traffic being diverted either rail (most likely) or truck. There environmental damages are measured two ways—by increased CO2 emissions and by increased fuel consumption. CO2 emission and fuel consumption rates are much lower than either rail or trucks.

Section 7 presents an analysis of the economic effects of deepening Oklahoma's portion of the MKARNS navigation channel an extra three feet. This project has been federally authorized but not funded by Congress. Finally, section 8 addresses the business costs and economic effects of traffic disruption delays on the MKARNS in Oklahoma.

II MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM

II.1 History of the McClellan-Kerr Arkansas River Navigation System

The Arkansas River (Figure 1) flows to the east and southeast through the states of Colorado, Kansas, Oklahoma, and Arkansas. At 1,460 miles, it is the fourth-longest river within the continental boundaries of the United States and the second-longest tributary in the Mississippi-Missouri River system. Its origin is in the Rocky Mountains near Leadville, Colorado and its mouth is at Napoleon, Arkansas. Numerous Native American bands lived and traveled along the Arkansas River long before it was ever discovered by Europeans. The earliest account of this river is to be found in the narratives of the Coronado Expedition of 1540-1541, in which the river was given the name "St. Peter's and St. Paul's River." Marquette names it on his map of 1673. The Mexicans named it "Rio Napete," but the river acquired the name "Akansa" from the early French voyagers on account of a tribe of the Dakota or Osage Indians which lived near its mouth.

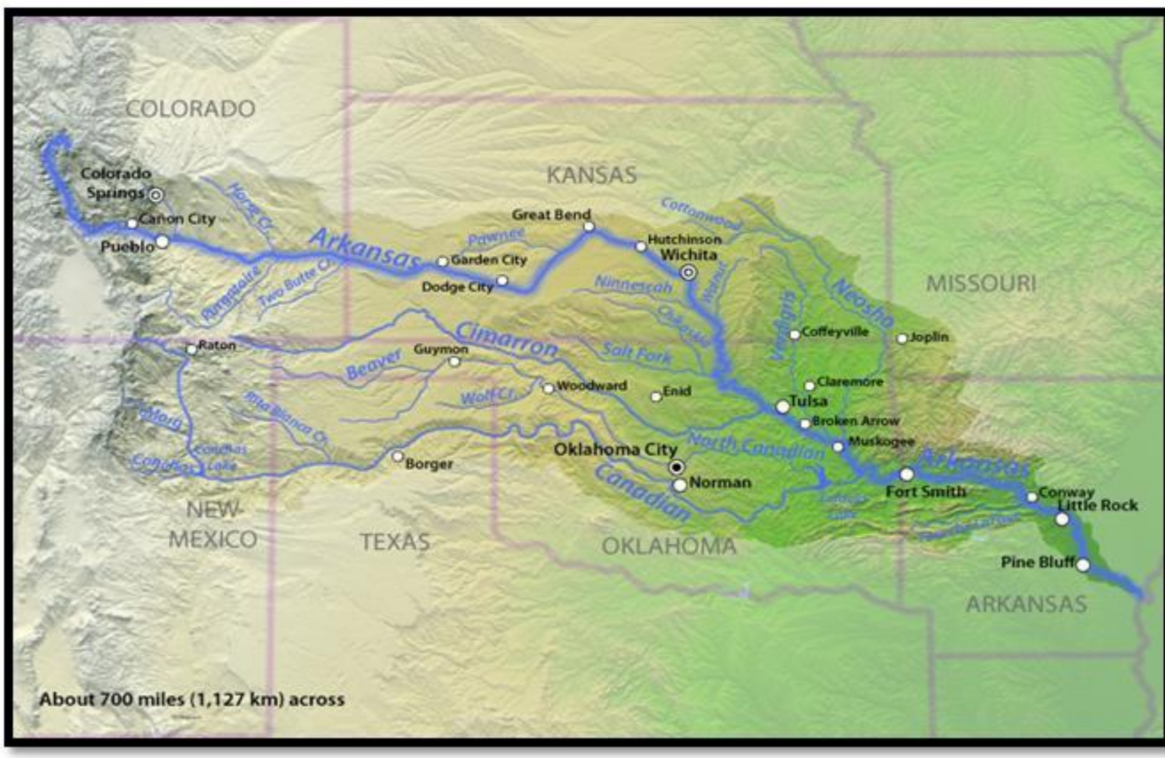

Figure 1 Arkansas River

In 1819 the Adams-Onís Treaty established the Arkansas River as part of the frontier between the United States and Spanish Mexico, which it remained until the annexation of Texas and Mexican-American War in 1846. Later, the Santa Fe Trail followed the Arkansas River through much of Kansas. In the 19th century, the river was rarely navigable above Fort Smith, Arkansas though in times of flood the channel was open to boats of light draft to a point much higher up. In 1854 a writer in the *New York Tribune*, in describing the territories of Kansas and Nebraska, gave Fort Mann (near Dodge City) as the "head of navigation" on the stream.

The steamboat called COMET first navigated the Arkansas River in 1820. Once the COMET reached its destination this captured the imagination of people who realized the potential the river could provide- reliable, year- round waterway which would reach deep into Oklahoma. However, due to the tumultuous nature of the Arkansas River during the 1800's and 1900's, the common sentiment suggested flooding prevention was needed to tame the Arkansas River especially after heavy rains penetrated the Mississippi and Ohio River valleys displacing 350,000 people, destroying 2,000,000 acres of land and an estimated cost of $43 million in 1927 dollars (Laymon, 2010).

Flooding along the Arkansas River in Oklahoma during 1923 and the disastrous 1927 flood in Arkansas[34] led to the formation of the Arkansas River Flood Control Association (ARFCA) to lobby members of Congress for a comprehensive flood control program. The next year (1928), Congress passed a flood control act (called the National Rivers and Harbors Act of 1927). The Act required the Corps of Engineers to author a series of surveys called "308 Reports". These reports discuss in great detail topics such as flood control, navigation improvement, power development, and establishing irrigation projects on the river. The reports also included a proposal for a " nine-foot deep channel from the mouth of the White River, continuing up the Arkansas to the Verdigris River in Oklahoma, and following the Verdigris to Catoosa" (Laymon, 2010). Yet before any of the proposed projects from these reports were brought into existence, the stock market crashed in 1929 which required the federal government to focus their attention on the recovery of the economy.

A lobbyist group—The Mississippi Valley, Arkansas Basin and Arkansas Valley Associations—was created to advertise the need for inland waterway development of the Arkansas River. The group needed an advocate with a powerful voice to champion their cause- John McClellan would be their champion. Representing the Sixth District of southern and central Arkansas, Congressman John McClellan was elected to congress in 1934 and appointed to the House Flood Control Committee. McClellan deemed that the federal government should bear sole responsibility in flood control not the state. McClellan believed inclusion of a national flood program "would end our ship-shop, hit- and-miss method, [and] it would take the pork entirely out of flood control legislation and give us a complete picture with the relative importance of each project" (Laymon, 2010). In addition, the U.S. Army Corps of Engineers informed Congress in 1935 that navigation on the Arkansas River was technically possible but not economically feasible due to the high cost of the project during the financial stresses of the Great Depression. However, Congress passed the 1936 Flood Control Act and work began in the upper Arkansas, Red, White, and Black river basins.

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[34] The 1927 Flood created an eight- to ten-foot wall of water that destroyed almost every levee on the Arkansas River downriver from Fort Smith to the Mississippi River (The Encyclopedia of Arkansas History & Culture: McClellan-Kerr Arkansas River Navigation System,

www.encyclopediaofarkansas.net/encyclopedia).

McClellan faced an uphill battle to change not just Congress perceptions of the Arkansas River but American public perceptions of the river as well.

The average person on the eastern seaboard thinks of the Arkansas as … a little creek that [goes through] Arkansas and drops down with a lot of floods into the Mississippi. And when I tell them that the Arkansas [starts] way west of Pueblo, Colorado, back of the transcontinental divide … that it wanders on down through Kansas and Oklahoma before it even reaches the Mississippi, they get their geography books to verify what I said … That river isn't just the problem of one state or one community, it [requires] . . . national planning for the Arkansas River . . . [not] only flood prevention, but irrigation, reclamation, reforestation, and power development.

McClellan wanted people to understand that making the Arkansas River navigable benefits not only Arkansas but allow for "businesses in states west of the Mississippi an alternative route for shipping their products to international markets" (Laymon, 2010). To help McClellan combat a society misconception of the Arkansas River and to gain society support of a comprehensive flood plan, McClellan gained a valuable ally once Oklahoma voters elected Robert S. Kerr to the Senate in 1948. Kerr shared McClellan's interests in water conservation and river development of the Arkansas River.

With Kerr as an ally, McClellan could focus on gaining congressional support for a "broad, all-inclusive flood control and water development program" that would benefit not only Arkansas but the nation as well. The first fruit of their labor was Congress passing the River and Harbor Act of 1950 appropriating $80 million for stabilization and rectification of riverbanks, and navigation of lakes and other structures. For the next twenty years, McClellan and Kerr would generate Congressional support for various legislative acts for water development, bank stabilization, and navigation of the Arkansas River despite life changing events like war (Korea), and lack of support from a fiscal conservative - President Eisenhower. McClellan and Kerr received pledges of support from John Kennedy and Lyndon Johnson to support legislation for the Arkansas River during the 1960 presidential campaign.

Once Kennedy became President, he was prompted by influential Arkansas delegation to sign Congress appropriating $83 million (1961) and $87 million bills (1962) into law. Once again life changing events threatened to derail funding for the Arkansas River project. Life magazine published an unflattering article on August 1963 describing the project as a wasteful spending of the taxpayer money. The Life article went so far as labeling the development of the Arkansas River as "the most outrageous pork-barrel project in United States history" creating a negative backlash forcing McClellan to go on the offensive and print a national rebuttal to the Life article.

With the negative Life article and the volatility in Vietnam, the Arkansas River project seemed doomed to be placed on the back burner when President Johnson ordered a freeze on construction of the project, however, McClellan was able to sway President Johnson to support the $84 million plus the additional $14 million needed for the river project to be completed by its completion date (Laymon, 2010). Navigation was finally opened to Little Rock on October 4, 1968 and a U.S. postage stamp was issued bearing the words "Arkansas River Navigation" to commemorate the occasion. The first commercial barges—from Wheeling, West Virginia and Pittsburgh, Pennsylvania—docked at the Port of Little Rock on January 4, 1969. The following year (during December 1970) the entire system was ready for use. The first commercial barge (containing steel pipe manufactured by Republic Steel) pulled into the Port of Muskogee on January 3, 1971. Finally, the McClellan- Kerr Arkansas River Navigation System was dedicated at the Tulsa Port of Catoosa on June 5, 1971.

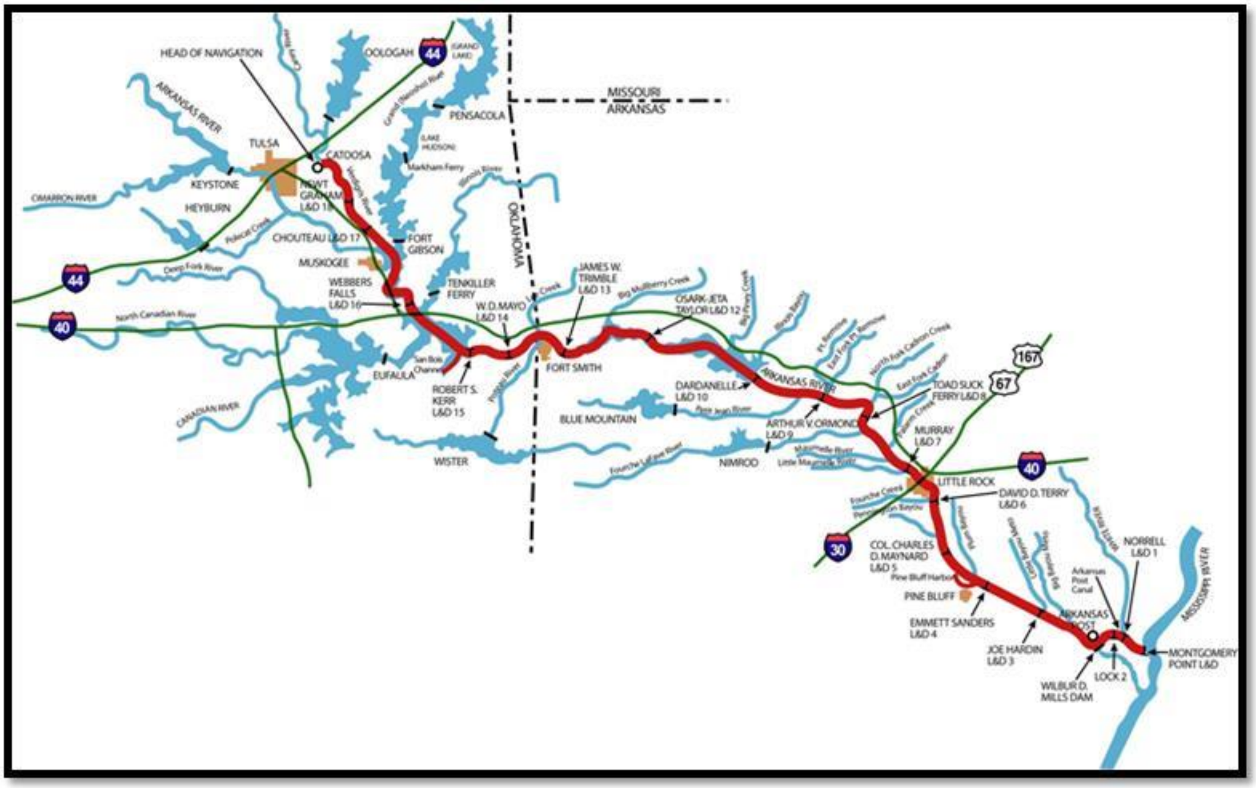

Figure 2 McClellan-Kerr Arkansas River Navigation System[35]

II.2 What is the McClellan-Kerr Arkansas River Navigation System?

The McClellan-Kerr Arkansas River Navigation System (Figure 2), or the "MKARNS", was established in June 1971 as a 445 mile 9-foot navigation channel. The Port of Catoosa is at the head of the system near Tulsa on the Verdigris River, which runs via an extensive Lock and Dam system to the Mississippi River. The MKARNS consists of a 445 mile, 9-foot navigation channel with 18 locks—309 miles and 13 locks in Arkansas. Through Oklahoma and Arkansas, dams have artificially deepened and widened the Arkansas River to build it into a commercially navigable body of water. From the mouth of the Verdigris River until the McClellan-Kerr system moves over to the White River near Arkansas Post, the Arkansas sustains commercial barge traffic and passenger and recreational use. The river is navigable by barges and large river craft to Muskogee, Oklahoma; however above Muskogee, the waterway

[35] Source: U.S. Army Corps of Engineers, Tulsa District.

is navigable only by small craft such as rafts or canoes. The downstream portion of the Arkansas River is the major component of the navigation system, but in all there are four distinct segments of the waterway:

> **White River Entrance Channel.** The McClellan-Kerr begins in Arkansas at mile 599 on the Mississippi River, about half way between New Orleans and St. Louis, using the first ten miles of the White River as its entrance channel.
>
> **Arkansas Post Channel.** The next nine miles of the waterway are totally manmade; a navigation canal connecting the White and Arkansas Rivers.
>
> **Arkansas River.** For the 377 miles, through Arkansas and into Oklahoma, the McClellan-Kerr and the Arkansas River are one and the same.
>
> **Verdigris River.** In Oklahoma the waterway leaves the Arkansas River once again, at Muskogee, and follows the Verdigris River north for the last 50 miles to the head of navigation at Tulsa's Port of Catoosa, 445 miles from the Mississippi River.

The Arkansas River Valley increases in elevation more rapidly than does the lower Mississippi River Valley. To go from New Orleans 500 miles upstream on the Mississippi, there is only about a 100-foot increase in elevation. A boat traveling 445 miles inland, on the other hand, would have to overcome a 420-foot difference in elevation. This relatively steep slope of the Arkansas River Valley—about one foot per mile—was a major factor that shaped the design of the McClellan-Kerr System. To make a 40 story climb possible, the Corps of Engineers designed the waterway as a "staircase of water" consisting of a series of navigation pools connect by locks (Figure 3).

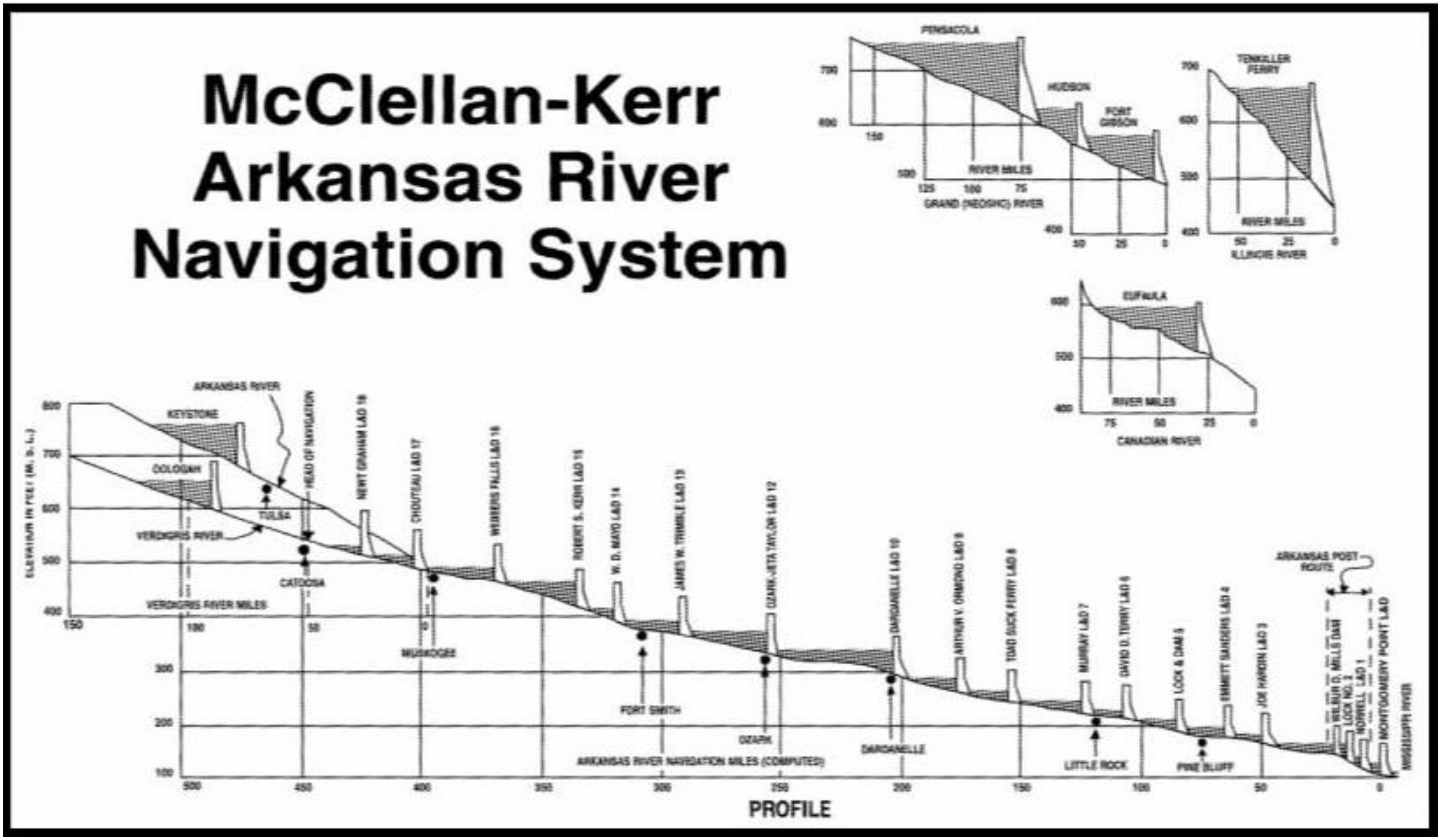

Figure 3 McClellan-Kerr Arkansas River Navigation System Lock Lift

The waterway enables vessels travel from the Mississippi River to the head of navigation at Catoosa, Oklahoma through a series of navigation pools connected by 17 locks and dams. The navigation system was designed for ease of navigation by multi-barge tows, with ample channel and lock dimensions and bridge clearances. Necessary dredging is done promptly, and the channel is open year round. The system of locks and dams are operated 24 hours a day by the Corps of Engineers. The Coast Guard maintains the channel markers and other navigation aids.

Channel depth:	9 feet or more
Channel width:	Mostly 250 feet to 300 feet
Normal current velocity range:	2 to 4 miles per hour
Bridge clearances:	Horizontal—generally 300 feet or more Vertical—52 feet or more
Lock size:	110 feet by 600 feet
Size of tow accommodated:	8 jumbo barges without double lockage More than 8 with double lockage using tow haulage[36]

Because barges are one of the most energy-efficient forms of transportation, many types of commodities are now shipped on the waterway and there is adequate capacity for future development. International trade is aided both by good access to foreign ports through the Gulf of Mexico and by the existence of two foreign trade zones on the waterway. The waterway will accommodate a variety of barges and towboats. In addition, there is good access to road, rail, and air transportation. The McClellan-Kerr system has five publicly developed ports and numerous privately developed facilities. A considerable amount of land suitable for development is available at the ports and in other areas. People interested in expanding, locating, or relocating along the McClellan-Kerr will find that there are many organizations able to advise and assist on development projects. The Corps issues permits for a wide variety of

[36] Tow haulage is a procedure for drawing barges through a lock by using equipment on the lock itself to minimize the maneuvering of a towboat when a tow exceeds the length of the lock. Since the locks on the waterway can hold only eight jumbo (35 feet by 195 feet) barges plus a towboat, when a tow with a larger number of barges reaches a lock, the towboat must split the tow into units or "cuts" that fit into the lock. The towboat must lock through with the first cut, push it out of the lock, and then lock back through to get the second cut of barges. Tow haulage equipment on a lock, on the other hand, can pull the first cut through by itself, so that the towboat can stay in its original pushing position and lock through with the second cut.

Lock operation for oversize tows is more efficient with tow haulage equipment. Towboats are used more expeditiously, and shippers can take advantage of the economy of large tows. Larger tows represent a potential for significant cost reduction for both shipper and their customers. Tow haulage equipment has been installed at all twelve locks on the McClellan-Kerr in Arkansas.

projects and can be especially helpful in enabling a potential developer to understand how the characteristics of the waterway may affect a particular site.

II.3 Commercial Traffic on the McClellan-Kerr Arkansas River Navigation System and US Waterborne Commerce

The typical cargo hauled on the MKARNS tends to be heavy, bulky commodities that are not time sensitive. According to the Oklahoma Department of Transportation, "… 5.75 million tons (valued at $2.2 billion) was transported on the Oklahoma segment of the MKARNS" (2013). There are 31 terminal facilities located along the Oklahoma portion of the MKARNS, most of these facilities are clustered along the Port of Catoosa and Muskogee.

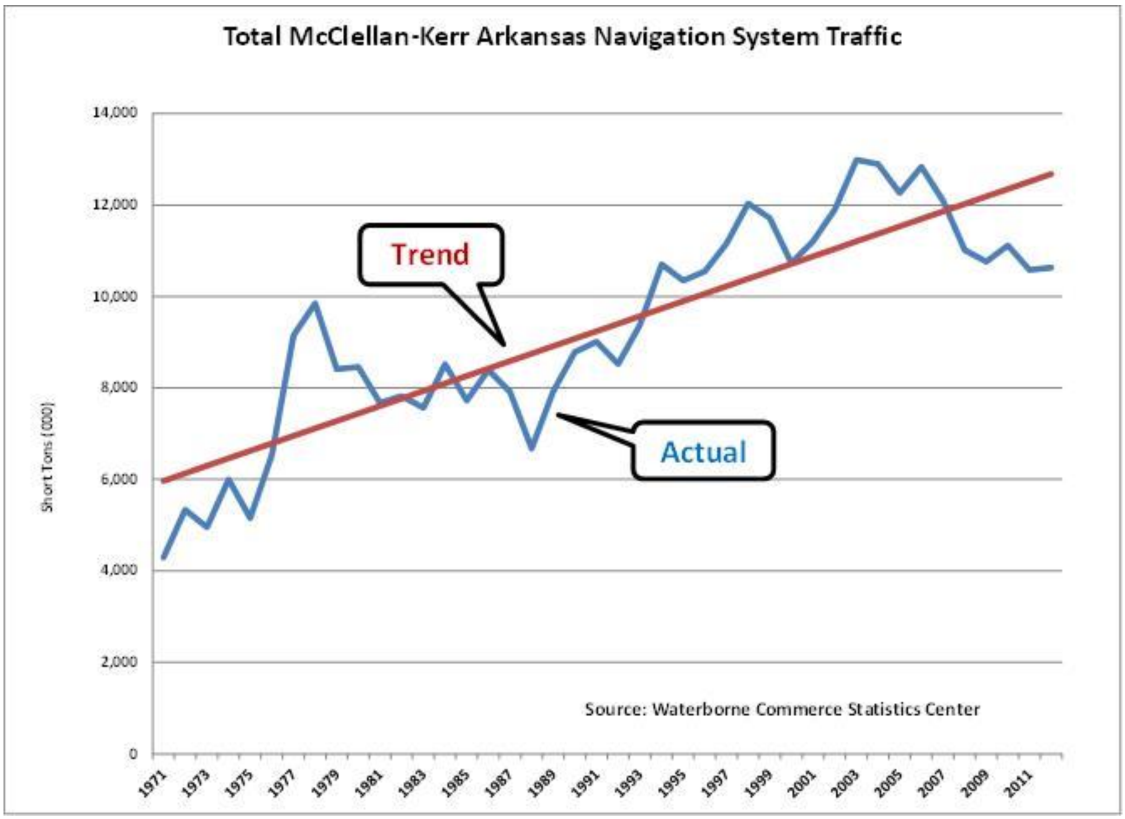

Figure 4 McClellan-Kerr Arkansas River Navigation System Traffic

Figure 4 shows the actual commodity tonnage traveling along the McClellan-Kerr Arkansas River Navigation System from 1971 to 2012. Figure 5 shows the reported (labeled "actual") commodity tonnage towed on all US waterways from 1972 to 2011. A trend line has been added to both Figures 4 and 5 to indicate the direction that waterborne commerce has taken since the early 1970s. It is apparent that traffic on the nation's waterways is growing, both nationally and locally, even though recent traffic estimates have fallen from their respective trend lines. Whether this downturn in waterborne traffic is related to a delayed response to the current economic expansion or is an indication of structural shifts in the nation's economy away from goods production is beyond the scope of this report. However, the past downturn waterway traffic during the first half of the 1980s was followed by strong growth. Traffic data for the last few years seem to indicate that the current downturn in tonnages may be turning around.

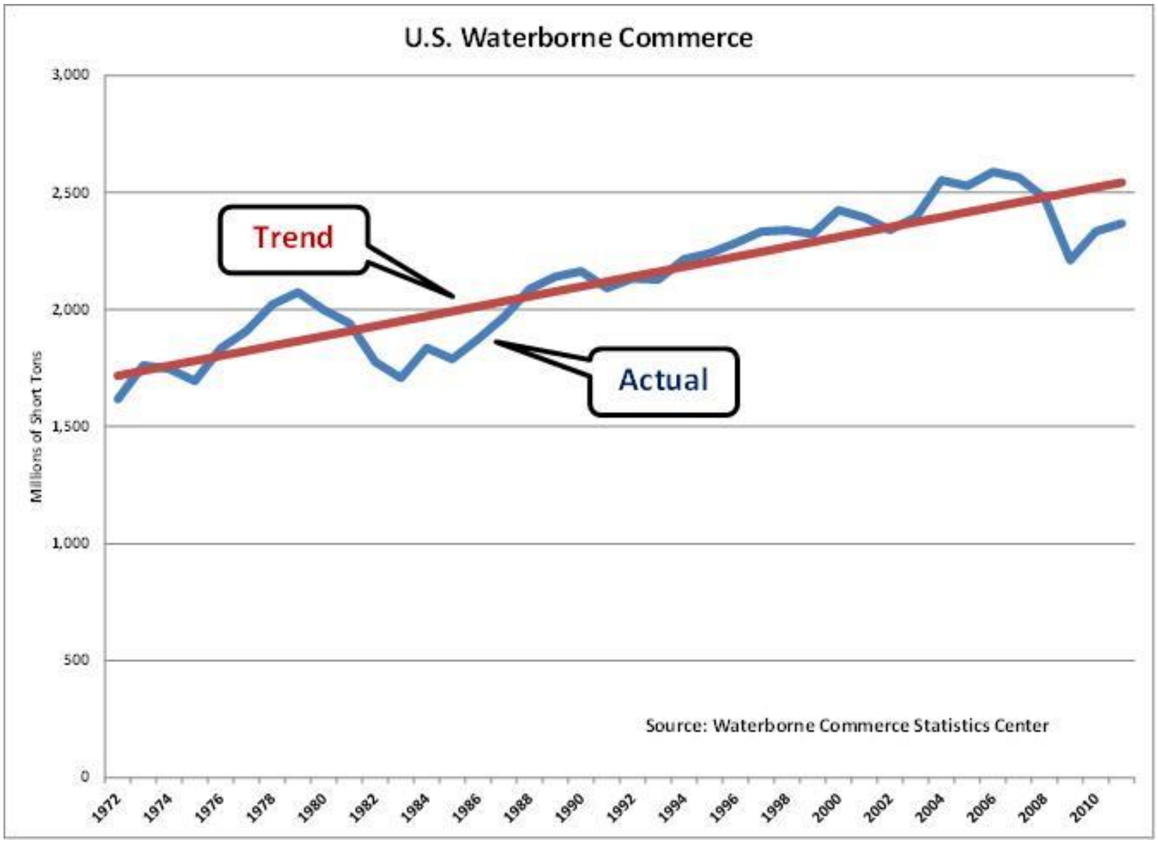

Figure 5 U.S. Waterborne Commerce

Using the Waterborne Statistics from the Institute for Water Resource (IWR), we examine the various types of commodities traveling the MKARNS during the five year period of 2008 to 2012. By and large the commodities shipped on the McClellan-Kerr Arkansas River Navigation System are either produced or consumed domestically. Reviewing the IWR's consolidated report of the McClellan-Kerr Arkansas River Navigation System, several things are apparent such as which commodity are most commonly shipped on the MKARNS. Total tonnages on the MKARNS average almost 11 million short tons annually during the 2008 to 2012 period while 11.4 million short tons traversed the MKARNS during 2012. Incoming and outgoing traffic averaged 3.5 and 4.9 million short tons annually over the period 2008 to 2012 (respectively). During 2012 the respective incoming and outgoing traffic tonnages were 3.9 and 5.4 million short tons. Nearly 2.5 million short tons, on average for 2008 to 2012, travel annually between ports located on the MKARNS. There were 2.0 million short tons that traveled between ports on the MKARNS during 2012.

Table 1 shows the 15 commodities having the largest total tonnages shipped on the MKARNS during 2012 and for the period 2008 to 2012. The commodity having the largest in-bound and out-bound traffic on the MKARNS during 2012 is sand and gravel (code 4331, 1.9 million tons) The next six commodities towed on the MKARNS are (in order) nitrogenous fertilizer (code 3110), wheat (code 6241), soybeans (code 6522), iron and steel scrap (code 4420), fertilizers and mixes (code 3190), and iron and steel plates and sheets (code 5330). However, comparing the 2012 tonnages to the 2008 to 2012 averages indicates some volatility in the mix of commodities shipped on the MKARNS from year to year.

Table 1 Commodities with the Largest Tonnages on the MKARNS: All Traffic, All Directions[37]

Code	Commodities	2012	2008-2012 Average
4331	Sand and Gravel	1,899,569	2,165,668
3110	Nitrogenous Fertilizers	1,616,442	1,222,933
6241	Wheat	1,051,007	717,312
6522	Soybeans	938,493	1,122,194
4420	Iron and Steel Scrap	588,414	500,633
3190	Fertilizers and Mixes, NEC	479,264	374,946
5330	Iron and Steel Plates and Sheets	406,600	338,843
1100	Coal and Lignite	389,491	203,346
2100	Crude Petroleum	384,374	95,027
1200	Coal Coke	336,826	192,462
4335	Waterway Improvement Materials	308,825	1,231,999
6344	Corn	301,195	136,258
6782	Animal Feed Preparations	251,922	262,464
2540	Petroleum Coke	239,623	295,341
2330	Distillate Fuel Oil	234,726	270,520

Table 2 shows the 15 commodities having the largest incoming tonnages shipped on the MKARNS during 2012 and for the period 2008 to 2012. The commodity having the largest in-bound traffic on the MKARNS during 2012 is nitrogenous fertilizer (code 3110, 1.1 million tons) The next six commodities towed on the MKARNS are (in order) fertilizer and mixes (code 3190), iron and steel plates and sheets (code 5330), prepared animal feeds (code 6782), primary iron and steel products (code 5390), distillate fuel oil (code 2330), and iron and steel bars and sheets (code 5360). The mix of commodities shipped in-bound on the MKARNS during 2012 appears quite similar to the mix of commodities over the 2008 to 2012 period (at least on average).

[37] Note: Tonnages are in short tons. Source: Waterborne Commerce Statistics Center.

Table 2 Commodities with the Largest Tonnages on the MKARNS: All Incoming Traffic[38]

Code	Commodities	2012	2008-2012 Average
3110	Nitrogenous Fertilizers	1,106,242	881,930
3190	Fertilizers and Mixes, NEC	478,012	373,760
5330	Iron and Steel Plates and Sheets	406,600	338,550
6782	Animal Feed Preparations	218,371	253,493
5390	Primary Iron and Steel, NEC	189,833	139,607
2330	Distillate Fuel Oil	170,189	211,636
5360	Iron and Steel Bars and Shapes	166,924	111,519
1200	Coal Coke	151,273	83,664
5220	Cement and Concrete	129,018	102,234
3130	Potassic Fertilizers	126,750	106,171
4782	Clay and Refractory Materials	105,883	82,830
3274	Sodium Hydroxide	77,378	77,755
5422	Aluminum	70,661	42,191
6865	Molasses	69,843	60,772
5480	Fabricated Metal Products	59,090	36,257

Table 3 shows the 15 commodities having the largest incoming tonnages shipped on the MKARNS during 2012 and for the period 2008 to 2012. The commodity having the largest out-bound traffic on the MKARNS during 2012 is wheat (code 6241, 1.0 million tons) The next six commodities towed on the MKARNS are (in order) soybeans (code 6522), iron and steel scrap (code 4420), nitrogenous fertilizer (code 3110), crude petroleum (code 2100), coal and lignite (code 1100), and corn (code 6344).

Table 3 Commodities with the Largest Tonnages on the MKARNS: All Outgoing Traffic[39]

Code	Commodities	2012	2008-2012 Average
6241	Wheat	1,043,252	674,079
6522	Soybeans	935,438	1,077,795
4420	Iron and Steel Scrap	585,562	497,058
3110	Nitrogenous Fertilizers	510,200	336,040
2100	Crude Petroleum	377,435	92,374
1100	Coal and Lignite	352,735	167,920
6344	Corn	244,903	109,385
2540	Petroleum Coke	205,037	219,394

[38] Note: Tonnages are in short tons. Source: Waterborne Commerce Statistics Center.

[39] Note: Tonnages are in short tons. Source: Waterborne Commerce Statistics Center.

Code	Commodities	2012	2008-2012 Average
1200	**Coal Coke**	**185,553**	**108,798**
6442	**Rice**	**181,336**	**200,550**
4335	**Waterway Improvement Materials**	**164,300**	**840,114**
2340	**Residual Fuel Oil**	**144,683**	**87,836**
2330	**Distillate Fuel Oil**	**58,229**	**56,625**
4310	**Building Stone**	**53,870**	**23,021**
4860	**Slag**	**53,655**	**62,211**

Figure 6 provides detailed subcomponent commodity shares of the fertilizer commodity. Figure 7 provides detailed subcomponent commodity shares of the sand, gravel, rock, and stone commodity. Figure 8 provides detailed subcomponent commodity shares of the grain commodity. Figure 9 provides detailed subcomponent commodity shares of the oilseeds commodity.

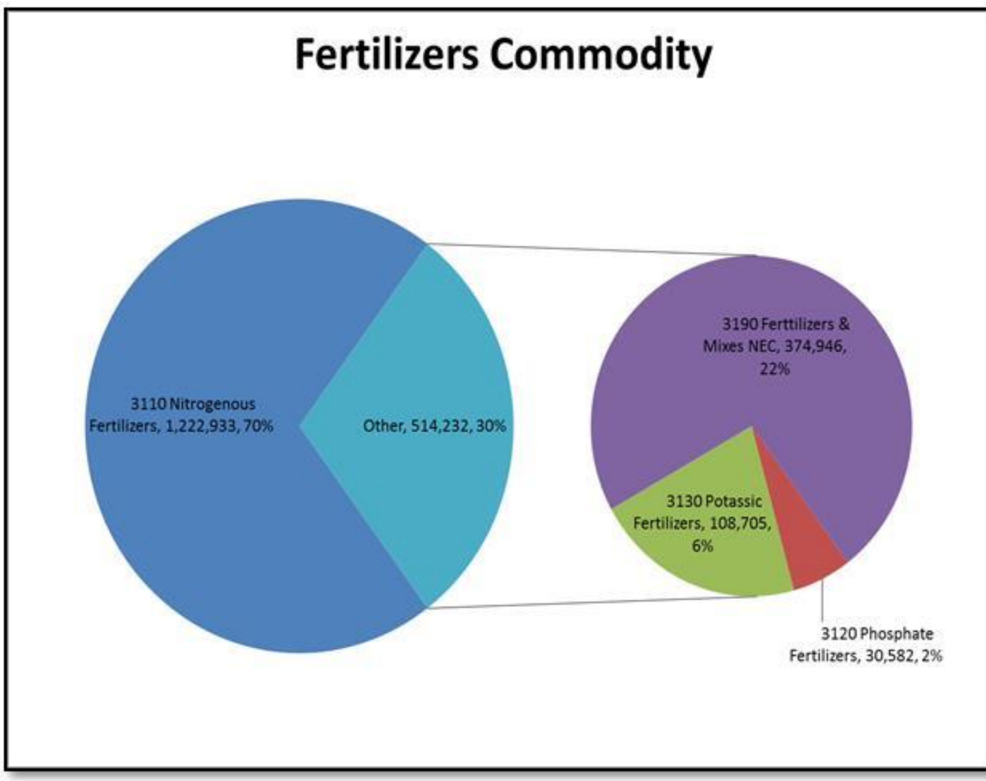

Figure 6 Fertilizer Commodity Shares[40]

[40] Source: Institute for Water Resources. U.S. Army Corps of Engineers.

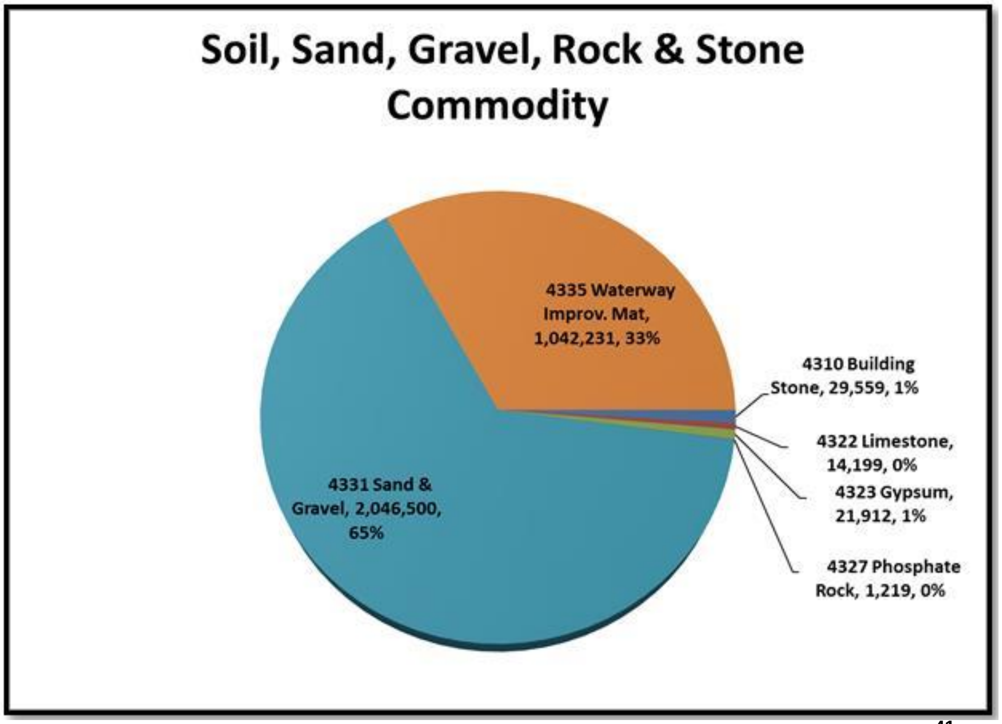

Figure 7 Soil, Sand, Gravel, Rock, and Stone Commodity Shares[41]

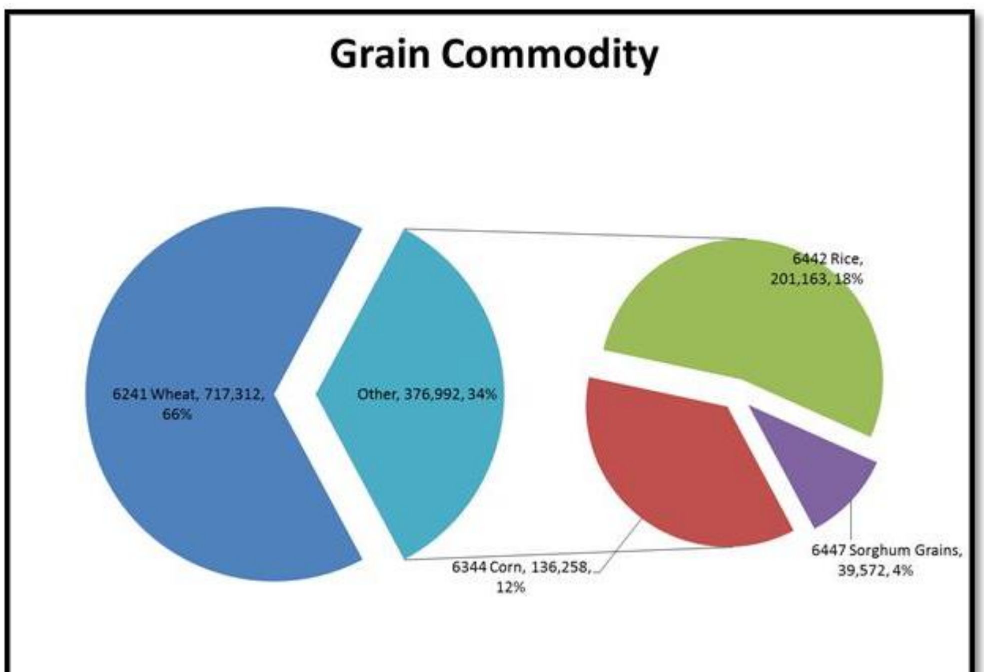

Figure 8 Grain Commodity Shares[42]

[41] Source: Institute for Water Resources. U.S. Army Corps of Engineers.

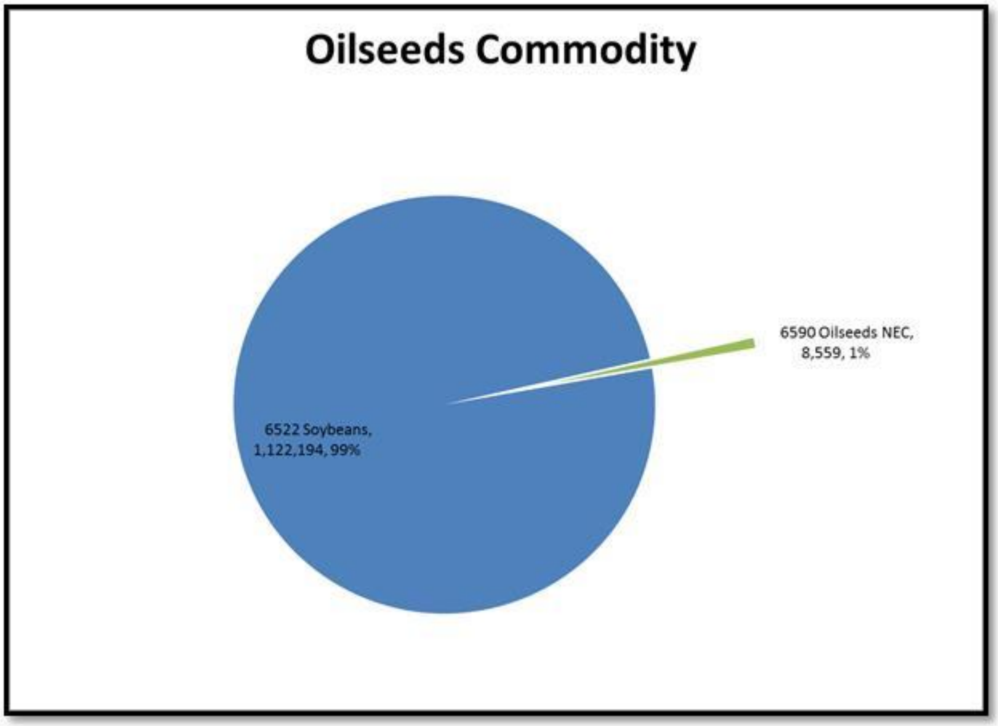

Figure 9 Oilseeds Commodity Shares[43]

II.4 Oklahoma's Public and Private Ports

Originating at the Tulsa Port of Catoosa and flowing southeast to the Mississippi River, the McClellan-Kerr Arkansas River Navigation System is Oklahoma's primary navigable waterway (Oklahoma Department of Transportation, December 2013). The MKARNS is geographically located near the center of the United States. Ports are accessible to the rest of the country via interstate highway system and railroads (Oklahoma Waterway & Arkansas River Navigation Study EIS). There are eight (8) ports located on the Oklahoma side of the McClellan-Kerr Arkansas River Navigation System (MKARNS) system. Figure 10 shows the ports located on the Oklahoma portion of the McClellan-Kerr Arkansas River Navigation System. Figure 10 also shows the lock and dams located on the Oklahoma portion of the McClellan- Kerr Arkansas River Navigation System.

[42] Source: Institute for Water Resources. U.S. Army Corps of Engineers.

[43] Source: Institute for Water Resources. U.S. Army Corps of Engineers.

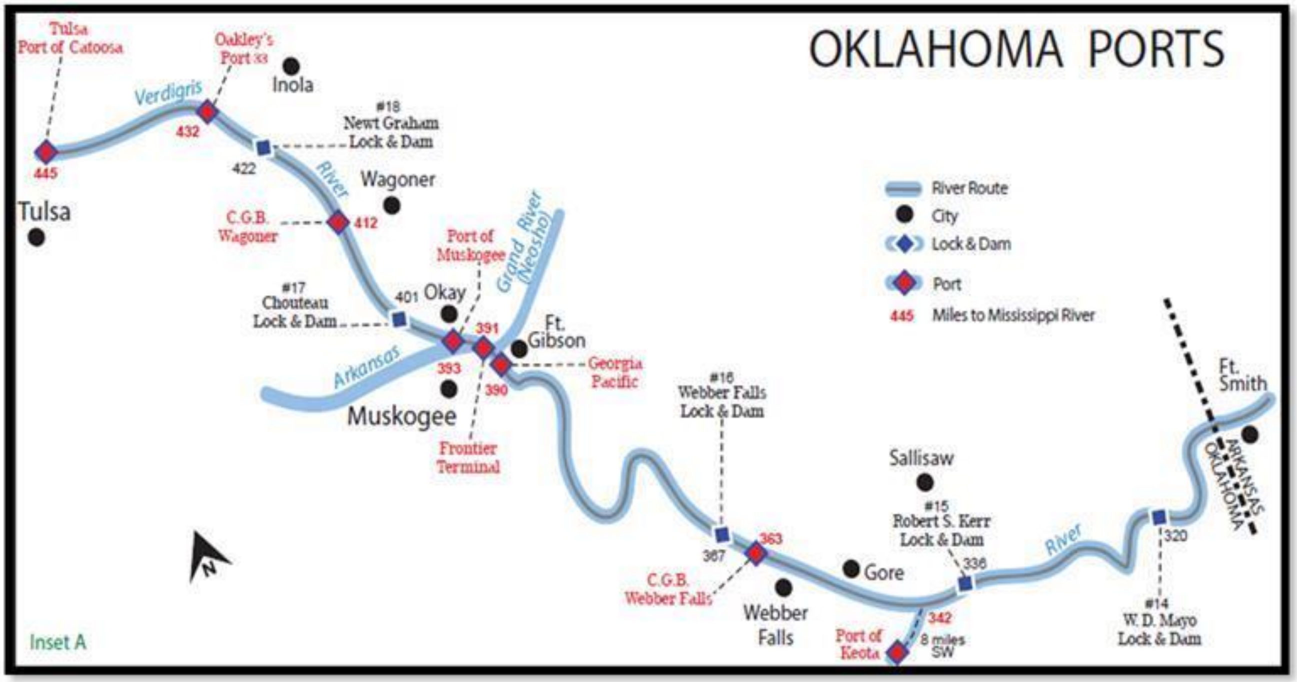

Figure 10 Oklahoma Ports Located on the McClellan-Kerr Arkansas River Navigation[44]

The Ports of Catoosa and Muskogee are the two public ports located on the Oklahoma segment of the MKARNS. There are six private ports located on the Oklahoma segment of the MAKARNS: CGB Enterprises, Frontier Terminal-Muskogee, Georgia Pacific-Muskogee, Oakley's Port 33, Oakley's Terminal Muskogee, and Port of Keota –Livestock Nutrition Center. Table 4 lists all of the Oklahoma's river ports and terminals by its river mile.

Table 4 River Ports and Terminals on the MKARNS[45]

River Mile	Name	City
342.0 R	Port Carl Albert	Keota, OK
342.0 R	Port of Keota	Keota, OK
363.2 R	CGB**	Webbers Falls, OK
391.0 R	Frontier Terminal	Muskogee, OK
393.0 R	Koch Pavement Solutions	Port of Muskogee
393.0 R	Quality Liquid Feeds, Inc.	Port of Muskogee
393.8 R	Oakley's Terminal Muskogee	Port of Muskogee
412.5 L	CGB** - Port of Dunkin	Wagoner, OK
426.5 L	Inola Station Slip - Public Service Co.	Inola, OK
431.8 R	Oakley's Port 33	Catoosa, OK
431.8 R	CGB - Oakley's Port 33	Catoosa, OK

44 Source: Oklahoma Department of Transportation.

45 *Facilities located on Catoosa Basin, a slackwater harbor off the Verdigris River. **Also known as Consolidated Grain and Barge

River Mile	Name	City
431.8 R	SIMS Metal Management - Oakley's Port 33	Catoosa, OK
431.8 R	Blue Knight Energy - Oakley's Port 33	Catoosa, OK
443.8 R	Mid-America Port	Catoosa, OK
443.8 R	Rogers Terminal	Catoosa, OK
444.8*	ArcelorMittal	Tulsa Port of Catoosa
445.2*	Tuloma Stevedoring, Inc.	Tulsa Port of Catoosa
445.2*	Gavilon Fertilizer, LLC	Tulsa Port of Catoosa
445.2*	Gavilon Grain, LLC	Tulsa Port of Catoosa
445.2*	Westway Terminal Co.	Tulsa Port of Catoosa
445.2*	Safety Kleen Systems, Inc.	Tulsa Port of Catoosa
445.2*	NuStar	Tulsa Port of Catoosa
445.2*	Blue Knight	Tulsa Port of Catoosa
445.2*	NGL Energy	Tulsa Port of Catoosa
445.2*	Brenntag Southwest, Inc.	Tulsa Port of Catoosa
445.2*	Terra Nitrogen	Tulsa Port of Catoosa

Port of Keota, OK. The Port of Keota, Livestock Nutrition Center (Figure 11) is located at river navigation mile 342 which is located 10 miles north of Keota, Oklahoma. Port of Keota is a privately owned port. The Livestock Nutrition Center operates as a self-sufficient facility in addition to transporting coal. The Livestock Nutrition Center also offers feeding programs to assist livestock community (http://www.lnc-online.com/#!about2/c1609).[46]

Figure 11 Towboat at the Port of Keota

[46] Source: Department of Oklahoma Transportation

CGB. Also known as Consolidated Grain and Barge, located at river navigation Mile 393.8 R, CBG is a privately owned port (Figure 12). The ability to offer a vast array of services to grain farmer enables CBG to be one of the largest shippers of grain on the inland river system. CGB also plans on expanding their services to include soybean processing and fertilizer products. To meet the ever increasing demand of providing for safe and efficient transportation and logistics operation through the national inland river system, CGB created of CTLC (Consolidated Terminals and Logistics Co.) which will provide logistics, transportation and bulk commodity services. With the creation of CTLC, CGB can provide a wide range of services far beyond the agricultural industry, providing transportation solutions using truck, rail and barge (http://www.cgb.com/aboutus.aspx).

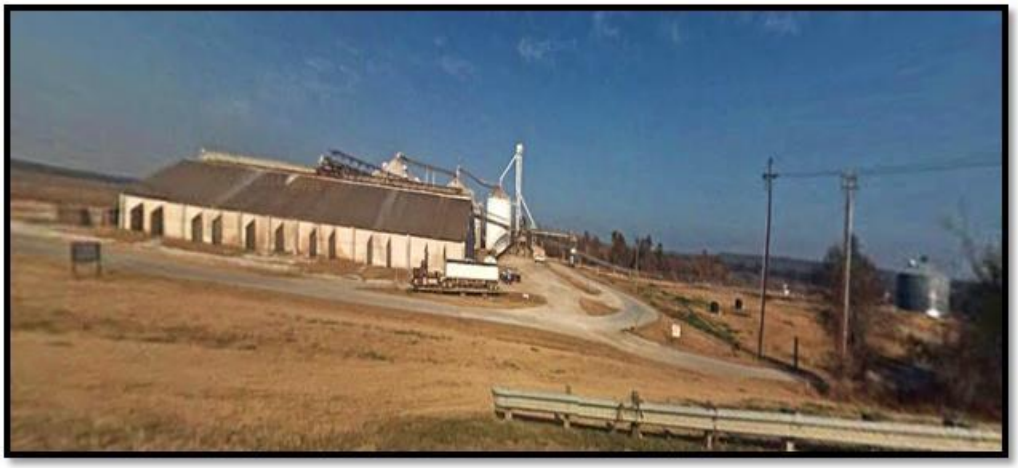

Figure 12 Street View of CGB

Frontier Terminal LLC. Frontier Terminal LLC is, a privately owned port specializing in petroleum products, located at river navigation mile 391.0 R in Muskogee, Oklahoma (Figure 13). Established in 2004 and incorporated in Oklahoma, current estimates show the company with annual revenue of $10 to 20 million (http://www.manta.com/c/mmg33zm/frontier-terminal-llc).[47]

[47] Source: Google Earth

Figure 13 Street View of Frontier Terminal LLC[48]

Port of Muskogee, OK. The Port of Muskogee is located at river navigation mile 393.0 in the city of Muskogee (Figure 14). The Port is a full-service facility offering easy access to rail, truck, and barge transportation. Industrial roads allow access to the Muskogee Turnpike and Highway 165 at the port entrance. The Port of Muskogee has a rail marshalling yard and an internal track system that is within the Muskogee switching limits of the Union Pacific Railroad. Davis Field Airport lies nine miles south of the Port, and Tulsa International Airport is 45 air miles north of the Port. The Port of Muskogee has 94,000 square feet of dockside warehouse.[49]

Figure 14 Aerial View of the Port of Muskogee

Oakley's Terminal Muskogee. Strategically located at the confluence of the Arkansas, Grand, and Verdigris Rivers in the Port of Muskogee, Oakley's Terminal Muskogee is located at river

[48] Source: Google Earth

[49] Source: Oklahoma Department of Transportation

navigation mile 393.8 R (Figure 15). This privately owned company provides extensive range of services conveniently located by two major highways: the north and south of the Muskogee Turnpike and to the east and west of I-40. The Oakley's Terminal Muskogee handles substantial volumes of bulk and break bulk commodities, containers, steel pipe, coil, plate, beam, sand, salt, coal, coke, fertilizer, grain, paper, scrap, glass, and ore clays **(http://www.bruceoakley.com/divisions/terminal-muskogee.html).**[50]

Figure 15 Street View of Oakley's Terminal

Georgia Pacific-Muskogee. Georgia Pacific-Muskogee is a privately owned port specializing in paper products located at river navigation mile 390.2 in Muskogee, Oklahoma (Figure 16). Established in 1935, this port employs on average 1,000 to almost 5,000 people (http://www.manta.com/c/mm2lyhb/georgia-pacific-corp). The paper mill receives power from the Muskogee Mill Power Plant which is also owned and operated by Georgia- Pacific Corporation (http://www.sourcewatch.org/index.php/Fort_James_Muskogee_Mill_Power_Plant).[51]

[50] Source: Google Earth

[51] Source: Google Earth

Figure 16 Street View of Georgia Pacific-Muskogee

Oakley Port 33. Positioned between Tulsa and Inola in eastern, Oklahoma Port 33 is located at river navigation mile 393.0 on the Verdigris River (Figure 17). Due to the port location, this allows port easy access via major highways so that commodities can be transported by truck to the Midwest quickly. Port 33 handles large and small volumes of dry bulk commodities, including fertilizer, pig iron, glass cullet, coal, petroleum coke, calcined coke, scrap steel, cement, clinker, sand, zinc, alumina, iron, and oxide (http://www.bruceoakley.com/divisions/port33.html). In February 2014, Johnston's Port 33 was acquired by Bruce Oakley, Inc., headquartered in Little Rock, Arkansas.

Figure 17 Aerial View of Oakley Port 33

Tulsa Port of Catoosa, OK. Located at the head of the McClellan-Kerr Arkansas River Navigation System (MKARNS), the Tulsa Port of Catoosa (Figure 18) is one of the nation's largest inland river ports (Inland Waterway Fact Sheet, 2012 & Waterway ODOT 2013). The port is owned and operated by the city of Tulsa-Rogers County Port Authority in Catoosa. Approximately 2,000 acres of industrial park space with multi-model access, this provides the businesses using the Tulsa Port to have direct access to the waterway. The Tulsa Port of Catoosa has five public terminal areas: a low water (roll/on-roll/off) wharf, liquid bulk, dry bulk, grain, and general dry cargo. With the Port being only five miles from Interstate 44, the Port of Catoosa has a vital link to the nation's interstate highway system. On average over 450 trucks indicates a daily procession of trucks that are being served by various trucking shippers, entering and leaving the port daily. For high-volume overland shipping, the Tulsa Port of Catoosa is served directly by Burlington Northern and Santa Fe Railway (BNSF) and indirectly by the Union Pacific Railway (UPR) using a short-line switch on the South Kansas and Oklahoma Railroad (Waterways, ODOT 2013).

In addition, the Tulsa International Airport is seven miles from the Port. The airport serves many big name carriers such as American Airlines, Delta, Southwest, and Continental which allow the port to provide freight shipping.[52]

Figure 18 Aerial View of Tulsa's Port of Catoosa

Oklahoma's Locks and Dams. With a total of five locks and dams located on the Oklahoma portion of the McClellan-Kerr Arkansas River Navigation System (MKARNS) system, these five structures has a vast and rich history on the MKARNS.

[52] Source: Oklahoma Department of Transportation

W.D. Mayo Lock & Dam (No. 14). The W.D. Mayo lock and dam is located on the Arkansas River at navigation mile 319.6 which is about 9 miles southwest of Fort Smith, Arkansas, in LeFlore and Sequoyah Counties, Oklahoma (Figure 19). With authorization for being part of the McClellan-Kerr Arkansas River Navigation System the River and Harbor Act, approved on July 24, 1946, and Section 1117 of the Water Resources Development Act of 1986 recognized that the Cherokee Nation of Oklahoma could design and construct hydroelectric generating facilities at W.D. Mayo Lock and Dam. Construction for the dam began in May 1966 and the work was completed on October 15, 1970. The lock and dam did not become operational for navigation until December 1970.

Figure 19 Aerial View of W.D. Mayo Lock and Dam

The 7,400-foot-long dam consists of a low concrete apron and sill surmounted by tainter gates separated by 10-foot concrete piers. The gates are operated with machinery constructed on the piers. Twelve 60- by 21-foot tainter gates are provided for the structure. The lock has a 110-by 600-foot chamber of single-lift type with miter gates. The lock has a 20-foot normal lift and 22-foot maximum lift. Table 5 represents the project data for the W.D. Mayo Lock and Dam.[53]

[53] Source: US Army Corps of Engineers Tulsa District

http://www.swt.usace.army.mil/Locations/TulsaDistrictLakes/Oklahoma/WDMayoLockandDam/PertinentData.aspx

Table 5 W.D. Mayo Lock and Dam Project Data[54]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Top of Overflow Section (left bank)	414	---	---
Top of Spillway Gates	413	---	---
Top of Upper Pool	413	1,595	15,800
Bottom of Upper Pool	411	---	---
Weir Crest	392	---	---
Top of Lower Pool	392	---	12,800
Bottom of Lower Pool	391	---	---

Robert S. Kerr Lock & Dam (No. 15). Located on the Arkansas River at navigation mile 336.2 which is about 8 miles south of Sallisaw in LeFlore County, Oklahoma, the Robert S. Kerr was originally named Short Mountain Lock and Dam (Figure 20). With the authorization as being part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act, approved July 24, 1946, and Project Document HD 758 from the 79th Congress, 2d Session, on July 8, 7963 Public Law 88-62 sanction Short Mountain Lock and Dam to legally change its name to Robert S. Lock and Dam. Construction for the lock and dam began on April 1964. The lock and dam did not become operational for navigation until December 1970. Power units 1, 2, 3, and 4 were placed on line on October 5, July 27, September 1, and November 2, 1971.

Figure 20 Aerial View of Robert S. Kerr Lock and Dam

The dam is constructed of rolled earth-filled material. The total length of the structure, including the spillway, powerhouse intake, and navigation lock, is 7,230 feet. With a maximum height of 75 feet above the streambed, a service road to the right of the embankment provides access to the lock located in the left embankment. A gated, concrete, ogee weir type spillway

[54] Source: US Army Corps of Engineers Tulsa District.

extends partly across the existing river channel and a portion of the right bank between the power improvements and the navigation lock. The spillway weir has a net length of 900 feet and is surmounted by eighteen 50-by 44-foot-high tainter gates. The gates are separated by seventeen 10-foot piers which supports a 5-foot-wide service roadway bridge.

The spillway has a capacity of 1,542,000 cubic square feet at the maximum pool elevation (19.5 feet above the top of the power pool). The lock, located on the left of the spillway, is a single-lift, Ohio River type with culvert and port filling system and has a chamber 110 feet wide by 600 feet long with a normal lift of 48 feet. The powerhouse is an integral-type structure with four 27,500-kW Kaplan-type units having a total capacity of 110,000 kW (http://www.swt.usace.army.mil/Locations/TulsaDistrictLakes/Oklahoma/WDMayoLockandDam/PertinentData.aspx).

Webbers Falls Lock and Dam (No. 16). Webbers Falls Lock and Dam is located on the Arkansas River at navigation mile 366.6 which is about 5 miles northwest of Webbers Falls in Muskogee County, Oklahoma (Figure 21). Since the lock and dam is part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act (approved July 24, 1946) and the Project Document HD 758 from the 79th Congress, 2d Session, construction started in January 1965. The lock and dam became operational for navigation December 1970 with Power units 1, 2, and 3 becoming operational on August, September, and November 1973.

Figure 21 Aerial View of Webber Falls Lock and Dam

The dam is constructed of rolled-earth material. The total crest length of the structures, including the spillway, powerhouse intake, and the navigation lock, is 4,370 feet. With a maximum height of 84 feet above the streambed, a service road is provided across the top of the dam. The spillway extends across the left half of the existing river channel with the powerhouse structure in the right half of the river channel. The spillway is a gated, concrete, ogee weir. The crest of the weir is 66.8 and 40.0 feet below the tops of the maximum and power pools. The weir is surmounted by twelve 50- by 41-foot-high tainter gates. The gates are separated by eleven 10-foot intermediate piers which also support a 5-foot-wide service roadway bridge. Spillway capacity at maximum pool (elevation 526.8) us 1,200,000 cubic feet per second.

The lock is a 30-foot normal lift, Ohio River-type, with a culvert and port filling system and side outlet discharge. The lock is located in the left overbank with excavated approach channels. The chamber is 110 feet wide by 600 feet long. The powerhouse is an integral-type structure with three inclined-axis type units having a total capacity of 60 MW.

Chouteau Lock and Dam (No. 17). The Chouteau Lock and Dam is located on the Verdigris River at the McClellan-Kerr navigation mile 401.4 which is about 4 miles northwest of Okay in Wagoner County, Oklahoma (Figure 22). The dam is in the old river channel at navigation mile 403.0. As part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act, approved July 24, 1946, and Project Document HD 758 from the 79th Congress, 2d Session construction for the lock and dam started on July 1966. The lock and dam became operational for navigation on December 26, 1970. The structure is a combination of earth-filled and concrete, gravity dam. The total dam length is 11,690 feet.

Figure 22 Aerial View of Chouteau Lock and Dam

The spillway is a gated, concrete, ogee weir with a crest elevation of 485.0 and with left and right uncontrolled overflow sections. The spillway has a total width of 386 feet with a net flow width of 346 feet. The left and right uncontrolled overflow sections of the spillway are separated by three 60- by 27-foot tainter gates with 10-foot-wide concrete piers. In addition, the left and right embankments are designed to overflow with lengths of 280 and 2,700 feet. A 24-foot-wide service bridge is constructed on the piers for access to the lock. The lock has a 110- by 600-foot chamber of the single-lift type with miter gates. The lick has a 21-foot normal lift and a 24-foot maximum lift (http://www.swt.usace.army.mil/Locations/TulsaDistrictLakes/Oklahoma/ChouteauLockandDam/PertinentData.aspx).

Newt Graham Lock and Dam (No. 18). The Newt Graham Lock and Dam located on the Verdigris River at McClellan-Karr navigation mile 421.7 which is about 8 miles southwest of Inola in Wagoner County, Oklahoma (Figure 23). As part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act, approved July 24, 1946 and Project Document HD 758 from 79th Congress, 2d Session, construction for the lock and dam started on October 1967. The lock and dam became operational for navigation on December 30, 1970. The 1,630-foot embankment is a combination of earthen fill and concrete, gravity dam.

Figure 23 Aerial View of Newt Graham Lock and Dam

The spillway is a gated, concrete ogee weir with a crest elevation of 506.0. Total width of the spillway is 220 feet with a net flow width of 180 feet. There are three 60- by 27-foot-high tainter gates with 10-foot-wide concrete piers. The right bank overflow section is 596 feet at crest elevation 533.5, and the left bank overflow section is 813 feet at crest elevation 542.0. A 5-foot-wide service bridge is constructed on the piers for personnel access to the gates. The lock is an ll0- by 600-foot chamber of the single-lift type with miter gates. The lock has a 21-foot normal lift (http://www.swt.usace.army.mil/Locations/TulsaDistrictLakes/Oklahoma/NewtGrahamLockandDam/PertinentData.aspx).

III THE MCCLELLAN-KERR ARKANSAS RIVER REGIONAL ECONOMY

III.1 Regional Economic Setting

The economic impact study undertaken herein has a geographic scope that includes the five States of Arkansas (AR), Oklahoma (OK), Kansas (KS), Missouri (MO), and Texas (TX) and a sixth region that includes the remaining portions of the nation as an aggregate. Although all six regions are used in the analysis of the regional economic effects of the McClellan-Kerr Arkansas River Navigation System, our main interest in this section of the report is a describe the regional economy of the immediate vicinity of the MKARNS (i.e., the States of Arkansas and Oklahoma). Tables 6 and 7 present summary statistics of several economic indicators for the States of Arkansas and Oklahoma over the period 2000 to 2012. In addition, annual average percentage changes in the indicators are also included for the periods 2000 to 2008, 2008 to 2012, and 2000 to 2012. For comparative purposes Table 8 is provided for the States of Kansas, Missouri, and Texas as a whole. In addition, Table 9 shows analogous information for the remaining parts of the nation. All monetary values in Tables 6, 7, 8, and 9 have been expressed in 2015 price levels (using the CPI index) in order to make their comparisons more meaningful.

Table 6 Economic Indicators for the State of Arkansas[55]

Economic Indicator	2000	2008	2012	2000-2008 Annual Percent Change	2008-2012 Annual Percent Change	2000-2012 Annual Percent Change
Personal income ($millions)	$85,266	$104,008	$112,596	2.4%	1.7%	2.5%
Population (thousands)	2,679	2,875	2,950	0.8%	0.5%	0.8%
Per capita personal income (dollars)	$31,832	$36,182	$38,170	1.5%	1.1%	1.5%
Earnings by place of work ($millions)	$62,818	$70,271	$71,358	1.3%	0.3%	1.0%
Wages and salaries ($millions)	$44,475	$49,675	$50,271	1.3%	0.2%	1.0%
Nonfarm proprietors' income ($millions)	$6,508	$6,810	$7,221	0.5%	1.2%	0.8%
Total full-time and part-time employment (thousands)	1,483	1,584	1,570	0.8%	-0.2%	0.5%
Wage and salary jobs (thousands)	1,211	1,263	1,233	0.5%	-0.5%	0.1%
Nonfarm proprietors (thousands)	223	278	296	2.7%	1.3%	2.5%
Average earnings per job (dollars)	$42,349	$44,375	$45,439	0.5%	0.5%	0.6%
Average wages and salaries (dollars)	$36,731	$39,346	$40,773	0.8%	0.7%	0.8%
Average nonfarm proprietors' income (dollars)	$29,176	$24,540	$24,382	-1.8%	-0.1%	-1.3%

Selecting a single indicator to a gauge the economic health of a particular region is a challenging task, but there are a number of economic indicators that can aid in assessing the

[55] Note: All monetary values are in 2015 price levels. Source: US Bureau of Economic Analysis.

economic well-being of the region. Real personal per capita income is probably the most widely used economic indicator of a state's well-being. The per capita income for Arkansas, Oklahoma and United States has increased substantially over the 12 year time period. In 2000, Arkansas per capita personal income (in 2015 dollars) was $31,832; eight years later (2008) it had increased to $36,182 and in 2012 per capita personal income was $38,170. The average annual growth in real per capital personal income over the period has been between 1.1% and 1.5%. Oklahoma's real per capita personal income has been slightly higher than Arkansas' and has experienced higher average annual growth rates (see Table 7). The surrounding States of Kansas, Missouri, and Texas and the remainder of the U.S. have higher real per capita personal income than either Arkansas or Oklahoma but their average annual percentage changes are lower (see Tables 8 and 9).

Table 7 Economic Indicators for the State of Oklahoma[56]

Economic Indicator	2000	2008	2012	2000-2008 Annual Percent Change	2008-2012 Annual Percent Change	2000-2012 Annual Percent Change
Personal income ($millions)	$119,709	$154,362	$165,547	3.2%	1.4%	2.9%
Population (thousands)	3,454	3,669	3,816	0.7%	0.8%	0.8%
Per capita personal income (dollars)	$34,655	$42,072	$43,385	2.4%	0.6%	1.9%
Earnings by place of work ($millions)	$86,581	$110,086	$116,347	3.0%	1.1%	2.6%
Wages and salaries ($millions)	$59,364	$70,727	$73,850	2.1%	0.9%	1.9%
Nonfarm proprietors' income ($millions)	$12,897	$22,683	$23,696	8.4%	0.9%	6.4%
Total full-time and part-time employment (thousands)	1,994	2,194	2,224	1.1%	0.3%	0.9%
Wage and salary jobs (thousands)	1,564	1,678	1,665	0.8%	-0.2%	0.5%
Nonfarm proprietors (thousands)	341	437	484	3.1%	2.1%	3.2%
Average earnings per job (dollars)	$43,429	$50,183	$52,314	1.7%	0.8%	1.6%
Average wages and salaries (dollars)	$37,958	$42,147	$44,353	1.2%	1.0%	1.3%
Average nonfarm proprietors' income (dollars)	$37,772	$51,865	$48,978	4.1%	-1.1%	2.3%

[56] Note: All monetary values are in 2015 price levels. Source: US Bureau of Economic Analysis.

Table 8 Economic Indicators for Kansas, Missouri, and Texas[57]

Economic Indicator	2000	2008	2012	2000-2008 Annual Percent Change	2008-2012 Annual Percent Change	2000-2012 Annual Percent Change
Personal income ($millions)	$1,157,070	$1,452,009	$1,565,049	2.8%	1.6%	2.7%
Population (thousands)	29,245	33,041	34,971	1.4%	1.2%	1.5%
Per capita personal income (dollars)	$39,564	$43,946	$44,753	1.2%	0.4%	1.0%
Earnings by place of work ($millions)	$925,851	$1,109,405	$1,165,345	2.2%	1.0%	2.0%
Wages and salaries ($millions)	$657,117	$760,111	$787,945	1.7%	0.7%	1.5%
Nonfarm proprietors' income ($millions)	$129,934	$183,439	$200,968	4.6%	1.9%	4.2%
Total full-time and part-time employment (thousands)	17,372	19,903	20,479	1.6%	0.6%	1.4%
Wage and salary jobs (thousands)	14,127	15,473	15,572	1.1%	0.1%	0.8%
Nonfarm proprietors (thousands)	2,831	4,059	4,547	4.8%	2.4%	4.7%
Average earnings per job (dollars)	$53,295	$55,742	$56,903	0.5%	0.4%	0.5%
Average wages and salaries (dollars)	$46,513	$49,126	$50,601	0.6%	0.6%	0.7%
Average nonfarm proprietors' income (dollars)	$45,890	$45,193	$44,200	-0.2%	-0.4%	-0.3%

Table 9 Economic Indicators for the Rest of the United States[58]

Economic Indicator	2000	2008	2012	2000-2008 Annual Percent Change	2008-2012 Annual Percent Change	2000-2012 Annual Percent Change
Personal income ($millions)	$10,901,943	$12,437,942	$12,973,509	1.6%	0.9%	1.5%
Population (thousands)	$252,917	$271,053	$278,903	0.8%	0.6%	0.8%
Per capita personal income (dollars)	$43,105	$45,888	$46,516	0.7%	0.3%	0.6%
Earnings by place of work ($millions)	$8,311,695	$9,064,061	$9,158,862	1.0%	0.2%	0.8%
Wages and salaries ($millions)	$6,082,876	$6,536,000	$6,464,925	0.8%	-0.2%	0.5%
Nonfarm proprietors' income ($millions)	$884,877	$911,153	$1,043,882	0.3%	2.9%	1.4%
Total full-time and part-time employment (thousands)	$147,999	$159,743	$158,367	0.9%	-0.2%	0.5%
Wage and salary jobs (thousands)	$123,483	$127,537	$123,920	0.4%	-0.6%	0.0%
Nonfarm proprietors (thousands)	$22,705	$30,674	$32,963	3.9%	1.5%	3.5%
Average earnings per job (dollars)	$56,161	$56,741	$57,833	0.1%	0.4%	0.2%
Average wages and salaries (dollars)	$49,261	$51,248	$52,170	0.4%	0.4%	0.5%
Average nonfarm proprietors' income (dollars)	$38,972	$29,705	$31,668	-2.6%	1.3%	-1.4%

57 Note: All monetary values are in 2015 price levels. Source: US Bureau of Economic Analysis.

58 Note: All monetary values are in 2015 price levels. Source: US Bureau of Economic Analysis.

We further evaluate the economic progress of our regions over time in several ways. First we look at several average income concepts. Real per capita personal income is used as an overall measure of economic well-being. It represents a comprehensive view of local "wealth" held by the average person in each region and we see how it has fared over time and in comparison with the nation as a whole. We also look at the earning power of workers in terms of their wages and salaries and in terms of their total earnings (wages and salaries plus supplements to income—the so called "unearned" income components). Figures 24, 25, and 26 show the real average income measures for each of the five states in the MKARNS region (i.e., Arkansas, Oklahoma, Kansas, Missouri, and Texas) and for the U.S. in total. We see that Texas has been able to maintain real average income levels on a par with the nation. However, the other four states have somewhat lower average income levels for the entire period examined (1969 to 2013). Oklahoma and Arkansas appear to have the lowest real average income levels. However, all of the states in the MKARNS region seem to be growing at a rate that is similar to the nation.

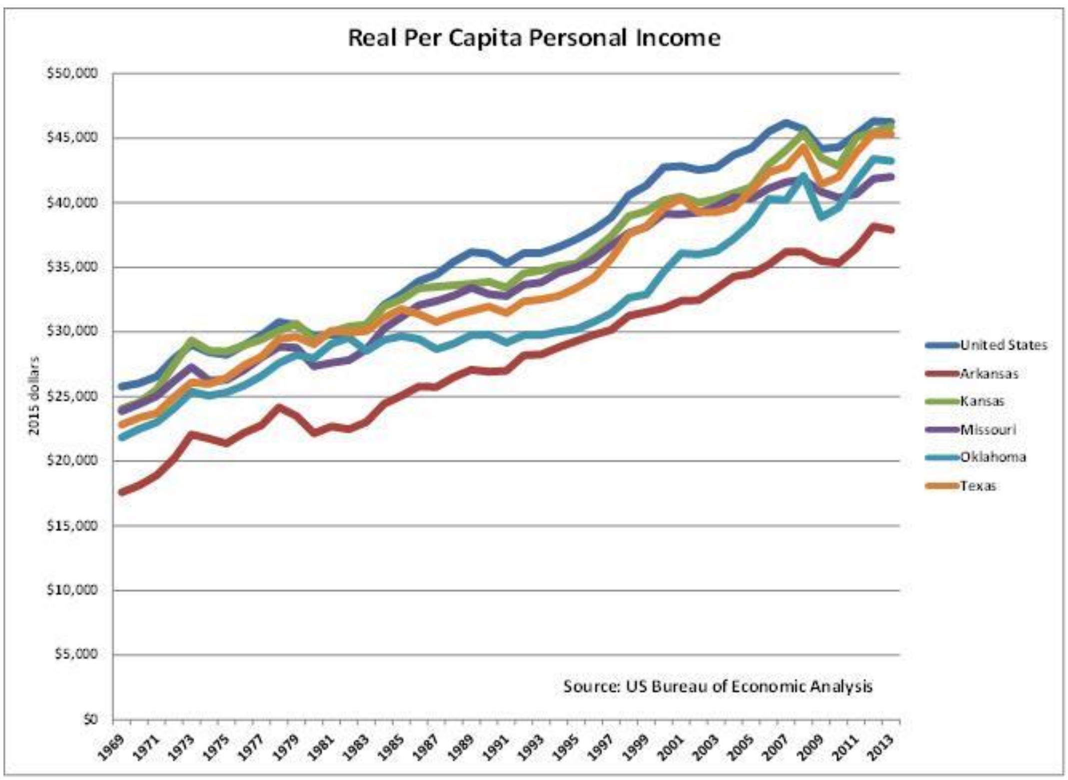

Figure 24 Real Per Capita Personal Income

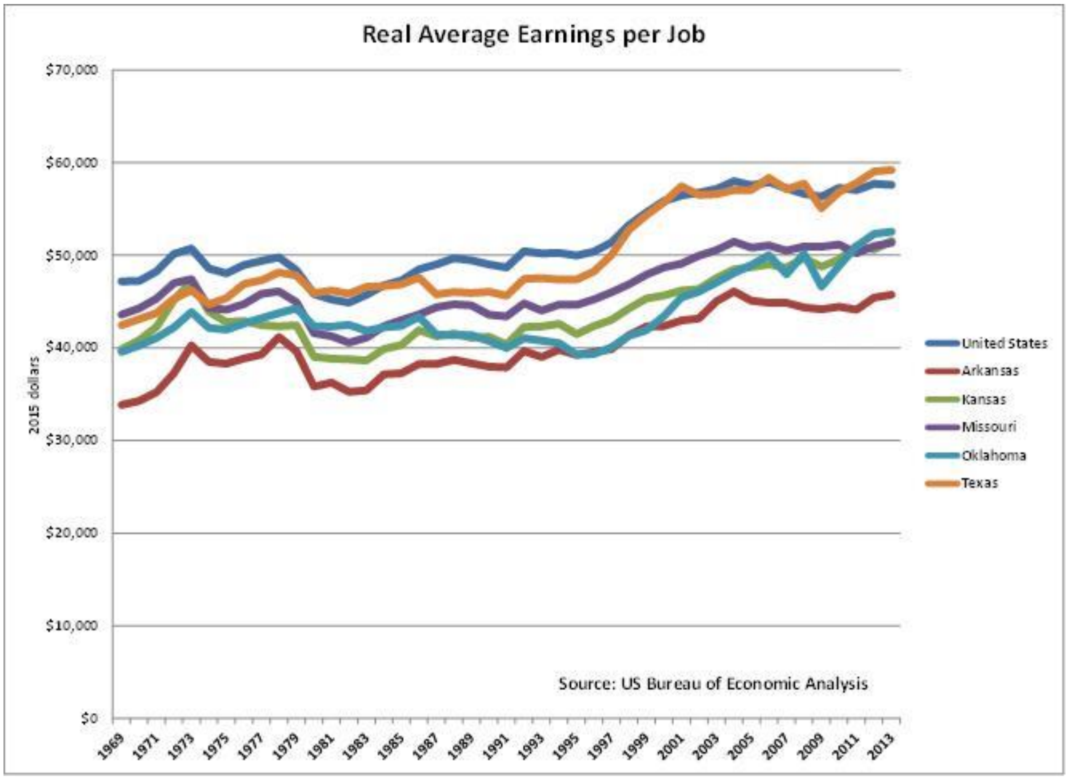

Figure 25 Real Average Earnings per Job

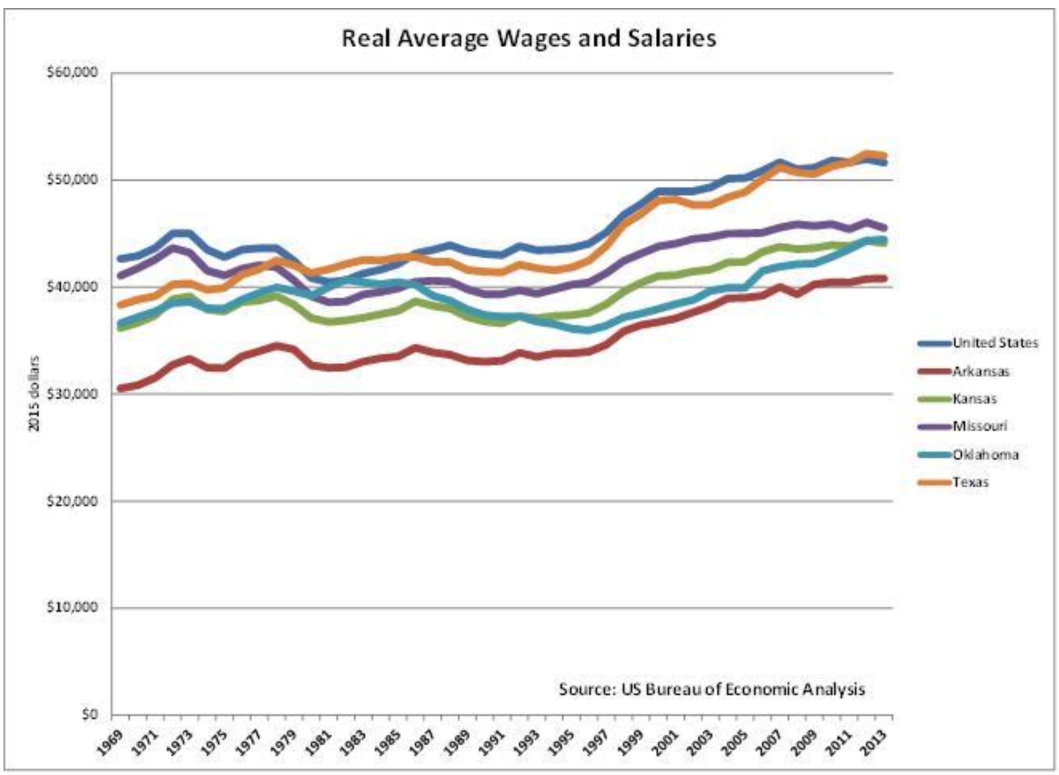

Figure 26 Real Average Wages and Salaries

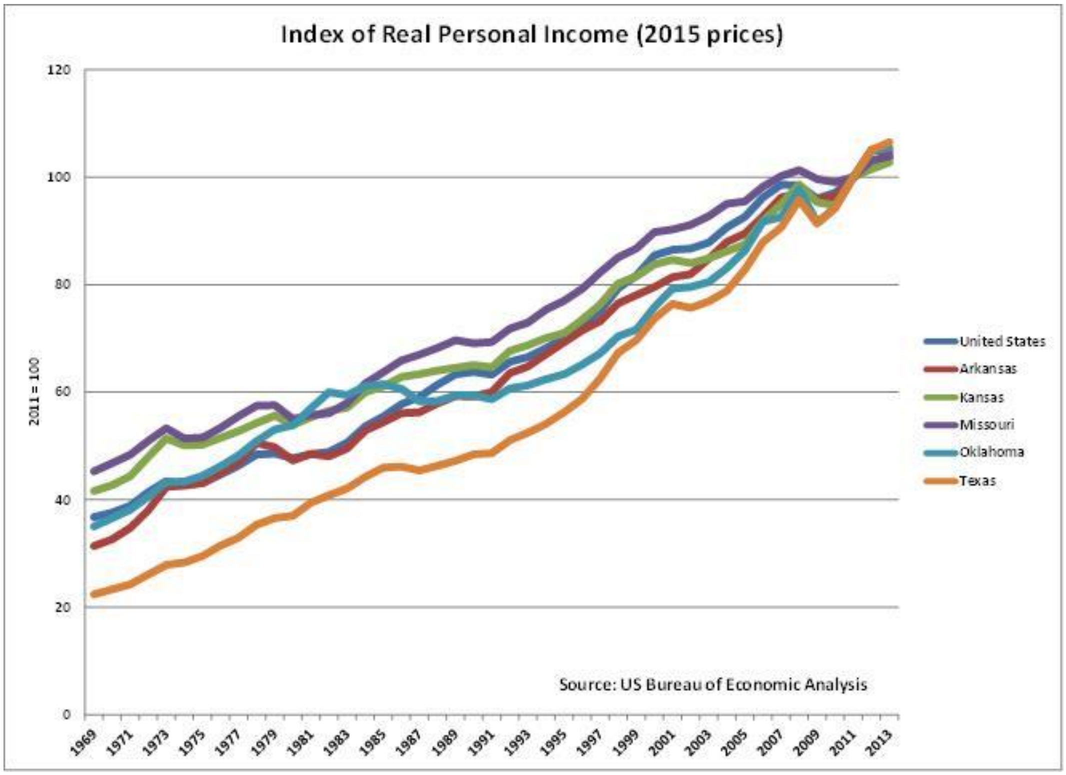

Figure 27 Real Personal Income Index

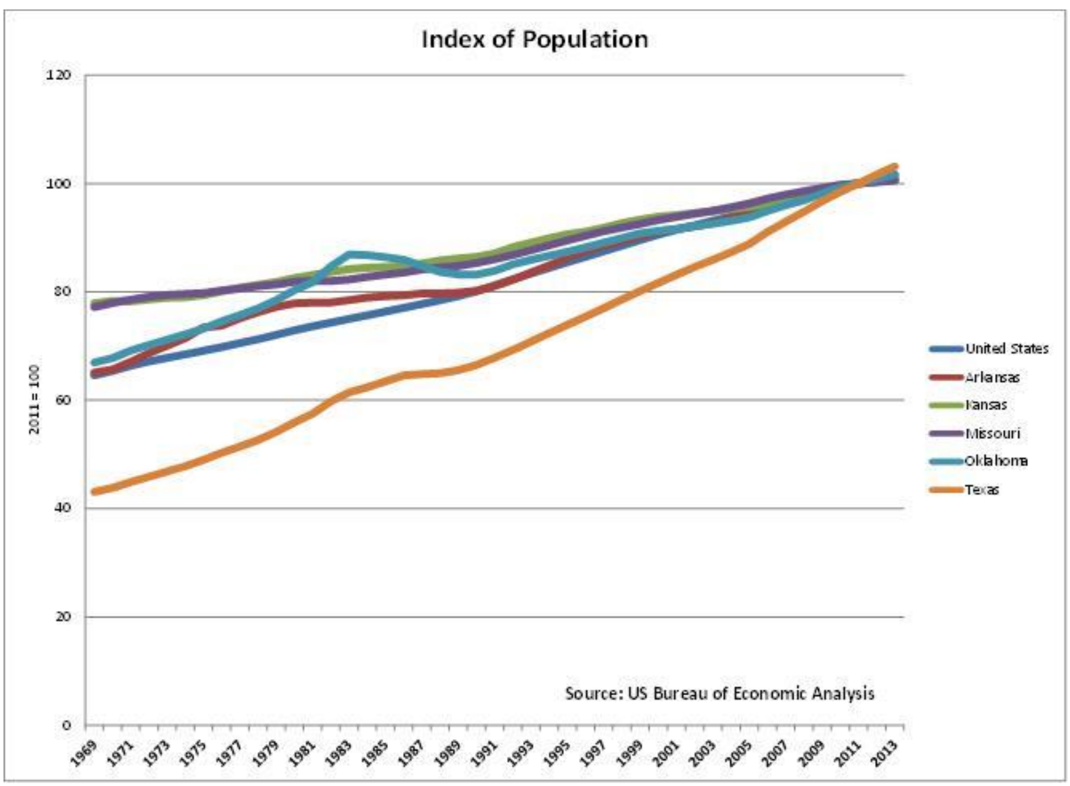

Figure 28 Population Index

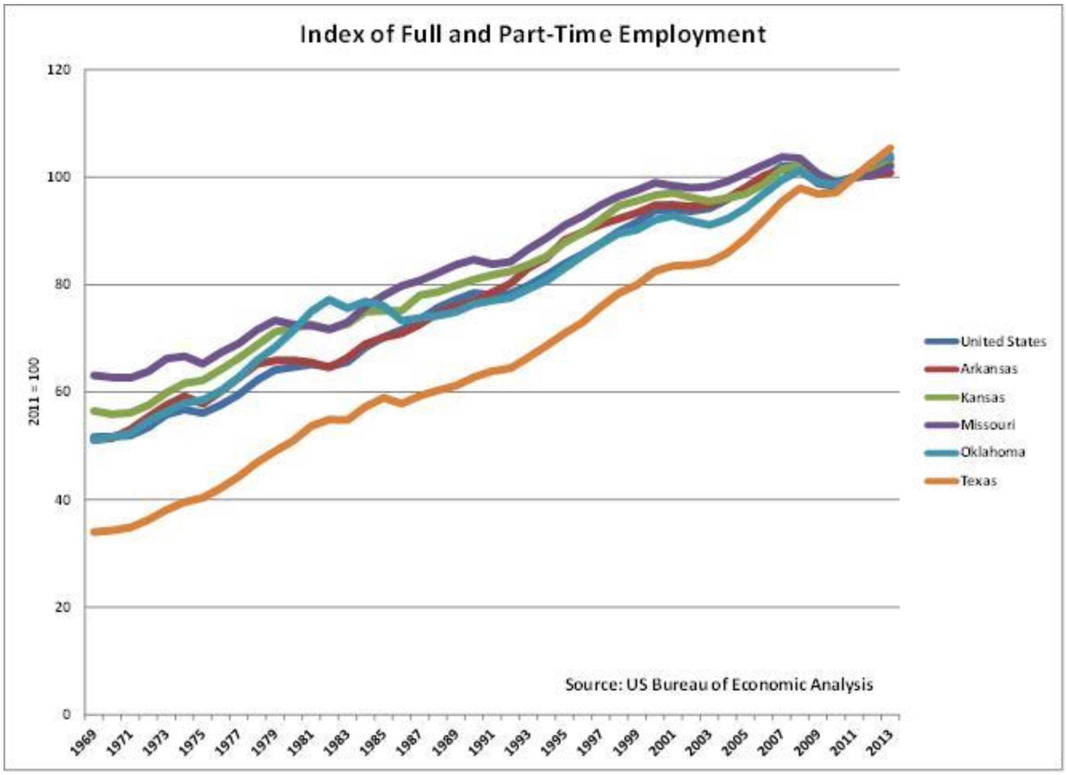

Figure 29 Full and Part-Time Employment Index

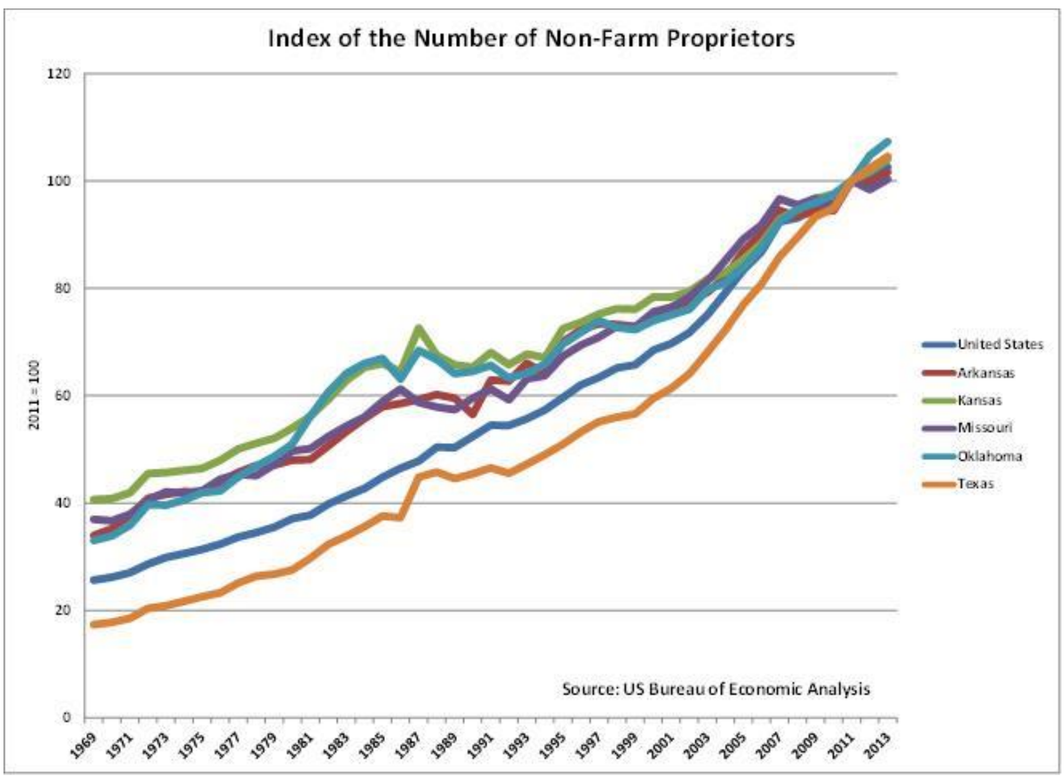

Figure 30 Number of Proprietors Index

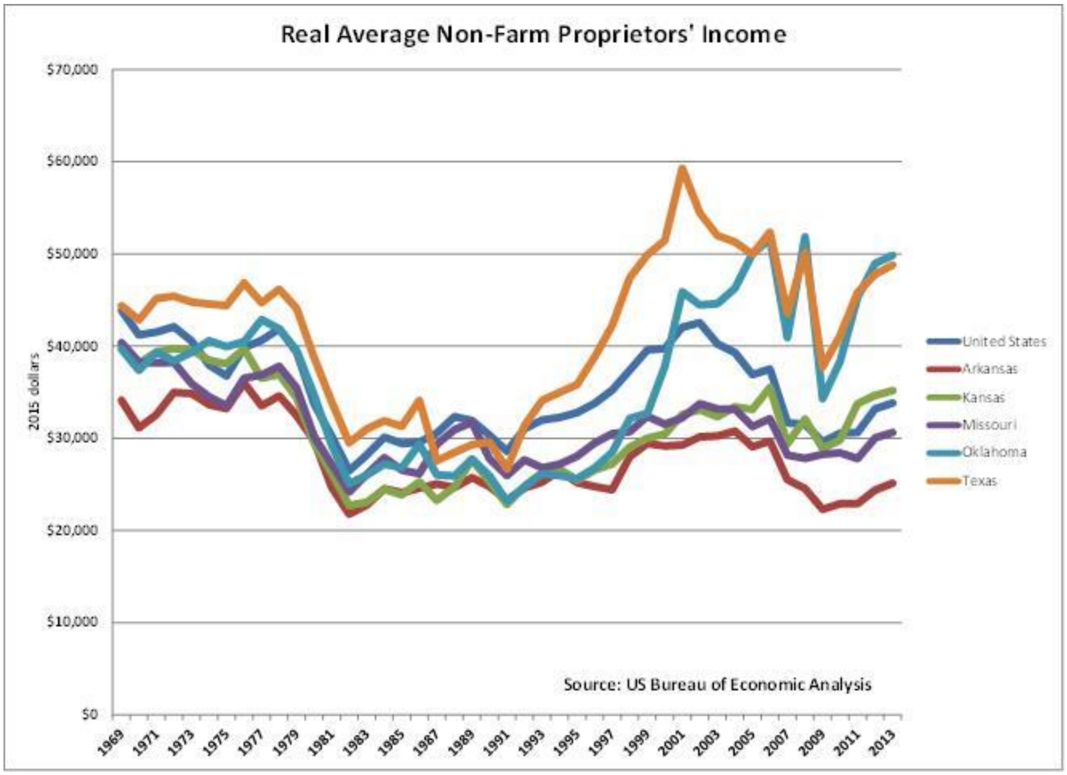

Figure 31 Real Average Non-Farm Proprietors Income

Real average non-farm proprietors' income (Figure 31) presents an interesting contrast to the other average income concepts (shown earlier in Figures 24, 25, and 26). While the earlier average income measures seem to mirror the nation and showing a rather consistent pattern of growth over time, average non-farm proprietors' income has much more volatile movement. Part of this volatility is due to some of its components—especially profits which can vary and swing from positive to negative from year-to-year.

III.2 MKARNS Multiregional Social Accounting Matrix (MKARNS MRSAM) Model

During the mid-20th Century, economists and other social scientists have wanted to extend the newly developed analytical techniques which focused on the details of the industrial structure and resource constraints (such as input-output models) to be able to design and implement specific government policies and programs that would address issues and problems involving people, social groups, and capital structures.[59] What evolved over a period of decades of research was an enhanced form of economic/social accounting techniques beyond that afforded by input-output accounting principles which provide a consistent, comprehensive, disaggregated, integrated, and systematic data base that describes and measures the

[59] Social accounting matrix models have a long history that became formalized by Pyatt and Thornbecke (1976). A number of excellent presentations of the conceptual framework and practical application of SAM models can be found in King (1981), Pyatt and Round (1985), Thornbecke (1998), Round (2007), and Breisinger, Thomas and Thurlow (2010).

interdependencies within a socioeconomic system. As it is called, a social accounting matrix (or SAM) can not only show the interindustry linkages like input-output accounts but SAM models can also provide information (when they are appropriately configured) concerning the determination of income distributions based on social groups, the production and use of resource endowments, and the economic and demographic flows between a given region and the other regional economies within a nation.

III.2.1 The Social Accounting Matrix Framework

A social accounting matrix is a double entry system of accounts that has three basic requirements: (1) a SAM is both comprehensive and disaggregated in that it includes transactions between industries, institutional sectors, and economic agents, (2) a SAM is consistent because incomes have corresponding and equal expenditures, and (3) a SAM shows both the receivers and senders of every transaction. Table 10 shows a simple version of a SAM for a single region of the nation's economy. The basic accounting framework for a SAM is similar to that of an input-output table: i.e., the columns represent purchasing or receiving entities and the rows represent the selling or sending entities. Reading across rows provides sales and distributions information and reading down columns shows payments and receipts.

Table 10 Single-Region Social Accounting Matrix Model Structure (Sales and Distribution)

Payments and Receipts	Industries	Commodities	Factors	Institutions	Domestic Trade	Foreign Trade
Industries	0	Industry Make	0	0	Domestic Exports by Industry	Foreign Exports by Industry
Commodities	Industry Use of Commodities	0	0	Institutional Use of Commodities	0	0
Factors	Factor Incomes	0	0	0	0	0
Institutions	0	Institutional Sales	Institution Factor Distributions	Institutional Transfers	Domestic Exports by Institutions	Foreign Exports by Institutions
Domestic Trade	Domestic Imports by Industry	0	Domestic Factor Imports	Domestic Imports by Institutions	0	0
Foreign Trade	Foreign Imports by Industry	0	Foreign Factor Imports	Foreign Imports by Institutions	0	Foreign Transshipments

The components of a social accounting matrix are as follows. Production is split between the producers (industries) and the things that the producers make (commodities). Firms are categorized into similar production activities (industrial sectors) and the products (good and services) they make are similarly classified. Factors are the human, capital, and land resources. Institutions include households, enterprises, and governments. Domestic trade is either the imports from or the exports to other parts of the nation and foreign trade is either the imports from or the exports to place outside the nation.

A social accounting matrix can provide a useful analytical framework for modeling policy changes and project-specific impact scenarios. For example, a typical policy might involve changes in household incomes (such as a consumption inducement). SAM models are capable of keeping track of these changes and measuring their consequences as they would pass through the economy. Most SAM models are used to example “partial” equilibrium changes of real shocks to the economic system. The model then treats the circular flow of income endogenously. As Jeffery Round (2007) explains, “the circular flow captures the generation of income by activities in producing goods and services, the mapping of these income payments to factors of production of various kinds, the distribution of factor and non-factor income to households, and the subsequent spending of that income by households on products.” This is all solved simultaneously (something beyond the capabilities of input-output models).

A SAM is not actually a model, as such. To make a SAM into an economic impact model we first have to designate which components of the social accounting matrix (Table 10) are “endogenous” or determine within the context of the model and analysis under consideration and which are not (the “exogenous” components). One possible endogenous/exogenous determination is to separate the labor and non-labor factors and the household and non-household institutions. Note that the resulting accounting matrix can become quite complicated, even with the simple designation considered here. To simplify the resulting configuration, we only show the endogenous components in Table 11. It is customary to designate transactions by governments, enterprises, and rest-of-the nation and world as exogenous (Round, 2007). However, it is entirely possible to consider other factor components (such as investment returns) and institutions (like local government activities—education, security services, etc.) endogenous.

Table 11 Endogenous Activities in a Single-Region SAM Model Structure (Sales and Distributions)

Endogenous Payments and Receipts	Industries	Commodities	Labor Factors	Household Institutions
Industries	0	Industry Make	0	0
Commodities	Industry Use of Commodities	0	0	Household Institutional Use of Commodities
Labor Factors	Labor Factor Incomes	0	0	0
Household Institutions	0	Household Sales	Household Labor Factor Distributions	Household Institutional Transfers

Second, SAM-based multipliers (i.e., a SAM model) are generated by computing column shares of outlays for each of the endogenous columns and then solving the resulting “Leontief-type” inverse matrix (as is done for input-output models). The model works to the extent that, external changes resulting in increases (decreases) in export activity cause increases (decreases) in the payroll of export firms which are then transmitted to the local service sector establishments. Furthermore, the inflow or outflow of money causes changes in local services to change by a multiple of the original change (i.e., the regional economic multiplier) as the influx of funds is spent and re-spent in the local economy or as the initial withdrawal of funds causes decreases in local sales which, in turn, causes further decreases in local sales as payrolls and employment shrink. For expansions, recirculation continues until the leakages from the system (such as imports, savings, and taxes) exhaust the amount of initial influx. In cases of decreases in export activity, the cumulative decline is halted by decreases in imports, savings, and taxes. Note that export base models predict that, without "new" injections of funds to the local economy through its export sector, the local economy will stagnate because service activities can only respond to changes in local economic conditions.

A fully articulated multiregional input-output and SAM model can be compiled using IMPLAN's regional interindustry accounts data (Olson and Lindall, 2004).[60] The MRIO model consists of three basic accounts—use, make (or by-product), and interregional trade accounts. The "use" accounts show the consumption of commodities by industries and by final users within each region. The "make" accounts present the production of commodities by each region's sectors. The interregional "trade" accounts indicate the distribution of commodities between regions from where they are produced to where they are consumed. The trade accounts were appropriately aggregated county-level IMPLAN commodity trade flow accounts.[61] Jackson (2004) describes the general procedures used to compile multiregional input-output accounts from IMPLAN social accounts matrix databases. The method requires one to make all appropriate adjustments to each county's social accounts data and then aggregate to the geographical level specified in the MRIO model. Robinson (2006) explains, in detail, how to compile a multiregional social accounts matrix from the single-region perspective of the IMPLAN accounts system. A detailed set of instructions for compiling multiregional input-output and SAM models is provided in Appendix A of this report.

III.2.2 McClellan-Kerr Arkansas River Navigation System Multiregional Social Accounting Matrix Model

A McClellan-Kerr Arkansas River Navigation System Multiregional Social Accounting Matrix (MKARNS MRSAM) model was compiled using IMPLAN's regional interindustry accounts data for 2011 which is the base year of the model and economic impact analysis undertaken in this study. The MKARNS MRSAM model has a six-regional geographic configuration. As described previously, five of the regions are the States of Arkansas (AR), Oklahoma (OK), Kansas (KS), Missouri (MO), and Texas (TX). A sixth region has been added for purposes of model balancing and to capture economic feedback effects through linkages between the above five states and the rest of the nation (i.e., the sixth region, called herein RUS). The MKARNS MRSAM model has an eighty-nine (89) industrial structure (see Table 12).

[60] However, impact results can be inflated to desired price levels.

[61] The county-level commodity trade accounts were provided by Minnesota IMPLAN staff.

Two additional sets of data are needed to construct a fully articulated MKARNS MRSAM model that IMPLAN's regional economic accounts data. One set of data are the "place-of-work" to "place-of-residence" commuting flows that are compiled as part of the latest county-to-county "journey-to-work" commuting flows available from the American Community Survey (U.S. Census Bureau). These data are published for the period 2006 to 2010. The commuting data allows our model to track income generated by "place-of-work" to workers "place-of-residence". We use these commuting flows to geographically distribute labor factor incomes (i.e., employee compensation and proprietors' income).

Table 12 MKARNS MRSAM Model Industries and Commodities

Code	Industry or Commodity	IMPLAN Codes
1	Live animals & fish	011 - 014, 017, 018
2	Cereal grains	002
3	Other agricultural products	001, 003 - 010
4	Animal feed	041 - 042
5	Meat, fish, seafood & preparations	059 - 061
6	Milled grains & bakery products	043, 044, 047, 062 - 065
7	Other foodstuffs and fats & oils	045, 046, 048 - 058, 066 - 070
8	Alcoholic beverages	071 - 073
9	Tobacco products	074
10	Monument & building stone	025, 166
11	Natural sands, gravel & crushed stone	026
12	Nonmetallic minerals, n.e.c.	027
13	Metallic ores & concentrates	022 - 024
14	Coal	021
15	Crude petroleum	020
16	Gasoline, aviation turbine fuel & fuel oils	115
17	Coal & petroleum products, n.e.c.	116 - 119
18	Basic chemicals	120 - 126
19	Pharmaceuticals	132 - 135
20	Fertilizers	130
21	Chemical products & preparations, n.e.c.	127 - 129, 131, 136 - 141
22	Plastics & rubber products	142 - 152
23	Logs & wood in the rough	015, 016, 095
24	Wood products	096 - 103
25	Pulp, newsprint, paper & paperboard	104 - 106, 108
26	Paper & paperboard articles	107, 109 - 112
27	Printed products	113
28	Textiles & leather products	075 - 094
29	Nonmetalic mineral products	153 - 165, 167 -169
30	Primary & semifinished base metal forms & shapes	170 - 182
31	Base metal products	183 - 190, 193 - 202

Code	Industry or Commodity	IMPLAN Codes
32	Machinery	203 - 233
33	Electronic & electrical equipment & components	234 - 258, 266 - 275
34	Motorized vehicles (including parts)	276 - 283, 292 - 294
35	Transport equipment	284 - 286, 289 - 291
36	Precision instruments & apparatus	305 - 309
37	Furniture, fixtures, lamps & lighting equipment	259 - 265, 295 - 304
38	Miscellaneous manufactured products	191, 192, 287, 288, 310 - 318
39	Waste & scrap	434, 435
40	Support Activities for Agriculture and Forestry	019
41	Support Activities for Mining	028-030
42	Utilities	031 - 033, 428, 431
43	Contract Construction	034 - 040
44	Support activities for printing	114
45	Wholesale Trade	319
46	Retail stores	320 - 331
47	Air Transportation	332
48	Rail Transportation	333
49	Water Transportation	334
50	Truck Transportation	335
51	Transit and Ground Passenger Transportation	336, 430
52	Pipeline Transportation	337
53	Scenic, Sightseeing and Transportation Support	338
54	Postal Service	427
55	Couriers and Messengers	339
56	Warehousing and Storage	340
57	Publishing Industries (except Internet)	341 - 345
58	Motion Picture and Sound Recording Industries	346, 347
59	Broadcasting (except Internet)	348, 349
60	Telecommunications	351
61	Data Processing, Hosting and Related Services	352
62	Other Information Services	350, 353
63	Monetary Authorities and Credit Intermediation	354, 355
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	356
65	Insurance Carriers and Related Activities	357, 358
66	Funds, Trusts, and Other Financial Vehicles	359
67	Real Estate	360, 361
68	Rental and Leasing Services	362 - 365
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	366
70	Professional, Scientific, and Technical Services	367 - 380
71	Management of Companies and Enterprises	381

Code	Industry or Commodity	IMPLAN Codes
72	**Administrative and Support Services**	**382 - 389**
73	**Waste Management and Remediation Services**	**390**
74	**Educational Services**	**391 - 393**
75	**Ambulatory Health Care Services**	**394 - 396**
76	**Hospitals**	**397**
77	**Nursing and Residential Care Facilities**	**398**
78	**Social Assistance**	**399 - 401**
79	**Performing Arts, Spectator Sports, and Related Industries**	**402 - 405**
80	**Museums, Historical Sites, and Similar Institutions**	**406**
81	**Amusement, Gambling, and Recreation Industries**	**407 - 410**
82	**Accommodation**	**411, 412**
83	**Food Services and Drinking Places**	**413**
84	**Repair and Maintenance**	**414 - 418**
85	**Personal and Laundry Services**	**419 - 422**
86	**Religious, Grantmaking, Civic, Professional, and Similar Organizations**	**423 - 425**
87	**Private Households**	**426**
88	**Public Institutions**	**429, 432, 437 - 440**
89	**Noncomparable imports and non-sector accounts**	**435, 436**

The second set of additional data is the commodity trade flows that spatially connect our industrial sectors. Unfortunately, U.S. interregional freight and commodity trade is not well documented in public sources due to the openness of the nation's economy. As a result, a number of indirect methods have been used to construct U.S. interregional trade patterns. Robinson and Liu (2006) showed that estimated MRSAM impact multipliers are very sensitive to the methods used to construct interregional freight and commodity trade flow patterns. We used two separate data sources for the interregional trade patterns in the MKARNS MRSAM model. State-to-state trade flows are available for 2011 from Federal Highway Administration's (FHWA) Freight Analysis Framework 3 (Battelle, 2012) data base for freight flows (MKARNS sectors 1 to 39). For the non-freight sectors (MKARNS sectors 40 to 89) we used IMPLAN's county-to-county trade flow data by commodity. The IMPLAN county-to-county commodity trade data are available for each of the 440 IMPLAN commodities. These data were aggregated regionally to the MKARNS regions and industrially to the MKARNS sectors. Each of the resulting MKARNS region-to-region commodity trade flow matrices were then updated to 2011 values using a double allocation procedure called "RAS".[62]

The full set of MKARNS MRSAM social accounts is too voluminous to be included as an Appendix to this report. As a result, the MKARNS multiregional social accounts are provided in

[62] The "RAS" procedure is usually attributed to Ronald A. Stone from his 1961 published report. Please refer to Miller and Blair (2009, pp. 313-336) for an extensive explanation of various "RAS" procedures.

a companion spreadsheet for the interested reader (called ***MKARNS_MRSAM.xlsx***). The ***MKARNS_MRSAM.xlsx*** spreadsheet file contains ten (10) separate files,

Sub-Sheet	**Sub-Sheet Contents**
MRSAM	MKARNS Multiregional Social Accounts Matrix
MRSAM_mult	Leontief inverse of the MKARNS Multiregional Social Accounts Matrix
ConvFact	Impact variable conversion factors
RegSAM	MKARNS single region social accounting matrices
TRDflw	MKARNS region-to-region commodity trade flows and coefficients
JRWflw	MKARNS journey-to-work commuting flows and coefficients
ForImp	Foreign import proportions
MktShr	MKARNS regional market share matrices
Codes	MKARNS MRSAM model codes
ModInd	MKARNS MRSAM model sectors and bridge to IMPLAN industries

Below is a set of tables (Tables 13 through 18) that includes the industrial output, employment, employee compensation, proprietors' income, other property-type income, and business taxes for each industry of each region in the MKARNS MRSAM model (89 sectors and 6 regions). Output is the production level for each sector. Generally, output measures the sales revenues of the respective industry. However, in the case of the trade (wholesale and retail) and transportation sectors output measures their respective service activities (i.e., does not include the value of the goods sold or transported). Employment is the number of full and part-time jobs and is not adjusted for "full-time" equivalency. Employee compensation is total payroll costs including benefits—the sum of wages and salaries plus supplements to wages and salaries (e.g., employer-provided contributions to retirement and health programs). Proprietors' income includes payments received by self-employed individuals and income. Other property-type income includes profits, dividends, rents, interests, etc. Business taxes consist of excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses.

Table 13 Input-Output Accounts Data for Arkansas[63]

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	$4,449	14.4	$239	$247	$465	$1
2	$1,798	28.7	$37	$257	$269	$0
3	$2,402	19.0	$91	$474	$427	$0
4	$1,806	1.6	$79	$1	$126	$4
5	$11,238	30.8	$1,029	$17	$559	$25
6	$3,400	5.8	$290	$3	$268	$12

[63] Note: Monetary values are in millions of 2011 dollars and employment is thousands of full and part-time jobs. Source: 2011 IMPLAN Database.

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
7	$4,330	7.3	$343	$4	$203	$10
8	$412	0.4	$25	$0	$13	$188
9	$0	0.0	$0	$0	$0	$0
10	$260	1.1	$54	$1	$100	$4
11	$196	1.2	$63	$1	$33	$3
12	$21	0.1	$4	$0	$5	$0
13	$47	0.1	$7	$0	$22	$2
14	$30	0.1	$6	$0	$5	$2
15	$2,699	8.0	$200	$22	$505	$149
16	$4,886	0.5	$50	$2	$383	$10
17	$531	0.5	$37	$1	$161	$1
18	$2,351	1.8	$154	$4	$91	$19
19	$116	0.2	$10	$0	$13	$0
20	$333	0.3	$21	$0	$12	$2
21	$2,097	2.8	$176	$4	$208	$8
22	$3,321	10.5	$597	$2	$390	$43
23	$1,712	8.5	$309	$255	$66	$23
24	$1,419	5.5	$255	$301	$113	$46
25	$3,262	4.4	$409	$6	$391	$37
26	$2,639	5.9	$350	$4	$244	$14
27	$706	4.6	$204	$2	$23	$7
28	$561	3.7	$132	$1	$30	$5
29	$933	3.4	$171	$0	$82	$11
30	$6,206	8.8	$666	$0	$350	$59
31	$2,806	11.4	$585	$22	$232	$17
32	$3,796	11.9	$583	$110	$273	$22
33	$2,965	8.3	$520	$0	$235	$7
34	$3,108	7.6	$364	$0	$56	$16
35	$1,849	4.6	$264	$0	$115	$12
36	$508	2.8	$132	$21	$117	$1
37	$1,544	6.0	$283	$27	$149	$4
38	$1,747	5.8	$321	$20	$232	$48
39	$0	0.0	$0	$0	$0	$0
40	$245	8.5	$187	$45	$0	$6
41	$1,730	5.8	$408	$0	$249	$30
42	$5,528	7.5	$732	$15	$1,399	$606
43	$8,010	84.2	$2,387	$1,023	$336	$76
44	$13	0.1	$5	$0	$0	$0
45	$8,029	49.4	$3,005	$237	$1,215	$1,198
46	$10,147	161.4	$3,765	$819	$1,053	$1,364
47	$362	1.3	$78	$1	$27	$26
48	$1,134	2.9	$258	$0	$196	$0

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
49	$52	0.1	$8	$0	$8	$1
50	$5,583	41.9	$1,755	$303	$394	$64
51	$93	1.9	$37	$10	$8	$2
52	$329	0.4	$43	$115	$0	$26
53	$146	2.2	$49	$6	$0	$3
54	$456	5.5	$392	$0	$0	$0
55	$471	4.8	$161	$1	$114	$10
56	$630	7.9	$312	$7	$89	$6
57	$888	5.7	$209	$0	$116	$5
58	$209	1.6	$34	$2	$28	$4
59	$287	2.0	$81	$57	$0	$2
60	$3,913	7.1	$542	$44	$1,271	$214
61	$381	1.7	$76	$1	$123	$4
62	$50	0.4	$14	$1	$5	$0
63	$5,704	21.0	$1,014	$36	$2,341	$78
64	$1,996	14.5	$383	$32	$16	$10
65	$3,333	20.0	$883	$114	$757	$96
66	$624	2.4	$47	$2	$73	$11
67	$14,454	43.6	$325	$84	$7,918	$1,306
68	$1,557	6.8	$202	$641	$196	$181
69	$257	0.1	$4	$1	$183	$4
70	$6,599	64.1	$2,683	$867	$856	$97
71	$5,281	26.4	$2,781	$9	$293	$134
72	$3,536	80.6	$1,612	$239	$255	$38
73	$612	3.3	$143	$23	$98	$19
74	$987	20.4	$454	$28	$61	$24
75	$6,058	56.4	$3,071	$558	$253	$69
76	$4,774	41.7	$2,076	$28	$178	$56
77	$1,703	31.9	$878	$54	$69	$73
78	$1,634	43.9	$870	$85	$63	$13
79	$297	7.6	$56	$43	$19	$10
80	$39	0.3	$10	$0	$11	$1
81	$498	10.8	$183	$6	$37	$27
82	$759	9.0	$172	$15	$82	$53
83	$4,516	88.8	$1,392	$148	$414	$294
84	$1,612	20.7	$460	$387	$63	$102
85	$970	16.7	$254	$361	$11	$31
86	$1,736	29.8	$864	$36	$56	$21
87	$98	7.8	$98	$0	$0	$0
88	$17,592	252.9	$14,551	$0	$2,407	$0
Sum	$218,395	1,563.9	$59,066	$8,294	$30,303	$7,209

Table 14 Input-Output Accounts Data for Oklahoma[64]

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	$5,889	65.9	$306	$188	$1,016	$23
2	$699	15.8	$15	$153	$51	$0
3	$764	6.1	$63	$319	$25	$0
4	$2,198	2.0	$103	$6	$192	$5
5	$3,193	9.6	$348	$26	$83	$6
6	$1,397	4.4	$184	$13	$89	$8
7	$3,549	5.3	$254	$9	$109	$9
8	$109	0.1	$10	$0	$12	$28
9	$10	0.0	$0	$0	$3	$2
10	$368	1.8	$68	$5	$124	$5
11	$88	0.6	$23	$2	$13	$1
12	$30	0.1	$5	$1	$8	$1
13	$2	0.0	$0	$0	$1	$0
14	$121	0.3	$25	$6	$24	$9
15	$29,722	70.3	$2,916	$531	$7,916	$2,342
16	$17,751	1.4	$221	$340	$3,771	$95
17	$1,728	1.0	$92	$118	$795	$8
18	$951	1.0	$84	$36	$108	$12
19	$351	0.4	$33	$15	$62	$1
20	$795	0.6	$56	$21	$43	$9
21	$1,444	1.6	$102	$38	$140	$7
22	$3,616	10.2	$649	$1	$414	$69
23	$890	1.4	$65	$474	$133	$61
24	$199	1.4	$44	$3	$6	$1
25	$1,417	2.0	$153	$2	$147	$14
26	$298	0.8	$46	$0	$12	$2
27	$525	3.6	$130	$5	$15	$5
28	$352	2.7	$81	$0	$17	$5
29	$1,901	6.8	$379	$0	$179	$22
30	$2,995	4.7	$274	$0	$164	$25
31	$5,629	22.5	$1,262	$120	$472	$36
32	$11,341	27.5	$1,907	$562	$843	$105
33	$2,634	6.8	$462	$5	$186	$10
34	$3,193	6.2	$331	$0	$65	$16
35	$3,036	6.0	$466	$0	$212	$15
36	$311	1.5	$72	$29	$47	$1
37	$785	3.2	$122	$15	$60	$2

[64] Note: Monetary values are in millions of 2011 dollars and employment is thousands of full and part-time jobs. Source: 2011 IMPLAN Database.

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
38	$630	3.7	$138	$48	$56	$5
39	$0	0.0	$0	$0	$0	$0
40	$169	7.2	$96	$52	$0	$3
41	$9,655	32.1	$2,451	$43	$1,357	$176
42	$10,535	13.3	$1,387	$169	$2,340	$1,005
43	$11,862	122.8	$3,787	$1,374	$444	$106
44	$6	0.1	$2	$0	$0	$0
45	$9,641	62.3	$3,438	$393	$1,419	$1,399
46	$14,649	215.5	$5,270	$1,378	$1,785	$2,009
47	$2,623	7.9	$710	$0	$243	$237
48	$597	1.5	$136	$0	$103	$0
49	$7	0.0	$0	$0	$0	$0
50	$3,692	26.5	$978	$464	$269	$44
51	$338	3.2	$120	$23	$11	$3
52	$1,606	1.9	$197	$656	$0	$141
53	$395	2.0	$16	$290	$0	$19
54	$597	7.0	$519	$0	$0	$0
55	$611	6.2	$209	$1	$148	$12
56	$327	4.5	$155	$3	$43	$3
57	$1,249	6.6	$319	$1	$159	$7
58	$312	2.3	$39	$3	$34	$4
59	$686	3.1	$148	$328	$0	$7
60	$6,385	13.1	$830	$7	$1,833	$309
61	$445	2.0	$83	$5	$139	$5
62	$90	0.6	$28	$4	$6	$0
63	$9,859	35.8	$1,737	$290	$4,142	$143
64	$3,502	27.4	$422	$103	$19	$13
65	$5,080	29.7	$1,320	$194	$1,170	$151
66	$551	1.5	$31	$65	$127	$19
67	$20,583	56.7	$445	$274	$11,528	$1,906
68	$2,357	13.4	$553	$250	$318	$254
69	$1,646	0.6	$26	$0	$1,343	$30
70	$11,121	107.1	$4,353	$1,308	$1,719	$173
71	$3,222	16.8	$1,648	$11	$174	$79
72	$6,910	126.1	$3,327	$379	$756	$67
73	$652	3.5	$152	$20	$102	$20
74	$1,473	26.0	$681	$42	$109	$35
75	$8,465	84.2	$4,100	$1,079	$466	$95
76	$6,382	51.4	$2,911	$129	$256	$81
77	$1,909	35.1	$1,011	$45	$78	$82
78	$1,438	37.9	$683	$154	$59	$11
79	$493	12.5	$145	$50	$16	$20

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
80	$90	0.8	$23	$0	$25	$2
81	$963	16.4	$323	$7	$139	$102
82	$863	10.0	$203	$15	$92	$60
83	$7,196	131.9	$2,194	$430	$703	$499
84	$2,109	28.0	$675	$404	$91	$135
85	$1,537	24.0	$372	$579	$20	$50
86	$2,409	41.9	$1,253	$44	$88	$34
87	$138	10.6	$138	$0	$0	$0
88	$32,957	393.0	$26,917	$0	$4,634	$0
Sum	$321,293	2,163.0	$88,052	$14,157	$56,119	$12,520

Table 15 Input-Output Accounts Data for Kansas[65]

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	$9,026	28.8	$368	$95	$1,524	$15
2	$5,265	36.6	$98	$995	$553	$0
3	$2,241	7.8	$57	$678	$209	$0
4	$3,544	3.1	$192	$3	$358	$9
5	$5,595	18.4	$826	$11	$0	$11
6	$1,949	3.7	$178	$3	$158	$7
7	$4,806	7.2	$376	$6	$473	$11
8	$39	0.1	$3	$0	$1	$6
9	$0	0.0	$0	$0	$0	$0
10	$251	1.2	$50	$2	$86	$4
11	$71	0.4	$21	$1	$12	$1
12	$43	0.1	$9	$1	$12	$1
13	$0	0.0	$0	$0	$0	$0
14	$28	0.1	$7	$1	$6	$2
15	$6,761	24.8	$195	$96	$636	$188
16	$16,927	1.4	$255	$194	$3,102	$78
17	$1,092	0.7	$73	$46	$476	$5
18	$2,462	1.9	$165	$68	$145	$27
19	$1,706	2.0	$143	$68	$261	$6
20	$335	0.3	$22	$9	$17	$3
21	$2,462	2.6	$181	$75	$314	$11
22	$2,854	9.1	$506	$4	$322	$34
23	$68	0.2	$1	$66	$0	$2
24	$278	1.8	$65	$5	$12	$2

[65] Note: Monetary values are in millions of 2011 dollars and employment is thousands of full and part-time jobs. Source: 2011 IMPLAN Database.

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
25	$156	0.3	$21	$0	$15	$1
26	$682	1.8	$130	$1	$23	$6
27	$1,447	9.2	$436	$6	$49	$16
28	$485	3.1	$120	$1	$24	$4
29	$1,389	4.9	$275	$0	$128	$21
30	$1,487	2.7	$169	$1	$103	$12
31	$3,181	13.6	$682	$101	$235	$22
32	$7,370	17.1	$1,033	$224	$781	$42
33	$4,650	10.5	$750	$0	$366	$26
34	$6,637	6.9	$511	$0	$6	$1
35	$18,378	35.2	$3,089	$0	$1,072	$69
36	$396	2.2	$103	$44	$64	$2
37	$814	4.3	$206	$27	$75	$4
38	$705	3.4	$158	$68	$85	$12
39	$0	0.0	$0	$0	$0	$0
40	$286	8.1	$100	$181	$0	$6
41	$1,933	6.5	$302	$4	$221	$25
42	$7,421	9.5	$1,046	$20	$1,945	$815
43	$8,292	78.4	$2,890	$1,007	$397	$91
44	$18	0.2	$8	$0	$1	$0
45	$10,690	62.8	$3,974	$434	$1,644	$1,622
46	$11,285	180.7	$4,195	$828	$1,208	$1,514
47	$172	0.7	$25	$0	$9	$8
48	$1,944	4.9	$463	$0	$352	$0
49	$16	0.0	$0	$6	$5	$1
50	$3,199	23.0	$899	$342	$232	$38
51	$250	5.1	$107	$17	$21	$6
52	$352	0.8	$72	$2	$0	$14
53	$33	0.4	$16	$2	$0	$0
54	$604	7.5	$516	$0	$0	$0
55	$957	8.4	$328	$30	$249	$21
56	$700	8.5	$359	$0	$104	$7
57	$1,720	7.3	$350	$1	$276	$9
58	$236	2.2	$30	$2	$24	$3
59	$329	2.4	$112	$22	$0	$2
60	$9,811	16.9	$1,518	$2	$3,336	$563
61	$496	1.9	$108	$2	$175	$6
62	$82	0.6	$23	$6	$8	$0
63	$8,105	29.2	$1,568	$169	$3,325	$120
64	$3,906	28.5	$696	$96	$30	$19
65	$6,342	35.7	$1,920	$210	$1,481	$171
66	$767	3.1	$48	$0	$71	$11

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
67	$16,902	50.6	$417	$155	$9,370	$1,549
68	$938	6.6	$211	$218	$87	$90
69	$897	0.4	$13	$1	$698	$16
70	$10,234	96.1	$4,344	$1,196	$1,213	$142
71	$2,838	15.2	$1,419	$10	$150	$68
72	$5,527	94.9	$2,929	$310	$386	$60
73	$633	3.3	$154	$21	$104	$21
74	$1,397	25.2	$623	$44	$107	$32
75	$7,200	65.5	$3,452	$943	$423	$83
76	$5,654	45.4	$2,547	$154	$227	$72
77	$2,161	40.5	$1,161	$19	$88	$93
78	$1,448	40.7	$629	$197	$35	$10
79	$387	11.6	$49	$31	$17	$9
80	$58	0.6	$12	$0	$13	$1
81	$665	14.8	$245	$9	$59	$44
82	$733	8.4	$163	$29	$79	$52
83	$5,545	103.0	$1,633	$371	$532	$378
84	$2,036	22.7	$580	$581	$87	$143
85	$1,192	19.0	$317	$424	$19	$38
86	$1,994	35.5	$1,089	$21	$65	$31
87	$89	6.5	$89	$0	$0	$0
88	$24,706	314.0	$19,883	$0	$3,886	$0
Sum	$288,763	1,821.4	$75,109	$11,018	$44,463	$8,662

Table 16 Input-Output Accounts Data for Missouri[66]

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	$4,254	41.9	$227	$143	$814	$1
2	$2,305	42.8	$45	$339	$337	$0
3	$3,571	35.1	$102	$828	$596	$0
4	$4,849	3.8	$322	$44	$803	$16
5	$6,141	18.1	$728	$134	$179	$14
6	$2,811	6.4	$281	$49	$317	$13
7	$9,424	12.7	$687	$100	$534	$24
8	$4,481	3.7	$399	$2	$454	$1,355
9	$25	0.0	$1	$0	$11	$7
10	$713	2.9	$161	$4	$277	$11
11	$84	0.5	$28	$1	$15	$1

[66] Note: Monetary values are in millions of 2011 dollars and employment is thousands of full and part-time jobs. Source: 2011 IMPLAN Database.

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
12	$4	0.0	$1	$0	$1	$0
13	$852	0.9	$108	$11	$464	$54
14	$237	0.3	$80	$6	$67	$26
15	$791	3.4	$2	$4	$12	$3
16	$398	0.0	$3	$1	$22	$1
17	$1,640	1.2	$134	$25	$677	$6
18	$5,082	3.2	$316	$84	$331	$54
19	$4,058	4.6	$468	$150	$661	$15
20	$615	0.5	$34	$9	$24	$5
21	$9,512	9.1	$682	$178	$1,342	$40
22	$4,379	14.8	$817	$11	$556	$30
23	$769	4.6	$83	$15	$12	$4
24	$845	5.9	$208	$5	$27	$5
25	$901	1.5	$117	$11	$99	$8
26	$2,240	6.0	$396	$24	$98	$17
27	$2,098	13.4	$625	$13	$71	$23
28	$1,098	7.0	$239	$2	$52	$10
29	$2,112	7.4	$420	$0	$191	$29
30	$4,771	7.8	$512	$1	$302	$43
31	$6,801	25.7	$1,466	$119	$639	$47
32	$8,799	26.8	$1,537	$769	$602	$73
33	$6,421	16.3	$1,075	$15	$744	$24
34	$15,759	18.9	$1,535	$0	$171	$10
35	$8,777	16.6	$1,640	$0	$726	$51
36	$1,190	5.1	$275	$143	$216	$6
37	$1,584	7.7	$331	$217	$176	$9
38	$2,570	8.8	$527	$133	$429	$92
39	$0	0.0	$0	$0	$0	$0
40	$214	9.1	$128	$59	$0	$4
41	$120	0.4	$19	$0	$12	$1
42	$10,655	14.7	$1,563	$21	$2,786	$1,129
43	$18,495	171.0	$6,246	$2,611	$836	$192
44	$99	0.8	$45	$1	$4	$2
45	$20,911	122.5	$7,769	$851	$3,224	$3,180
46	$24,715	372.5	$9,208	$1,578	$3,242	$3,383
47	$1,330	4.3	$324	$0	$111	$108
48	$2,618	6.6	$628	$0	$477	$0
49	$214	0.4	$36	$0	$38	$6
50	$7,186	52.2	$1,947	$818	$516	$84
51	$1,039	14.9	$386	$73	$57	$16
52	$140	0.3	$31	$0	$0	$6
53	$748	8.9	$355	$13	$0	$25

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
54	$1,465	16.5	$1,288	$0	$0	$0
55	$1,554	14.0	$439	$141	$394	$33
56	$1,183	14.0	$598	$15	$176	$13
57	$4,401	16.7	$1,058	$2	$832	$28
58	$561	4.4	$78	$10	$68	$8
59	$2,450	6.7	$356	$1,892	$0	$36
60	$12,091	22.9	$1,684	$42	$3,774	$637
61	$4,530	10.5	$1,277	$9	$2,051	$67
62	$184	1.2	$53	$9	$25	$1
63	$16,771	63.2	$3,503	$193	$6,814	$251
64	$8,340	56.6	$1,996	$134	$81	$52
65	$12,624	62.5	$3,591	$563	$3,203	$413
66	$2,388	8.6	$195	$42	$341	$51
67	$37,514	121.7	$1,052	$428	$20,847	$3,453
68	$2,168	15.3	$502	$290	$238	$214
69	$1,839	0.8	$30	$1	$1,437	$32
70	$24,499	194.1	$10,374	$3,319	$3,646	$390
71	$12,186	62.1	$6,355	$4	$668	$305
72	$11,441	192.3	$5,149	$1,396	$1,122	$126
73	$1,304	6.7	$324	$43	$217	$43
74	$4,494	71.5	$2,200	$94	$207	$124
75	$13,984	127.0	$7,151	$1,475	$762	$163
76	$15,080	120.0	$7,140	$122	$613	$195
77	$3,886	73.5	$2,058	$53	$158	$166
78	$2,816	75.8	$1,331	$312	$98	$21
79	$1,645	28.1	$753	$253	$51	$104
80	$270	2.2	$68	$2	$76	$7
81	$2,868	39.2	$956	$13	$518	$383
82	$2,215	23.0	$613	$48	$263	$172
83	$12,174	227.8	$4,016	$383	$1,145	$813
84	$3,676	46.9	$1,186	$797	$131	$239
85	$2,953	43.5	$815	$953	$46	$98
86	$4,023	72.9	$2,368	$83	$116	$71
87	$198	14.8	$198	$0	$0	$0
88	$35,384	452.2	$28,881	$0	$4,863	$0
Sum	$486,606	3,473.2	$144,931	$22,731	$79,335	$18,973

Table 17 Input-Output Accounts Data for Texas[67]

[67] Note: Monetary values are in millions of 2011 dollars and employment is thousands of full and part-time jobs. Source: 2011 IMPLAN Database.

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	$16,585	155.9	$855	$379	$2,501	$65
2	$1,731	43.2	$42	$420	$80	$0
3	$5,843	43.9	$683	$2,420	$216	$0
4	$3,532	3.3	$150	$14	$202	$8
5	$14,018	42.9	$1,556	$164	$299	$28
6	$8,845	23.2	$1,010	$99	$875	$42
7	$21,886	32.2	$1,711	$150	$1,374	$68
8	$2,992	2.9	$238	$38	$291	$814
9	$143	0.1	$4	$0	$35	$23
10	$780	4.4	$176	$8	$214	$11
11	$671	4.2	$197	$16	$112	$10
12	$223	0.7	$45	$9	$63	$5
13	$200	0.4	$24	$9	$98	$8
14	$1,423	4.2	$283	$56	$262	$100
15	$135,902	240.1	$17,865	$2,417	$47,032	$13,915
16	$250,073	22.0	$4,581	$1,122	$40,852	$1,031
17	$4,389	3.2	$345	$76	$1,810	$15
18	$172,637	32.0	$4,409	$454	$13,795	$1,412
19	$9,936	9.8	$1,112	$121	$1,881	$38
20	$1,462	1.2	$80	$7	$50	$10
21	$31,454	30.4	$3,018	$287	$3,236	$223
22	$12,310	37.7	$2,142	$22	$1,580	$86
23	$1,427	8.0	$272	$37	$68	$26
24	$2,860	17.8	$720	$36	$111	$35
25	$3,026	4.4	$396	$94	$341	$37
26	$5,555	13.2	$826	$115	$462	$38
27	$4,914	32.0	$1,388	$60	$160	$51
28	$3,462	22.0	$693	$5	$150	$41
29	$8,651	31.9	$1,781	$0	$829	$111
30	$15,965	25.7	$1,806	$60	$513	$89
31	$31,363	119.0	$7,154	$1,534	$3,105	$247
32	$44,614	98.3	$8,591	$3,192	$3,405	$624
33	$97,007	113.2	$13,149	$130	$16,699	$666
34	$26,508	32.4	$2,166	$0	$686	$92
35	$27,307	55.1	$5,422	$0	$1,794	$142
36	$4,164	15.4	$765	$847	$927	$19
37	$6,107	28.3	$1,242	$409	$730	$29
38	$7,828	28.4	$1,640	$1,067	$1,095	$185
39	$0	0.0	$0	$0	$0	$0
40	$988	41.6	$672	$200	$0	$21
41	$54,529	150.3	$13,598	$175	$9,723	$1,093
42	$51,320	64.3	$6,879	$2,026	$15,292	$6,227

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
43	$108,353	937.8	$36,728	$17,213	$5,183	$1,189
44	$177	1.6	$69	$3	$6	$3
45	$109,492	550.3	$40,864	$6,911	$17,762	$17,518
46	$100,362	1,444.0	$38,246	$8,489	$10,867	$14,038
47	$20,744	63.2	$5,531	$1	$1,891	$1,846
48	$6,115	14.5	$1,586	$0	$1,206	$0
49	$2,793	5.2	$535	$8	$566	$84
50	$26,722	197.5	$6,885	$3,194	$1,875	$306
51	$3,408	40.0	$1,269	$415	$203	$55
52	$12,521	15.4	$2,489	$3,956	$0	$1,091
53	$1,984	26.4	$808	$54	$0	$57
54	$3,704	40.6	$3,283	$0	$0	$0
55	$5,247	56.2	$1,726	$9	$1,220	$102
56	$4,434	56.5	$2,122	$88	$632	$45
57	$14,883	48.1	$3,499	$15	$3,144	$101
58	$3,734	21.3	$618	$91	$641	$70
59	$4,927	22.0	$1,298	$1,445	$0	$46
60	$54,241	100.5	$7,718	$176	$17,266	$2,913
61	$10,408	31.2	$2,590	$92	$4,259	$139
62	$1,033	6.3	$348	$59	$99	$5
63	$78,325	276.2	$16,847	$4,962	$31,742	$1,318
64	$41,579	297.6	$7,760	$1,311	$339	$218
65	$46,898	229.9	$13,425	$1,776	$12,151	$1,613
66	$20,714	74.5	$2,016	$4	$2,983	$447
67	$175,652	495.0	$6,859	$1,896	$101,731	$16,914
68	$14,730	73.8	$3,214	$3,390	$1,851	$1,573
69	$17,175	4.2	$247	$59	$14,724	$331
70	$125,658	964.9	$55,551	$17,198	$17,142	$1,989
71	$21,040	117.2	$10,242	$67	$1,082	$494
72	$53,271	937.8	$26,911	$4,396	$4,315	$558
73	$6,409	29.7	$1,709	$294	$1,180	$234
74	$12,507	216.0	$6,332	$488	$848	$342
75	$65,644	706.0	$32,700	$8,239	$3,055	$744
76	$42,038	296.8	$18,233	$4,049	$1,836	$583
77	$10,352	183.7	$5,469	$372	$430	$452
78	$8,403	222.7	$3,753	$1,006	$450	$70
79	$5,387	105.0	$1,562	$922	$342	$253
80	$910	7.3	$235	$2	$260	$25
81	$6,272	117.4	$2,521	$133	$553	$406
82	$8,687	83.7	$2,341	$336	$1,141	$746
83	$52,891	936.9	$17,553	$2,329	$5,309	$3,772
84	$21,137	209.6	$6,420	$6,184	$1,094	$1,521

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
85	$13,051	172.9	$3,206	$5,254	$215	$453
86	$14,272	230.8	$7,818	$326	$853	$229
87	$1,229	101.2	$1,229	$0	$0	$0
88	$158,725	1,815.3	$130,302	$0	$22,940	$0
Sum	$2,612,868	14,223.9	$652,350	$125,485	$468,332	$102,578

Table 18 Input-Output Accounts Data for the Rest of the U.S.[68]

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	$16,585	155.9	$855	$379	$2,501	$65
2	$1,731	43.2	$42	$420	$80	$0
3	$5,843	43.9	$683	$2,420	$216	$0
4	$3,532	3.3	$150	$14	$202	$8
5	$14,018	42.9	$1,556	$164	$299	$28
6	$8,845	23.2	$1,010	$99	$875	$42
7	$21,886	32.2	$1,711	$150	$1,374	$68
8	$2,992	2.9	$238	$38	$291	$814
9	$143	0.1	$4	$0	$35	$23
10	$780	4.4	$176	$8	$214	$11
11	$671	4.2	$197	$16	$112	$10
12	$223	0.7	$45	$9	$63	$5
13	$200	0.4	$24	$9	$98	$8
14	$1,423	4.2	$283	$56	$262	$100
15	$135,902	240.1	$17,865	$2,417	$47,032	$13,915
16	$250,073	22.0	$4,581	$1,122	$40,852	$1,031
17	$4,389	3.2	$345	$76	$1,810	$15
18	$172,637	32.0	$4,409	$454	$13,795	$1,412
19	$9,936	9.8	$1,112	$121	$1,881	$38
20	$1,462	1.2	$80	$7	$50	$10
21	$31,454	30.4	$3,018	$287	$3,236	$223
22	$12,310	37.7	$2,142	$22	$1,580	$86
23	$1,427	8.0	$272	$37	$68	$26
24	$2,860	17.8	$720	$36	$111	$35
25	$3,026	4.4	$396	$94	$341	$37
26	$5,555	13.2	$826	$115	$462	$38
27	$4,914	32.0	$1,388	$60	$160	$51
28	$3,462	22.0	$693	$5	$150	$41
29	$8,651	31.9	$1,781	$0	$829	$111

[68] Note: Monetary values are in millions of 2011 dollars and employment is thousands of full and part-time jobs. Source: 2011 IMPLAN Database.

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
30	$15,965	25.7	$1,806	$60	$513	$89
31	$31,363	119.0	$7,154	$1,534	$3,105	$247
32	$44,614	98.3	$8,591	$3,192	$3,405	$624
33	$97,007	113.2	$13,149	$130	$16,699	$666
34	$26,508	32.4	$2,166	$0	$686	$92
35	$27,307	55.1	$5,422	$0	$1,794	$142
36	$4,164	15.4	$765	$847	$927	$19
37	$6,107	28.3	$1,242	$409	$730	$29
38	$7,828	28.4	$1,640	$1,067	$1,095	$185
39	$0	0.0	$0	$0	$0	$0
40	$988	41.6	$672	$200	$0	$21
41	$54,529	150.3	$13,598	$175	$9,723	$1,093
42	$51,320	64.3	$6,879	$2,026	$15,292	$6,227
43	$108,353	937.8	$36,728	$17,213	$5,183	$1,189
44	$177	1.6	$69	$3	$6	$3
45	$109,492	550.3	$40,864	$6,911	$17,762	$17,518
46	$100,362	1,444.0	$38,246	$8,489	$10,867	$14,038
47	$20,744	63.2	$5,531	$1	$1,891	$1,846
48	$6,115	14.5	$1,586	$0	$1,206	$0
49	$2,793	5.2	$535	$8	$566	$84
50	$26,722	197.5	$6,885	$3,194	$1,875	$306
51	$3,408	40.0	$1,269	$415	$203	$55
52	$12,521	15.4	$2,489	$3,956	$0	$1,091
53	$1,984	26.4	$808	$54	$0	$57
54	$3,704	40.6	$3,283	$0	$0	$0
55	$5,247	56.2	$1,726	$9	$1,220	$102
56	$4,434	56.5	$2,122	$88	$632	$45
57	$14,883	48.1	$3,499	$15	$3,144	$101
58	$3,734	21.3	$618	$91	$641	$70
59	$4,927	22.0	$1,298	$1,445	$0	$46
60	$54,241	100.5	$7,718	$176	$17,266	$2,913
61	$10,408	31.2	$2,590	$92	$4,259	$139
62	$1,033	6.3	$348	$59	$99	$5
63	$78,325	276.2	$16,847	$4,962	$31,742	$1,318
64	$41,579	297.6	$7,760	$1,311	$339	$218
65	$46,898	229.9	$13,425	$1,776	$12,151	$1,613
66	$20,714	74.5	$2,016	$4	$2,983	$447
67	$175,652	495.0	$6,859	$1,896	$101,731	$16,914
68	$14,730	73.8	$3,214	$3,390	$1,851	$1,573
69	$17,175	4.2	$247	$59	$14,724	$331
70	$125,658	964.9	$55,551	$17,198	$17,142	$1,989
71	$21,040	117.2	$10,242	$67	$1,082	$494

Code	Sales	Employment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
72	$53,271	937.8	$26,911	$4,396	$4,315	$558
73	$6,409	29.7	$1,709	$294	$1,180	$234
74	$12,507	216.0	$6,332	$488	$848	$342
75	$65,644	706.0	$32,700	$8,239	$3,055	$744
76	$42,038	296.8	$18,233	$4,049	$1,836	$583
77	$10,352	183.7	$5,469	$372	$430	$452
78	$8,403	222.7	$3,753	$1,006	$450	$70
79	$5,387	105.0	$1,562	$922	$342	$253
80	$910	7.3	$235	$2	$260	$25
81	$6,272	117.4	$2,521	$133	$553	$406
82	$8,687	83.7	$2,341	$336	$1,141	$746
83	$52,891	936.9	$17,553	$2,329	$5,309	$3,772
84	$21,137	209.6	$6,420	$6,184	$1,094	$1,521
85	$13,051	172.9	$3,206	$5,254	$215	$453
86	$14,272	230.8	$7,818	$326	$853	$229
87	$1,229	101.2	$1,229	$0	$0	$0
88	$158,725	1,815.3	$130,302	$0	$22,940	$0
Sum	$2,612,868	14,223.9	$652,350	$125,485	$468,332	$102,578

III.2.3 MKARNS Multiregional Social Accounting Matrix Multipliers

A multiregional social accounting matrix (MRSAM) analysis explicitly considers the both the relationships between industrial sectors and among regions of an economy and the interconnections between institutions (i.e., households and governments) and industries. The analysis examines how these relationships affect the process of changes throughout the entire economic system. Analogous to standard input-output (IO) analysis, MRSAM models start with a balancing equation between inputs and outputs. However, MRIO models take interregional trading patterns into account. Following the development of Miller and Blair (2009), one can write the MRSAM balancing equation between inputs and outputs (taking into account interregional trading patterns) as,

[1] $$X = TA\,X + Y$$

Given r to be the number of regions in the economic system and n to be the number of industrial sectors, X is an $rn \times 1$ vector of industrial output levels and institutional activities, T is an $rn \times rn$ matrix of multiregional trading patterns, A is an $rn \times rn$ matrix of regional SAM technical coefficients, and Y is an $rn \times 1$ vector of industrial and regional final demand purchases (Miller and Blair, 2009).[69]

[69] Multiregional transportation (T) and technological coefficients (A) are treated as a single factor (TA) for modeling convenience. They can be considered separately to be able to separate the effects due to changes in trading patterns from those related to changes in the technical production relationships. In

The works of analysts such as Isard (1951), Moses (1955), Leontief and Strout (1963), Polenske (1970) and others have been important in the historical development of MRIO theory and models. The conventional MRIO model assumes:

- Each industry in each region produces a single output;
- The regional input-output coefficients are fixed regardless of changes in output prices, input costs, tax structures, or shipping costs;
- Neither input cost nor output price will affect an industry's decision on output and input mixes or employment, income, and trade structures; and
- Trade coefficients remain fixed regardless of changes in shipping costs or in purchase prices of inputs in the regions.

The standard solution to the multiregional input-output model is derived by solving for output (X) in equation [1] in terms of final demand (Y) and assuming that the multiregional trading/commuting patterns and interindustry SAM technical coefficients are constant.

[2] $$X = (I - TA)^{-1}Y \quad \text{or} \quad \Delta X = (I - TA)^{-1}\Delta Y.$$

The $(I - TA)^{-1}$ matrix (called the Leontief multiregional inverse matrix) provides the direct, indirect, and induced requirements (if the households are "endogenized") that will occur if each of the industries experience a one dollar change in final demand. Column multipliers for each industrial sector are calculated by summing the elements of each of the columns of the $(I - TA)^{-1}$ matrix. However, multiregional SAM models have added features not available to their single-region counterparts. We derive interregional impacts or even interregional column multipliers from the MRIO models.

Table 19 Structure of Multiregional SAM Multipliers

Impacted Regions	Region A	Region B	Region C
Region A	Region A's Economic Impact on Region A	Region B's Economic Impact on Region A	Region C's Economic Impact on Region A
Region B	Region A's Economic Impact on Region B	Region B's Economic Impact on Region B	Region C's Economic Impact on Region B
Region C	Region A's Economic Impact on Region C	Region B's Economic Impact on Region C	Region C's Economic Impact on Region C
Region A	Region A's Impact on Region A's Employee Compensation	Region B's Impact on Region A's Employee Compensation	Region C's Impact on Region A's Employee Compensation
Region B	Region A's Impact on Region B's Proprietors' Income	Region B's Impact on Region B's Proprietors' Income	Region C's Impact on Region B's Proprietors' Income
Region C	Region A's Impact on Region C's Household Income	Region B's Impact on Region C's Household Income	Region C's Impact on Region C's Household Income

addition, commuting patterns are introduced to account for the locations where workers are employed and places were households spend their incomes.

Table 19 illustrates the types of column multipliers that MRSAM model can provided. By partitioning the multiregional Leontief inverse matrix according to its regional configuration (the hypothetical model in Table 19 has three regions). All we have to do is sum the columns of each partition sub-matrix. The interpretation is as follows the sub-matrix partition formed by the intersection of Regions ***A*** and ***B*** provide the interregional column multipliers that represent Region ***A***'s impact on Region ***B***.

Suppose we have compiled a multiregional SAM model for a two-region area (say the MKARNS region and the rest of the nation). Suppose further that each regional economy has three industrial sectors (resources, processing, and services). There are two institutions: labor and households. The multiplier matrix for the resulting MR SAM model is given the first ten (10) rows and ten (10) columns of Table 20. Let us look at a specific sector in region 1 to help interpret the meaning of the MR SAM multipliers. For example, if a dollar's worth of Processing Goods is purchased in Region 1 (second column) we see that Region 1's Resources sector will experience an increase in sales by \$0.13, Processing in Region 1 will increase by \$1.40, Processing in Region 2 will increase by \$0.39 (read down the second column). Workers residing in Region 1 and employed by Processing in Region 1 will get \$0.41. Workers residing in Region 2 and employed by Processing in Region 1 will get \$0.26. Household income in Region 1 will increase by \$0.32 and household income in Region 2 will increase by \$0.21.[70]

The last five (5) rows and ten (10) columns of Table 17 are the column multipliers (i.e., partial column sums) for the MR SAM model. Column multipliers have particular meanings that summarize the myriad of detailed impact estimates in the MR SAM multiplier matrix (even for our very simplified, two-region three-sector example). For example, a dollar purchase of Resources in Region 2 (4th column) will generate \$0.14 in regional economic activity in Region 1 (\$0.026 + \$0.059 + \$\$0.051) and \$2.44 in Region 2 (\$1.096 + \$0.404 + \$0.936). The total national level impact is \$2.57. Workers will be paid \$0.61 and households will earn \$0.49.

[70] Interpretation of other columns of Table 17 is analogous.

Table 20 Hypothetical Multiregional SAM Multipliers

Industry or Institution	Region 1 Resources	Region 1 Processing	Region 1 Services	Region 2 Resources	Region 2 Processing	Region 2 Services	Region 1: Labor	Region 2: Labor	Region 1: HH	Region 2: HH
Region 1: Resources	1.080	0.127	0.021	0.026	0.025	0.007	0.027	0.009	0.034	0.012
Region 1: Processing	0.252	1.403	0.181	0.059	0.086	0.040	0.233	0.051	0.291	0.063
Region1: Services	0.602	0.596	1.848	0.051	0.066	0.042	1.091	0.052	1.364	0.065
Region 2: Resources	0.035	0.055	0.015	1.096	0.084	0.018	0.020	0.023	0.025	0.029
Region 2: Processing	0.253	0.393	0.193	0.404	1.612	0.282	0.247	0.357	0.308	0.447
Region 2: Services	0.361	0.466	0.378	0.936	1.171	2.262	0.478	1.597	0.597	1.996
Region 1: Labor	0.396	0.407	0.692	0.030	0.039	0.022	1.426	0.027	0.533	0.034
Region 2: Labor	0.194	0.262	0.190	0.579	0.752	0.924	0.236	1.682	0.295	0.853
Reg 1: Households (HH)	0.317	0.326	0.554	0.024	0.031	0.018	1.141	0.022	1.426	0.027
Reg 2: Households (HH)	0.155	0.210	0.152	0.463	0.602	0.739	0.189	1.346	0.236	1.682
Column Multipliers										
Region 1: Industry Impact	1.934	2.126	2.050	0.136	0.177	0.089	1.351	0.112	1.688	0.140
Region 2: Industry Impact	0.649	0.914	0.587	2.437	2.866	2.562	0.744	1.978	0.930	2.472
Total Industry Impact	2.583	3.041	2.637	2.574	3.043	2.651	2.095	2.090	2.618	2.612
Labor Impact	0.590	0.669	0.882	0.609	0.791	0.946	1.662	1.710	0.828	0.887
Households (HH) Impact	0.472	0.536	0.706	0.488	0.633	0.757	1.330	1.368	1.662	1.710

The MKARNS MRSAM interregional industrial column multipliers are shown in Tables 21 through 26. The interregional industrial column multipliers indicate the effects that a one dollar purchase from a specific industry will have on the economies of each region in the multiregional system. Be assured that the multipliers provided below include the direct, indirect, and induced effects of changes in final demand. For the readers who are familiar with the usual presentation of economic multipliers may find the interpretation of the multipliers provided below a bit different. For example, look at Table 21—the multiregional SAM column multipliers for the State of Oklahoma. Suppose we examine the multipliers for sector 15 (Crude Petroleum). The last column of Table 22 indicates the total effect that a dollar's worth of final demand for crude petroleum produced in Oklahoma will have on the entire nation's economy (i.e., $2.68). Columns 3 through 8 indicate how that effect will be distributed among the regions of our model (region 1 is Arkansas, regional 2 is Oklahoma, and so on). Arkansas will get almost $0.02 of the $2.68 and Oklahoma will get $1.38. Note that Texas will experience $0.69 and the rest of the U.S. region will get $0.52.

Table 21 MRSAM Interregional Multipliers for Arkansas

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
1	Live animals and fish	2.134	0.042	0.053	0.358	0.164	0.972	3.724
2	Cereal grains	2.060	0.046	0.016	0.163	0.239	0.645	3.169
3	Other agricultural products	1.482	0.036	0.013	0.139	0.165	0.648	2.481
4	Animal feed	1.210	0.038	0.142	0.881	0.124	1.100	3.495
5	Meat, fish, seafood and preparations	2.010	0.133	0.036	0.220	0.270	1.410	4.080
6	Milled grains and bakery products	1.410	0.064	0.027	0.196	0.195	1.771	3.663
7	Other foodstuffs and fats and oils	1.642	0.057	0.033	0.176	0.302	1.596	3.806
8	Alcoholic beverages	1.454	0.028	0.010	0.096	0.184	0.513	2.285
9	Tobacco products	1.000	0.000	0.000	0.000	0.000	0.000	1.000
10	Monument and building stone	1.740	0.115	0.012	0.083	0.153	0.535	2.637
11	Natural sands, gravel and crushed stone	1.871	0.087	0.013	0.087	0.223	0.946	3.226
12	Nonmetallic minerals, n.e.c.	1.412	0.049	0.093	0.072	0.314	1.060	3.000
13	Metallic ores and concentrates	1.188	0.014	0.005	0.026	0.069	0.868	2.169
14	Coal	1.198	0.032	0.009	0.036	0.102	1.770	3.146
15	Crude petroleum	1.121	0.068	0.023	0.023	0.915	0.808	2.957
16	Gasoline, aviation turbine fuel and fuel oils	1.530	0.061	0.015	0.144	0.294	0.408	2.453
17	Coal and petroleum products, n.e.c.	1.305	0.049	0.029	0.036	0.304	0.851	2.574
18	Basic chemicals	1.230	0.066	0.027	0.061	0.564	1.563	3.511
19	Pharmaceuticals	1.154	0.016	0.010	0.078	0.105	1.564	2.927
20	Fertilizers	1.567	0.057	0.024	0.045	1.003	0.625	3.322
21	Chemical products and preparations, n.e.c.	1.365	0.213	0.028	0.146	0.378	1.313	3.443
22	Plastics and rubber products	1.436	0.073	0.024	0.104	0.338	1.426	3.402
23	Logs and wood in the rough	2.297	0.048	0.013	0.094	0.206	0.751	3.410
24	Wood products	1.887	0.105	0.027	0.135	0.235	0.967	3.356
25	Pulp, newsprint, paper and paperboard	1.412	0.155	0.015	0.052	0.231	1.295	3.160

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
26	Paper and paperboard articles	1.592	0.114	0.023	0.081	0.307	1.231	3.348
27	Printed products	1.482	0.046	0.061	0.136	0.346	1.355	3.425
28	Textiles and leather products	1.433	0.065	0.173	0.078	0.201	1.481	3.431
29	Nonmetalic mineral products	1.919	0.110	0.032	0.153	0.237	1.080	3.533
30	Primary and semifinished base metal forms and shapes	1.361	0.129	0.011	0.052	0.321	1.552	3.425
31	Base metal products	1.707	0.105	0.017	0.116	0.298	1.263	3.505
32	Machinery	1.733	0.068	0.018	0.090	0.255	1.240	3.405
33	Electronic and electrical equipment and components	1.519	0.053	0.021	0.088	0.219	1.468	3.366
34	Motorized vehicles (including parts)	1.198	0.071	0.024	0.052	1.153	1.076	3.575
35	Transport equipment	1.211	0.048	0.672	0.127	0.168	1.262	3.487
36	Precision instruments and apparatus	1.397	0.038	0.050	0.059	0.207	1.207	2.957
37	Furniture, fixtures, lamps and lighting equipment	1.507	0.056	0.024	0.082	0.286	1.496	3.451
38	Miscellaneous manufactured products	1.326	0.032	0.013	0.069	0.239	1.682	3.361
39	Waste and scrap	1.000	0.000	0.000	0.000	0.000	0.000	1.000
40	Support Activities for Agriculture and Forestry	1.831	0.065	0.023	0.119	0.303	1.125	3.465
41	Support Activities for Mining	1.602	0.427	0.018	0.070	0.379	0.759	3.255
42	Utilities	1.615	0.055	0.010	0.059	0.249	0.457	2.445
43	Contract Construction	2.142	0.068	0.017	0.113	0.260	0.961	3.560
44	Support activities for printing	1.407	0.039	0.023	0.110	0.242	1.785	3.605
45	Wholesale Trade	1.765	0.045	0.012	0.092	0.261	0.647	2.822
46	Retail stores	1.871	0.050	0.013	0.100	0.209	0.748	2.990
47	Air Transportation	1.413	0.161	0.011	0.051	0.642	0.569	2.848
48	Rail Transportation	1.865	0.045	0.049	0.308	0.193	0.851	3.312
49	Water Transportation	1.192	0.015	0.010	0.030	0.303	1.264	2.815
50	Truck Transportation	2.132	0.059	0.016	0.124	0.285	0.785	3.400
51	Transit and Ground Passenger Transportation	1.615	0.045	0.016	0.161	0.219	1.173	3.229
52	Pipeline Transportation	1.670	0.118	0.015	0.083	0.672	0.786	3.345
53	Scenic, Sightseeing and Transportation Support	1.686	0.048	0.016	0.100	0.219	1.574	3.642
54	Postal Service	2.037	0.062	0.017	0.135	0.280	0.946	3.478
55	Couriers and Messengers	1.627	0.042	0.012	0.097	0.169	0.891	2.838
56	Warehousing and Storage	1.895	0.048	0.015	0.117	0.236	0.879	3.191
57	Publishing Industries (except Internet)	1.278	0.041	0.023	0.092	0.224	1.729	3.388
58	Motion Picture and Sound Recording Industries	1.485	0.023	0.009	0.048	0.131	1.696	3.392
59	Broadcasting (except Internet)	1.588	0.044	0.016	0.170	0.169	1.984	3.971
60	Telecommunications	1.711	0.077	0.017	0.194	0.145	0.547	2.691
61	Data Processing, Hosting and Related Services	1.576	0.030	0.027	0.406	0.135	0.600	2.774
62	Other Information Services	1.526	0.038	0.011	0.062	0.157	1.581	3.375
63	Monetary Authorities and Credit Intermediation	1.696	0.033	0.008	0.064	0.146	0.714	2.660

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	1.851	0.030	0.010	0.071	0.150	1.547	3.658
65	Insurance Carriers and Related Activities	1.783	0.031	0.017	0.220	0.162	0.823	3.036
66	Funds, Trusts, and Other Financial Vehicles	1.761	0.023	0.015	0.154	1.003	0.923	3.880
67	Real Estate	1.458	0.014	0.004	0.031	0.140	0.336	1.984
68	Rental and Leasing Services	1.888	0.110	0.014	0.096	0.230	0.782	3.120
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	1.082	0.005	0.002	0.009	0.037	0.532	1.667
70	Professional, Scientific, and Technical Services	1.798	0.045	0.015	0.143	0.255	0.995	3.251
71	Management of Companies and Enterprises	1.954	0.047	0.015	0.127	0.217	1.089	3.449
72	Administrative and Support Services	1.931	0.062	0.015	0.116	0.292	0.975	3.392
73	Waste Management and Remediation Services	1.811	0.037	0.014	0.090	0.227	1.038	3.215
74	Educational Services	1.835	0.043	0.014	0.114	0.238	1.119	3.364
75	Ambulatory Health Care Services	2.015	0.060	0.016	0.118	0.279	0.975	3.462
76	Hospitals	2.082	0.048	0.015	0.119	0.222	1.006	3.492
77	Nursing and Residential Care Facilities	2.055	0.052	0.016	0.129	0.258	0.880	3.390
78	Social Assistance	2.145	0.054	0.016	0.117	0.253	0.927	3.511
79	Performing Arts, Spectator Sports, and Related Industries	1.672	0.033	0.015	0.148	0.197	1.559	3.624
80	Museums, Historical Sites, and Similar Institutions	1.513	0.027	0.009	0.063	0.141	0.987	2.741
81	Amusement, Gambling, and Recreation Industries	1.761	0.045	0.019	0.196	0.184	1.149	3.353
82	Accommodation	1.250	0.027	0.014	0.059	0.184	1.730	3.265
83	Food Services and Drinking Places	2.000	0.054	0.015	0.106	0.270	0.861	3.305
84	Repair and Maintenance	1.941	0.062	0.016	0.112	0.339	0.865	3.336
85	Personal and Laundry Services	1.955	0.060	0.016	0.119	0.273	1.123	3.546
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	1.963	0.048	0.017	0.167	0.286	1.126	3.608
87	Private Households	1.964	0.064	0.017	0.130	0.285	0.977	3.437
88	Public Institutions	1.859	0.055	0.015	0.111	0.245	0.837	3.121
89	Noncomparable imports and non-sector accounts	1.000	0.000	0.000	0.000	0.000	0.000	1.000

Table 22 MRSAM Multipliers for Oklahoma

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
1	Live animals and fish	0.046	1.916	0.160	0.104	0.227	0.956	3.408
2	Cereal grains	0.022	1.917	0.246	0.135	0.307	0.721	3.349
3	Other agricultural products	0.038	1.936	0.049	0.137	0.316	0.826	3.301
4	Animal feed	0.363	1.102	0.072	0.549	0.129	1.161	3.376
5	Meat, fish, seafood and preparations	0.129	1.837	0.112	0.100	0.589	1.304	4.071
6	Milled grains and bakery products	0.064	1.450	0.165	0.267	0.397	1.413	3.756
7	Other foodstuffs and fats and oils	0.089	1.750	0.181	0.113	0.540	1.340	4.014
8	Alcoholic beverages	0.032	1.814	0.035	0.070	0.206	0.619	2.776
9	Tobacco products	0.024	1.377	0.118	0.030	0.107	0.386	2.040
10	Monument and building stone	0.031	1.847	0.028	0.035	0.328	0.502	2.771
11	Natural sands, gravel and crushed stone	0.041	1.875	0.060	0.078	0.553	0.664	3.271
12	Nonmetallic minerals, n.e.c.	0.040	1.765	0.135	0.052	0.265	0.708	2.964
13	Metallic ores and concentrates	0.103	1.284	0.011	0.021	0.097	0.704	2.220
14	Coal	0.014	1.403	0.019	0.030	0.142	1.356	2.963
15	Crude petroleum	0.019	1.382	0.039	0.023	0.693	0.523	2.679
16	Gasoline, aviation turbine fuel and fuel oils	0.024	1.565	0.023	0.022	0.286	0.232	2.152
17	Coal and petroleum products, n.e.c.	0.017	1.312	0.024	0.020	0.228	0.591	2.193
18	Basic chemicals	0.028	1.641	0.089	0.037	0.468	0.904	3.166
19	Pharmaceuticals	0.016	1.414	0.016	0.039	0.211	1.075	2.771
20	Fertilizers	0.034	1.694	0.043	0.036	0.918	0.522	3.247
21	Chemical products and preparations, n.e.c.	0.035	1.733	0.050	0.094	0.504	1.003	3.420
22	Plastics and rubber products	0.028	1.519	0.045	0.066	0.482	1.193	3.333
23	Logs and wood in the rough	0.034	2.051	0.043	0.059	0.277	0.580	3.043
24	Wood products	0.092	2.110	0.060	0.076	0.342	0.940	3.619
25	Pulp, newsprint, paper and paperboard	0.073	1.347	0.026	0.030	0.318	1.391	3.185
26	Paper and paperboard articles	0.140	1.597	0.042	0.092	0.344	1.278	3.492
27	Printed products	0.104	1.613	0.057	0.074	0.313	1.262	3.424
28	Textiles and leather products	0.021	1.559	0.222	0.059	0.272	1.307	3.440
29	Nonmetalic mineral products	0.075	2.093	0.074	0.088	0.311	0.813	3.455
30	Primary and semifinished base metal forms and shapes	0.102	1.985	0.023	0.062	0.336	0.926	3.435
31	Base metal products	0.116	1.819	0.033	0.074	0.491	0.950	3.483
32	Machinery	0.041	1.922	0.033	0.057	0.394	0.955	3.403
33	Electronic and electrical equipment and components	0.043	1.465	0.062	0.059	0.360	1.397	3.384
34	Motorized vehicles (including parts)	0.031	1.585	0.050	0.158	0.363	1.234	3.422
35	Transport equipment	0.028	1.292	0.070	0.143	0.339	1.540	3.413
36	Precision instruments and apparatus	0.017	1.496	0.031	0.041	0.232	1.408	3.226
37	Furniture, fixtures, lamps and lighting equipment	0.082	1.699	0.039	0.091	0.307	1.347	3.564
38	Miscellaneous manufactured products	0.026	1.485	0.033	0.095	0.391	1.277	3.307

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
39	Waste and scrap	0.000	1.000	0.000	0.000	0.000	0.000	1.000
40	Support Activities for Agriculture and Forestry	0.037	1.905	0.060	0.072	0.383	1.007	3.465
41	Support Activities for Mining	0.085	1.929	0.071	0.051	0.452	0.641	3.229
42	Utilities	0.016	1.764	0.024	0.026	0.218	0.340	2.389
43	Contract Construction	0.043	2.207	0.042	0.059	0.469	0.697	3.517
44	Support activities for printing	0.030	1.401	0.046	0.091	0.324	1.754	3.646
45	Wholesale Trade	0.023	1.865	0.029	0.044	0.362	0.489	2.812
46	Retail stores	0.023	1.982	0.033	0.054	0.259	0.545	2.896
47	Air Transportation	0.018	1.778	0.023	0.032	0.499	0.412	2.762
48	Rail Transportation	0.052	1.834	0.114	0.098	0.298	0.854	3.250
49	Water Transportation	0.016	1.052	0.011	0.016	0.419	1.621	3.135
50	Truck Transportation	0.068	2.196	0.046	0.083	0.363	0.582	3.337
51	Transit and Ground Passenger Transportation	0.024	1.946	0.040	0.072	0.306	0.895	3.283
52	Pipeline Transportation	0.031	2.190	0.041	0.056	0.394	0.601	3.312
53	Scenic, Sightseeing and Transportation Support	0.032	2.140	0.049	0.073	0.338	0.932	3.563
54	Postal Service	0.031	2.200	0.072	0.072	0.345	0.692	3.412
55	Couriers and Messengers	0.023	1.796	0.035	0.053	0.231	0.653	2.791
56	Warehousing and Storage	0.085	1.829	0.080	0.108	0.260	0.824	3.186
57	Publishing Industries (except Internet)	0.024	1.392	0.045	0.071	0.310	1.515	3.357
58	Motion Picture and Sound Recording Industries	0.012	1.532	0.017	0.027	0.234	1.645	3.467
59	Broadcasting (except Internet)	0.026	2.044	0.041	0.062	0.328	1.384	3.885
60	Telecommunications	0.016	1.985	0.021	0.031	0.305	0.453	2.812
61	Data Processing, Hosting and Related Services	0.024	1.646	0.027	0.051	0.558	0.471	2.778
62	Other Information Services	0.020	1.695	0.027	0.042	0.472	1.176	3.431
63	Monetary Authorities and Credit Intermediation	0.015	1.874	0.020	0.030	0.236	0.424	2.598
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.017	2.129	0.023	0.035	0.280	1.189	3.673
65	Insurance Carriers and Related Activities	0.021	1.941	0.053	0.052	0.247	0.679	2.994
66	Funds, Trusts, and Other Financial Vehicles	0.013	1.593	0.020	0.027	1.041	0.681	3.376
67	Real Estate	0.008	1.510	0.010	0.014	0.175	0.214	1.931
68	Rental and Leasing Services	0.036	2.043	0.031	0.047	0.340	0.564	3.061
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.002	1.082	0.002	0.004	0.128	0.189	1.407
70	Professional, Scientific, and Technical Services	0.026	1.926	0.037	0.061	0.351	0.743	3.144
71	Management of Companies and Enterprises	0.172	2.007	0.037	0.099	0.280	0.824	3.420
72	Administrative and Support Services	0.030	2.123	0.043	0.058	0.340	0.665	3.259
73	Waste Management and Remediation Services	0.045	2.023	0.044	0.052	0.266	0.766	3.197

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
74	Educational Services	0.028	2.004	0.045	0.080	0.265	0.877	3.299
75	Ambulatory Health Care Services	0.033	2.173	0.047	0.063	0.352	0.713	3.380
76	Hospitals	0.038	2.234	0.052	0.135	0.295	0.669	3.423
77	Nursing and Residential Care Facilities	0.035	2.152	0.081	0.070	0.336	0.661	3.335
78	Social Assistance	0.045	2.211	0.089	0.080	0.309	0.742	3.476
79	Performing Arts, Spectator Sports, and Related Industries	0.022	1.891	0.033	0.071	0.307	1.317	3.642
80	Museums, Historical Sites, and Similar Institutions	0.015	1.737	0.038	0.042	0.169	0.758	2.760
81	Amusement, Gambling, and Recreation Industries	0.030	1.899	0.045	0.104	0.233	0.681	2.993
82	Accommodation	0.017	1.301	0.024	0.046	0.208	1.654	3.251
83	Food Services and Drinking Places	0.035	2.173	0.045	0.061	0.315	0.622	3.251
84	Repair and Maintenance	0.030	2.077	0.046	0.064	0.381	0.671	3.270
85	Personal and Laundry Services	0.032	2.193	0.049	0.066	0.383	0.798	3.520
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.029	2.211	0.038	0.060	0.298	0.896	3.532
87	Private Households	0.032	2.135	0.050	0.075	0.357	0.723	3.373
88	Public Institutions	0.028	2.005	0.042	0.063	0.306	0.616	3.060
89	Noncomparable imports and non-sector accounts	0.000	1.000	0.000	0.000	0.000	0.000	1.000

Table 23 MRSAM Interregional Multipliers for Kansas

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
1	Live animals and fish	0.010	0.120	2.025	0.139	0.182	0.953	3.429
2	Cereal grains	0.009	0.069	2.181	0.161	0.179	0.685	3.284
3	Other agricultural products	0.017	0.080	1.453	0.133	0.937	0.655	3.275
4	Animal feed	0.026	0.030	1.128	0.054	0.108	1.349	2.695
5	Meat, fish, seafood and preparations	0.087	0.135	1.334	0.203	0.209	2.076	4.045
6	Milled grains and bakery products	0.028	0.049	1.516	0.277	0.160	1.638	3.669
7	Other foodstuffs and fats and oils	0.021	0.042	1.606	0.216	0.249	1.504	3.637
8	Alcoholic beverages	0.010	0.035	1.868	0.154	0.204	0.780	3.052
9	Tobacco products	0.000	0.000	1.000	0.000	0.000	0.000	1.000
10	Monument and building stone	0.010	0.047	1.909	0.191	0.092	0.520	2.769
11	Natural sands, gravel and crushed stone	0.023	0.085	1.757	0.426	0.141	0.821	3.253
12	Nonmetallic minerals, n.e.c.	0.014	0.190	1.598	0.177	0.137	0.802	2.917
13	Metallic ores and concentrates	0.000	0.000	1.000	0.000	0.000	0.000	1.000
14	Coal	0.007	0.051	1.356	0.095	0.077	1.321	2.905
15	Crude petroleum	0.015	0.136	1.247	0.044	0.819	1.023	3.285
16	Gasoline, aviation turbine fuel and fuel oils	0.006	0.058	1.558	0.073	0.277	0.368	2.341
17	Coal and petroleum products, n.e.c.	0.009	0.059	1.372	0.069	0.229	0.540	2.278
18	Basic chemicals	0.029	0.073	1.749	0.135	0.278	1.171	3.435
19	Pharmaceuticals	0.010	0.129	1.342	0.231	0.096	1.042	2.850
20	Fertilizers	0.019	0.331	1.347	0.065	0.763	0.741	3.265

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
21	Chemical products and preparations, n.e.c.	0.019	0.048	1.454	0.184	0.378	1.321	3.404
22	Plastics and rubber products	0.018	0.072	1.480	0.160	0.282	1.407	3.419
23	Logs and wood in the rough	0.011	0.060	2.108	0.299	0.162	0.951	3.590
24	Wood products	0.030	0.115	1.966	0.305	0.193	1.032	3.641
25	Pulp, newsprint, paper and paperboard	0.037	0.099	1.226	0.101	0.127	1.738	3.327
26	Paper and paperboard articles	0.044	0.058	1.591	0.314	0.171	1.355	3.534
27	Printed products	0.014	0.041	1.899	0.214	0.149	1.122	3.439
28	Textiles and leather products	0.014	0.033	1.877	0.159	0.150	1.211	3.444
29	Nonmetalic mineral products	0.017	0.066	1.740	0.383	0.217	1.049	3.472
30	Primary and semifinished base metal forms and shapes	0.031	0.256	1.161	0.269	0.218	1.347	3.281
31	Base metal products	0.023	0.107	1.608	0.260	0.271	1.248	3.516
32	Machinery	0.015	0.054	1.706	0.207	0.149	1.183	3.313
33	Electronic and electrical equipment and components	0.017	0.031	1.528	0.145	0.184	1.444	3.349
34	Motorized vehicles (including parts)	0.010	0.058	1.423	0.153	0.115	1.525	3.284
35	Transport equipment	0.035	0.043	1.395	0.127	0.182	1.670	3.451
36	Precision instruments and apparatus	0.017	0.030	1.555	0.161	0.140	1.308	3.210
37	Furniture, fixtures, lamps and lighting equipment	0.016	0.038	1.481	0.218	0.130	1.582	3.464
38	Miscellaneous manufactured products	0.016	0.034	1.474	0.206	0.224	1.386	3.339
39	Waste and scrap	0.000	0.000	1.000	0.000	0.000	0.000	1.000
40	Support Activities for Agriculture and Forestry	0.014	0.055	1.949	0.267	0.177	1.091	3.553
41	Support Activities for Mining	0.019	0.331	1.658	0.127	0.366	0.862	3.363
42	Utilities	0.006	0.060	1.666	0.109	0.141	0.438	2.420
43	Contract Construction	0.013	0.054	2.107	0.250	0.173	0.914	3.511
44	Support activities for printing	0.014	0.035	1.536	0.207	0.170	1.594	3.555
45	Wholesale Trade	0.007	0.033	1.816	0.180	0.175	0.596	2.807
46	Retail stores	0.008	0.038	1.961	0.211	0.098	0.666	2.982
47	Air Transportation	0.009	0.230	1.265	0.134	0.571	0.706	2.914
48	Rail Transportation	0.010	0.045	1.833	0.254	0.119	1.002	3.263
49	Water Transportation	0.007	0.021	1.424	0.122	0.124	0.858	2.556
50	Truck Transportation	0.025	0.080	2.055	0.307	0.160	0.756	3.383
51	Transit and Ground Passenger Transportation	0.009	0.042	1.818	0.339	0.123	0.914	3.245
52	Pipeline Transportation	0.016	0.374	1.693	0.182	0.463	0.648	3.375
53	Scenic, Sightseeing and Transportation Support	0.011	0.052	1.744	0.460	0.115	1.233	3.616
54	Postal Service	0.010	0.049	2.132	0.302	0.136	0.851	3.479
55	Couriers and Messengers	0.007	0.038	1.818	0.182	0.110	0.638	2.794
56	Warehousing and Storage	0.014	0.040	1.893	0.287	0.106	0.827	3.168
57	Publishing Industries (except Internet)	0.010	0.032	1.344	0.160	0.161	1.585	3.292
58	Motion Picture and Sound Recording Industries	0.006	0.017	1.449	0.098	0.082	1.888	3.541

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
59	Broadcasting (except Internet)	0.008	0.024	1.506	0.270	0.088	2.089	3.985
60	Telecommunications	0.005	0.042	1.776	0.148	0.083	0.575	2.630
61	Data Processing, Hosting and Related Services	0.007	0.026	1.637	0.380	0.077	0.552	2.679
62	Other Information Services	0.007	0.029	1.675	0.161	0.102	1.389	3.362
63	Monetary Authorities and Credit Intermediation	0.006	0.035	1.801	0.195	0.079	0.538	2.653
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.007	0.031	2.222	0.229	0.089	1.108	3.685
65	Insurance Carriers and Related Activities	0.006	0.028	1.929	0.200	0.078	0.767	3.008
66	Funds, Trusts, and Other Financial Vehicles	0.007	0.023	1.954	0.547	0.203	1.258	3.992
67	Real Estate	0.003	0.012	1.469	0.068	0.044	0.363	1.958
68	Rental and Leasing Services	0.011	0.146	1.865	0.203	0.180	0.848	3.254
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.001	0.004	1.106	0.030	0.025	0.340	1.506
70	Professional, Scientific, and Technical Services	0.009	0.039	1.901	0.273	0.112	0.946	3.280
71	Management of Companies and Enterprises	0.030	0.036	1.926	0.320	0.108	1.055	3.474
72	Administrative and Support Services	0.010	0.089	2.049	0.280	0.134	0.837	3.398
73	Waste Management and Remediation Services	0.009	0.048	1.911	0.215	0.101	0.913	3.196
74	Educational Services	0.009	0.037	2.018	0.246	0.108	0.925	3.342
75	Ambulatory Health Care Services	0.010	0.050	2.121	0.251	0.127	0.864	3.422
76	Hospitals	0.011	0.045	2.222	0.278	0.117	0.800	3.473
77	Nursing and Residential Care Facilities	0.010	0.044	2.166	0.250	0.119	0.796	3.385
78	Social Assistance	0.010	0.048	2.245	0.275	0.125	0.872	3.575
79	Performing Arts, Spectator Sports, and Related Industries	0.008	0.025	1.748	0.312	0.094	1.591	3.778
80	Museums, Historical Sites, and Similar Institutions	0.006	0.023	1.690	0.283	0.070	0.878	2.951
81	Amusement, Gambling, and Recreation Industries	0.010	0.038	1.888	0.392	0.100	0.852	3.280
82	Accommodation	0.011	0.024	1.293	0.106	0.144	1.682	3.260
83	Food Services and Drinking Places	0.012	0.046	2.094	0.220	0.127	0.783	3.281
84	Repair and Maintenance	0.010	0.058	2.003	0.235	0.172	0.817	3.295
85	Personal and Laundry Services	0.011	0.059	2.085	0.284	0.139	0.957	3.535
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.009	0.048	2.112	0.270	0.116	1.026	3.581
87	Private Households	0.011	0.049	2.060	0.293	0.136	0.895	3.444
88	Public Institutions	0.009	0.041	1.920	0.243	0.116	0.749	3.078
89	Noncomparable imports and non-sector accounts	0.000	0.000	1.000	0.000	0.000	0.000	1.000

Table 24 MRSAM Interregional Multipliers of Missouri

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
1	Live animals and fish	0.029	0.054	0.078	2.301	0.122	0.684	3.269
2	Cereal grains	0.017	0.035	0.092	2.187	0.142	0.719	3.192
3	Other agricultural products	0.023	0.089	0.070	1.464	0.715	0.641	3.001
4	Animal feed	0.037	0.200	0.097	1.219	0.105	0.998	2.656
5	Meat, fish, seafood and preparations	0.128	0.041	0.099	1.639	0.188	1.892	3.987
6	Milled grains and bakery products	0.057	0.037	0.148	1.642	0.107	1.590	3.581
7	Other foodstuffs and fats and oils	0.047	0.047	0.143	1.709	0.162	1.747	3.855
8	Alcoholic beverages	0.015	0.017	0.064	1.723	0.078	0.815	2.712
9	Tobacco products	0.005	0.008	0.049	1.278	0.032	0.315	1.687
10	Monument and building stone	0.029	0.038	0.082	1.803	0.149	0.510	2.612
11	Natural sands, gravel and crushed stone	0.017	0.043	0.166	2.130	0.097	0.741	3.194
12	Nonmetallic minerals, n.e.c.	0.036	0.100	0.285	1.616	0.101	0.701	2.840
13	Metallic ores and concentrates	0.008	0.012	0.035	1.490	0.034	0.381	1.960
14	Coal	0.009	0.011	0.051	1.449	0.055	1.004	2.580
15	Crude petroleum	0.022	0.039	0.139	2.431	0.108	0.894	3.632
16	Gasoline, aviation turbine fuel and fuel oils	0.009	0.025	0.058	1.823	0.075	0.621	2.613
17	Coal and petroleum products, n.e.c.	0.010	0.048	0.112	1.434	0.138	0.644	2.386
18	Basic chemicals	0.016	0.033	0.099	1.546	0.351	1.450	3.494
19	Pharmaceuticals	0.008	0.009	0.039	1.336	0.080	1.307	2.778
20	Fertilizers	0.032	0.080	0.034	1.390	0.986	0.788	3.312
21	Chemical products and preparations, n.e.c.	0.018	0.087	0.185	1.659	0.197	1.220	3.367
22	Plastics and rubber products	0.027	0.038	0.121	1.568	0.220	1.442	3.417
23	Logs and wood in the rough	0.024	0.017	0.079	1.946	0.085	1.301	3.452
24	Wood products	0.093	0.078	0.161	1.946	0.137	1.219	3.635
25	Pulp, newsprint, paper and paperboard	0.049	0.051	0.063	1.570	0.162	1.336	3.231
26	Paper and paperboard articles	0.041	0.081	0.133	1.737	0.135	1.360	3.486
27	Printed products	0.018	0.027	0.206	1.693	0.104	1.367	3.415
28	Textiles and leather products	0.026	0.026	0.477	1.489	0.133	1.326	3.478
29	Nonmetalic mineral products	0.025	0.052	0.135	2.169	0.136	0.969	3.486
30	Primary and semifinished base metal forms and shapes	0.023	0.045	0.034	1.425	0.107	1.603	3.236
31	Base metal products	0.047	0.037	0.089	1.799	0.137	1.331	3.439
32	Machinery	0.020	0.030	0.098	1.999	0.104	1.139	3.390
33	Electronic and electrical equipment and components	0.022	0.026	0.109	1.562	0.114	1.411	3.243
34	Motorized vehicles (including parts)	0.018	0.018	0.058	1.498	0.123	1.659	3.375
35	Transport equipment	0.035	0.036	0.078	1.745	0.172	1.308	3.373
36	Precision instruments and apparatus	0.012	0.018	0.092	1.549	0.108	1.369	3.149
37	Furniture, fixtures, lamps and lighting equipment	0.027	0.031	0.148	1.820	0.116	1.251	3.393
38	Miscellaneous manufactured products	0.019	0.021	0.075	1.622	0.127	1.303	3.166

39	Waste and scrap	0.000	0.000	0.000	1.000	0.000	0.000	1.000
40	Support Activities for Agriculture and Forestry	0.028	0.033	0.131	2.003	0.154	1.131	3.480
41	Support Activities for Mining	0.030	0.258	0.169	1.676	0.277	1.069	3.479
42	Utilities	0.013	0.030	0.094	1.809	0.073	0.446	2.465
43	Contract Construction	0.026	0.032	0.132	2.342	0.104	0.883	3.519
44	Support activities for printing	0.020	0.021	0.100	1.689	0.134	1.569	3.534
45	Wholesale Trade	0.015	0.017	0.113	1.944	0.104	0.599	2.792
46	Retail stores	0.015	0.017	0.096	2.044	0.070	0.649	2.891
47	Air Transportation	0.017	0.144	0.056	1.627	0.313	0.696	2.853
48	Rail Transportation	0.019	0.026	0.293	2.034	0.095	0.818	3.283
49	Water Transportation	0.014	0.009	0.040	1.446	0.094	1.156	2.760
50	Truck Transportation	0.050	0.026	0.152	2.302	0.097	0.806	3.433
51	Transit and Ground Passenger Transportation	0.016	0.022	0.113	2.223	0.091	0.894	3.358
52	Pipeline Transportation	0.041	0.149	0.162	1.494	0.602	0.911	3.358
53	Scenic, Sightseeing and Transportation Support	0.017	0.021	0.101	2.064	0.087	1.259	3.548
54	Postal Service	0.020	0.024	0.130	2.310	0.099	0.878	3.461
55	Couriers and Messengers	0.013	0.019	0.166	1.907	0.076	0.680	2.861
56	Warehousing and Storage	0.021	0.021	0.152	2.067	0.080	0.813	3.153
57	Publishing Industries (except Internet)	0.015	0.020	0.084	1.479	0.123	1.474	3.194
58	Motion Picture and Sound Recording Industries	0.009	0.011	0.049	1.576	0.066	1.723	3.433
59	Broadcasting (except Internet)	0.020	0.024	0.129	2.477	0.102	1.063	3.815
60	Telecommunications	0.013	0.029	0.179	1.923	0.072	0.505	2.721
61	Data Processing, Hosting and Related Services	0.011	0.013	0.069	1.767	0.049	0.454	2.363
62	Other Information Services	0.012	0.015	0.080	1.814	0.077	1.242	3.240
63	Monetary Authorities and Credit Intermediation	0.010	0.012	0.071	1.958	0.063	0.526	2.640
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.013	0.017	0.111	2.406	0.075	1.010	3.631
65	Insurance Carriers and Related Activities	0.013	0.014	0.108	2.069	0.061	0.641	2.907
66	Funds, Trusts, and Other Financial Vehicles	0.013	0.013	0.079	2.236	0.394	1.020	3.755
67	Real Estate	0.005	0.006	0.036	1.566	0.036	0.297	1.946
68	Rental and Leasing Services	0.035	0.047	0.108	2.097	0.134	0.760	3.181
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.002	0.003	0.014	1.230	0.015	0.232	1.496
70	Professional, Scientific, and Technical Services	0.016	0.020	0.110	2.086	0.081	0.857	3.170
71	Management of Companies and Enterprises	0.045	0.021	0.111	2.344	0.087	0.824	3.433
72	Administrative and Support Services	0.019	0.024	0.124	2.226	0.098	0.827	3.319
73	Waste Management and Remediation Services	0.026	0.020	0.150	2.089	0.077	0.822	3.184
74	Educational Services	0.017	0.020	0.117	2.220	0.084	0.911	3.370

75	Ambulatory Health Care Services	0.021	0.025	0.126	2.251	0.094	0.882	3.399
76	Hospitals	0.018	0.021	0.109	2.381	0.088	0.826	3.444
77	Nursing and Residential Care Facilities	0.019	0.021	0.114	2.313	0.087	0.813	3.366
78	Social Assistance	0.023	0.022	0.122	2.362	0.091	0.894	3.513
79	Performing Arts, Spectator Sports, and Related Industries	0.018	0.019	0.107	2.140	0.084	1.114	3.482
80	Museums, Historical Sites, and Similar Institutions	0.011	0.012	0.066	1.913	0.054	0.711	2.767
81	Amusement, Gambling, and Recreation Industries	0.018	0.018	0.095	1.994	0.065	0.649	2.839
82	Accommodation	0.014	0.017	0.050	1.393	0.126	1.583	3.182
83	Food Services and Drinking Places	0.023	0.022	0.103	2.264	0.085	0.773	3.270
84	Repair and Maintenance	0.021	0.024	0.124	2.170	0.112	0.852	3.302
85	Personal and Laundry Services	0.025	0.025	0.134	2.316	0.096	0.926	3.522
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.019	0.024	0.126	2.236	0.090	1.038	3.533
87	Private Households	0.021	0.024	0.135	2.218	0.102	0.917	3.417
88	Public Institutions	0.018	0.021	0.115	2.084	0.088	0.783	3.109
89	Noncomparable imports and non-sector accounts	0.000	0.000	0.000	1.000	0.000	0.000	1.000

Table 25 MRSAM Interregional Multipliers for Texas

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
1	Live animals and fish	0.019	0.091	0.111	0.029	2.332	0.930	3.512
2	Cereal grains	0.019	0.055	0.121	0.082	2.297	0.847	3.420
3	Other agricultural products	0.017	0.021	0.019	0.016	2.435	0.699	3.208
4	Animal feed	0.009	0.007	0.013	0.035	1.137	2.367	3.569
5	Meat, fish, seafood and preparations	0.061	0.083	0.061	0.042	2.439	1.368	4.054
6	Milled grains and bakery products	0.037	0.027	0.042	0.049	2.198	1.292	3.645
7	Other foodstuffs and fats and oils	0.025	0.034	0.038	0.042	2.350	1.372	3.862
8	Alcoholic beverages	0.012	0.019	0.011	0.020	2.029	0.714	2.804
9	Tobacco products	0.009	0.032	0.006	0.012	1.943	0.560	2.563
10	Monument and building stone	0.014	0.033	0.007	0.011	2.372	0.525	2.962
11	Natural sands, gravel and crushed stone	0.021	0.039	0.012	0.061	2.484	0.626	3.244
12	Nonmetallic minerals, n.e.c.	0.031	0.056	0.025	0.014	1.852	0.904	2.882
13	Metallic ores and concentrates	0.060	0.010	0.004	0.009	1.337	0.729	2.149
14	Coal	0.009	0.015	0.007	0.011	2.022	0.989	3.053
15	Crude petroleum	0.007	0.023	0.009	0.008	1.923	0.448	2.418
16	Gasoline, aviation turbine fuel and fuel oils	0.005	0.013	0.004	0.004	1.888	0.232	2.146
17	Coal and petroleum products, n.e.c.	0.010	0.030	0.007	0.007	1.714	0.538	2.306
18	Basic chemicals	0.010	0.017	0.010	0.015	2.699	0.741	3.492
19	Pharmaceuticals	0.008	0.062	0.008	0.014	1.608	1.021	2.721
20	Fertilizers	0.032	0.139	0.015	0.017	2.471	0.632	3.305
21	Chemical products and preparations, n.e.c.	0.029	0.066	0.023	0.033	2.149	1.137	3.437

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
22	Plastics and rubber products	0.018	0.035	0.019	0.026	2.261	1.109	3.468
23	Logs and wood in the rough	0.010	0.032	0.012	0.014	2.224	1.065	3.357
24	Wood products	0.054	0.030	0.013	0.026	2.410	1.050	3.582
25	Pulp, newsprint, paper and paperboard	0.026	0.070	0.013	0.022	1.841	1.300	3.272
26	Paper and paperboard articles	0.031	0.098	0.015	0.066	2.045	1.142	3.397
27	Printed products	0.015	0.029	0.022	0.060	2.100	1.216	3.442
28	Textiles and leather products	0.019	0.022	0.033	0.034	1.896	1.512	3.516
29	Nonmetalic mineral products	0.029	0.049	0.018	0.030	2.518	0.842	3.486
30	Primary and semifinished base metal forms and shapes	0.053	0.085	0.009	0.026	1.906	1.353	3.432
31	Base metal products	0.036	0.046	0.011	0.025	2.286	1.047	3.451
32	Machinery	0.019	0.039	0.012	0.020	2.373	0.952	3.416
33	Electronic and electrical equipment and components	0.015	0.020	0.016	0.025	1.682	1.331	3.090
34	Motorized vehicles (including parts)	0.013	0.029	0.020	0.067	2.137	1.085	3.350
35	Transport equipment	0.087	0.022	0.186	0.051	1.649	1.457	3.452
36	Precision instruments and apparatus	0.009	0.017	0.013	0.015	1.834	1.166	3.055
37	Furniture, fixtures, lamps and lighting equipment	0.019	0.024	0.011	0.022	2.200	1.129	3.405
38	Miscellaneous manufactured products	0.017	0.030	0.011	0.035	2.043	1.085	3.221
39	Waste and scrap	0.000	0.000	0.000	0.000	1.000	0.000	1.000
40	Support Activities for Agriculture and Forestry	0.018	0.034	0.022	0.021	2.390	1.018	3.505
41	Support Activities for Mining	0.015	0.046	0.012	0.013	2.434	0.635	3.156
42	Utilities	0.007	0.037	0.011	0.007	1.878	0.367	2.308
43	Contract Construction	0.014	0.022	0.010	0.015	2.691	0.759	3.512
44	Support activities for printing	0.018	0.022	0.021	0.044	1.991	1.516	3.613
45	Wholesale Trade	0.009	0.015	0.007	0.010	2.223	0.503	2.767
46	Retail stores	0.010	0.017	0.008	0.011	2.350	0.568	2.964
47	Air Transportation	0.008	0.015	0.007	0.008	2.318	0.435	2.791
48	Rail Transportation	0.018	0.021	0.020	0.018	2.375	0.746	3.199
49	Water Transportation	0.009	0.011	0.009	0.010	1.929	0.756	2.725
50	Truck Transportation	0.015	0.022	0.009	0.014	2.717	0.594	3.371
51	Transit and Ground Passenger Transportation	0.011	0.020	0.009	0.014	2.520	0.694	3.267
52	Pipeline Transportation	0.011	0.023	0.009	0.012	2.644	0.604	3.302
53	Scenic, Sightseeing and Transportation Support	0.011	0.028	0.010	0.015	2.152	1.386	3.601
54	Postal Service	0.014	0.025	0.014	0.016	2.638	0.794	3.501
55	Couriers and Messengers	0.012	0.016	0.007	0.012	2.165	0.638	2.850
56	Warehousing and Storage	0.017	0.023	0.011	0.016	2.461	0.679	3.206
57	Publishing Industries (except Internet)	0.012	0.019	0.016	0.028	1.872	1.185	3.131
58	Motion Picture and Sound Recording Industries	0.007	0.010	0.006	0.011	1.946	1.270	3.251
59	Broadcasting (except Internet)	0.011	0.018	0.009	0.015	2.469	1.423	3.946

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
60	Telecommunications	0.007	0.011	0.005	0.008	2.238	0.432	2.701
61	Data Processing, Hosting and Related Services	0.007	0.011	0.005	0.008	2.065	0.412	2.508
62	Other Information Services	0.009	0.014	0.008	0.014	2.129	1.204	3.379
63	Monetary Authorities and Credit Intermediation	0.007	0.011	0.005	0.008	2.175	0.432	2.637
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.008	0.014	0.007	0.011	2.694	0.945	3.679
65	Insurance Carriers and Related Activities	0.008	0.014	0.007	0.009	2.330	0.541	2.909
66	Funds, Trusts, and Other Financial Vehicles	0.008	0.012	0.006	0.009	3.047	0.706	3.788
67	Real Estate	0.003	0.006	0.002	0.004	1.651	0.201	1.867
68	Rental and Leasing Services	0.011	0.017	0.008	0.012	2.481	0.594	3.123
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.001	0.001	0.001	0.001	1.132	0.168	1.305
70	Professional, Scientific, and Technical Services	0.011	0.018	0.009	0.013	2.432	0.745	3.227
71	Management of Companies and Enterprises	0.018	0.017	0.009	0.025	2.306	1.119	3.494
72	Administrative and Support Services	0.012	0.024	0.009	0.014	2.614	0.702	3.375
73	Waste Management and Remediation Services	0.014	0.017	0.008	0.012	2.467	0.595	3.112
74	Educational Services	0.014	0.022	0.009	0.015	2.440	0.845	3.345
75	Ambulatory Health Care Services	0.013	0.022	0.010	0.014	2.654	0.744	3.455
76	Hospitals	0.012	0.022	0.010	0.014	2.618	0.784	3.460
77	Nursing and Residential Care Facilities	0.016	0.021	0.016	0.020	2.440	0.871	3.384
78	Social Assistance	0.019	0.022	0.016	0.018	2.515	0.914	3.503
79	Performing Arts, Spectator Sports, and Related Industries	0.011	0.018	0.009	0.013	2.442	1.044	3.536
80	Museums, Historical Sites, and Similar Institutions	0.007	0.012	0.006	0.009	2.113	0.616	2.762
81	Amusement, Gambling, and Recreation Industries	0.011	0.020	0.009	0.014	2.333	0.893	3.280
82	Accommodation	0.012	0.016	0.012	0.026	1.615	1.461	3.142
83	Food Services and Drinking Places	0.012	0.020	0.011	0.015	2.553	0.644	3.255
84	Repair and Maintenance	0.012	0.021	0.010	0.015	2.529	0.684	3.270
85	Personal and Laundry Services	0.013	0.022	0.010	0.015	2.744	0.731	3.534
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.025	0.026	0.009	0.014	2.548	0.894	3.517
87	Private Households	0.014	0.023	0.011	0.016	2.638	0.786	3.489
88	Public Institutions	0.012	0.020	0.010	0.013	2.421	0.666	3.141
89	Noncomparable imports and non-sector accounts	0.000	0.000	0.000	0.000	1.000	0.000	1.000

Table 26 MRSAM Interregional Multipliers for the Rest of the U.S.

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
1	Live animals and fish	0.006	0.006	0.023	0.027	0.050	3.089	3.201
2	Cereal grains	0.010	0.008	0.012	0.038	0.073	3.026	3.166
3	Other agricultural products	0.008	0.005	0.019	0.016	0.063	2.667	2.779
4	Animal feed	0.009	0.009	0.027	0.044	0.063	3.323	3.475
5	Meat, fish, seafood and preparations	0.033	0.014	0.026	0.035	0.111	3.643	3.862
6	Milled grains and bakery products	0.016	0.009	0.021	0.043	0.082	3.423	3.594
7	Other foodstuffs and fats and oils	0.012	0.009	0.018	0.032	0.095	3.508	3.672
8	Alcoholic beverages	0.006	0.005	0.008	0.019	0.053	2.714	2.805
9	Tobacco products	0.003	0.003	0.003	0.007	0.032	1.827	1.875
10	Monument and building stone	0.005	0.010	0.005	0.011	0.074	2.617	2.721
11	Natural sands, gravel and crushed stone	0.006	0.008	0.009	0.051	0.072	3.015	3.160
12	Nonmetallic minerals, n.e.c.	0.006	0.010	0.034	0.014	0.064	2.690	2.818
13	Metallic ores and concentrates	0.011	0.004	0.003	0.007	0.034	2.153	2.212
14	Coal	0.005	0.005	0.006	0.012	0.051	2.888	2.967
15	Crude petroleum	0.006	0.014	0.011	0.009	0.225	2.330	2.595
16	Gasoline, aviation turbine fuel and fuel oils	0.003	0.006	0.004	0.005	0.088	2.078	2.184
17	Coal and petroleum products, n.e.c.	0.011	0.031	0.011	0.010	0.196	2.055	2.314
18	Basic chemicals	0.011	0.011	0.014	0.029	0.418	2.947	3.430
19	Pharmaceuticals	0.004	0.004	0.005	0.013	0.062	2.613	2.701
20	Fertilizers	0.010	0.041	0.012	0.018	0.201	2.992	3.273
21	Chemical products and preparations, n.e.c.	0.016	0.019	0.020	0.053	0.209	3.092	3.410
22	Plastics and rubber products	0.013	0.017	0.015	0.036	0.199	3.124	3.405
23	Logs and wood in the rough	0.009	0.008	0.038	0.017	0.058	3.226	3.356
24	Wood products	0.018	0.007	0.014	0.022	0.075	3.401	3.537
25	Pulp, newsprint, paper and paperboard	0.023	0.014	0.009	0.022	0.096	3.024	3.189
26	Paper and paperboard articles	0.018	0.021	0.014	0.042	0.098	3.182	3.375
27	Printed products	0.010	0.010	0.020	0.044	0.094	3.218	3.396
28	Textiles and leather products	0.012	0.010	0.025	0.029	0.126	3.327	3.528
29	Nonmetalic mineral products	0.012	0.012	0.012	0.027	0.087	3.260	3.410
30	Primary and semifinished base metal forms and shapes	0.024	0.014	0.007	0.025	0.089	3.176	3.334
31	Base metal products	0.014	0.013	0.009	0.024	0.104	3.266	3.431
32	Machinery	0.009	0.011	0.011	0.022	0.088	3.157	3.298
33	Electronic and electrical equipment and components	0.009	0.010	0.015	0.023	0.119	2.944	3.120
34	Motorized vehicles (including parts)	0.009	0.012	0.020	0.035	0.105	3.169	3.350
35	Transport equipment	0.033	0.013	0.069	0.084	0.139	3.060	3.399
36	Precision instruments and apparatus	0.009	0.008	0.011	0.018	0.078	2.929	3.052
37	Furniture, fixtures, lamps and lighting equipment	0.013	0.009	0.011	0.025	0.112	3.210	3.379
38	Miscellaneous manufactured products	0.010	0.009	0.010	0.040	0.133	3.154	3.356

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
39	Waste and scrap	0.000	0.000	0.000	0.000	0.000	1.000	1.000
40	Support Activities for Agriculture and Forestry	0.009	0.010	0.013	0.021	0.092	3.293	3.439
41	Support Activities for Mining	0.008	0.013	0.010	0.015	0.111	3.081	3.238
42	Utilities	0.004	0.005	0.005	0.010	0.064	2.273	2.361
43	Contract Construction	0.007	0.006	0.008	0.017	0.072	3.337	3.446
44	Support activities for printing	0.010	0.008	0.014	0.035	0.098	3.375	3.540
45	Wholesale Trade	0.004	0.004	0.005	0.012	0.049	2.677	2.751
46	Retail stores	0.005	0.004	0.006	0.012	0.049	2.796	2.872
47	Air Transportation	0.004	0.007	0.005	0.010	0.090	2.664	2.779
48	Rail Transportation	0.010	0.006	0.023	0.037	0.071	3.054	3.201
49	Water Transportation	0.005	0.003	0.006	0.011	0.048	2.639	2.713
50	Truck Transportation	0.011	0.007	0.008	0.021	0.079	3.197	3.325
51	Transit and Ground Passenger Transportation	0.005	0.005	0.007	0.015	0.069	3.147	3.248
52	Pipeline Transportation	0.011	0.023	0.009	0.014	0.305	2.930	3.292
53	Scenic, Sightseeing and Transportation Support	0.005	0.005	0.007	0.015	0.062	3.388	3.483
54	Postal Service	0.006	0.005	0.008	0.018	0.064	3.337	3.438
55	Couriers and Messengers	0.004	0.004	0.005	0.012	0.049	2.680	2.754
56	Warehousing and Storage	0.005	0.004	0.007	0.014	0.054	3.040	3.124
57	Publishing Industries (except Internet)	0.006	0.006	0.010	0.021	0.071	2.939	3.052
58	Motion Picture and Sound Recording Industries	0.004	0.003	0.005	0.011	0.043	2.882	2.948
59	Broadcasting (except Internet)	0.006	0.005	0.008	0.016	0.063	3.689	3.787
60	Telecommunications	0.004	0.003	0.010	0.013	0.052	2.566	2.649
61	Data Processing, Hosting and Related Services	0.003	0.003	0.006	0.020	0.056	2.424	2.512
62	Other Information Services	0.005	0.005	0.007	0.015	0.058	3.257	3.347
63	Monetary Authorities and Credit Intermediation	0.003	0.003	0.004	0.009	0.039	2.506	2.564
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.004	0.004	0.006	0.013	0.053	3.470	3.551
65	Insurance Carriers and Related Activities	0.003	0.003	0.006	0.011	0.038	2.723	2.785
66	Funds, Trusts, and Other Financial Vehicles	0.004	0.004	0.005	0.011	0.113	3.409	3.546
67	Real Estate	0.001	0.001	0.002	0.004	0.019	1.858	1.886
68	Rental and Leasing Services	0.006	0.004	0.006	0.014	0.065	2.981	3.076
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.001	0.001	0.001	0.002	0.009	1.446	1.460
70	Professional, Scientific, and Technical Services	0.005	0.004	0.006	0.013	0.054	3.071	3.153
71	Management of Companies and Enterprises	0.005	0.005	0.007	0.020	0.057	3.303	3.397
72	Administrative and Support Services	0.005	0.005	0.008	0.015	0.066	3.152	3.251
73	Waste Management and Remediation Services	0.005	0.004	0.006	0.012	0.051	2.988	3.066

Code	Industry	AR	OK	KS	MO	TX	RUS	Total
74	Educational Services	0.005	0.005	0.007	0.015	0.057	3.242	3.330
75	Ambulatory Health Care Services	0.005	0.005	0.007	0.014	0.063	3.270	3.365
76	Hospitals	0.005	0.005	0.007	0.016	0.059	3.310	3.403
77	Nursing and Residential Care Facilities	0.005	0.005	0.007	0.015	0.058	3.226	3.315
78	Social Assistance	0.006	0.005	0.007	0.015	0.060	3.372	3.466
79	Performing Arts, Spectator Sports, and Related Industries	0.005	0.004	0.006	0.015	0.052	3.206	3.288
80	Museums, Historical Sites, and Similar Institutions	0.003	0.003	0.004	0.010	0.037	2.639	2.696
81	Amusement, Gambling, and Recreation Industries	0.005	0.004	0.006	0.014	0.048	2.959	3.035
82	Accommodation	0.008	0.009	0.010	0.025	0.101	2.928	3.081
83	Food Services and Drinking Places	0.006	0.005	0.007	0.015	0.061	3.113	3.207
84	Repair and Maintenance	0.006	0.005	0.008	0.016	0.076	3.143	3.254
85	Personal and Laundry Services	0.006	0.006	0.008	0.017	0.067	3.380	3.483
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.005	0.004	0.008	0.015	0.055	3.303	3.391
87	Private Households	0.006	0.005	0.008	0.016	0.065	3.314	3.415
88	Public Institutions	0.005	0.005	0.007	0.014	0.057	3.010	3.097
89	Noncomparable imports and non-sector accounts	0.000	0.000	0.000	0.000	0.000	1.000	1.000

Multiregional SAM models also provide additional types of multipliers not given by standard input-output models. For example, Tables 27, 28, and 29 show the MKARNS MRSAM employee compensation, proprietors' income, and household income multipliers (respectively) for each region. Shown below, we find that crude petroleum (Industry 15) workers in Oklahoma are compensated by $0.51, proprietors will get almost $0.11, and households will have $0.56 to spend—however, the tables does not indicate where the workers, proprietors, or households reside. However, the location of these workers, proprietors, and households are given in the detailed multipliers of the MKARNS MRSAM multiplier matrix.

Table 27 MKARNS MRSAM Employee Compensation Multipliers

Code	Industry	AR	OK	KS	MO	TX	RUS
1	Live animals & fish	0.567	0.495	0.461	0.480	0.527	0.515
2	Cereal grains	0.477	0.516	0.487	0.478	0.554	0.513
3	Other agricultural products	0.442	0.687	0.560	0.502	0.761	0.689
4	Animal feed	0.568	0.552	0.486	0.479	0.584	0.585
5	Meat, fish, seafood & preparations	0.737	0.706	0.721	0.722	0.709	0.717
6	Milled grains & bakery products	0.689	0.771	0.699	0.700	0.736	0.729
7	Other foodstuffs and fats & oils	0.694	0.717	0.651	0.675	0.701	0.691
8	Alcoholic beverages	0.364	0.519	0.571	0.503	0.518	0.541
9	Tobacco products	0.000	0.262	0.000	0.202	0.350	0.239
10	Monument & building stone	0.628	0.633	0.655	0.644	0.735	0.698
11	Natural sands, gravel & crushed	0.884	0.837	0.870	0.889	0.870	0.894

Code	Industry	AR	OK	KS	MO	TX	RUS
	stone						
12	Nonmetallic minerals, n.e.c.	0.708	0.667	0.688	0.697	0.687	0.713
13	Metallic ores & concentrates	0.431	0.400	0.000	0.368	0.405	0.436
14	Coal	0.752	0.715	0.738	0.752	0.727	0.754
15	Crude petroleum	0.555	0.508	0.588	0.637	0.484	0.473
16	Gasoline, aviation turbine fuel & fuel oils	0.278	0.233	0.261	0.297	0.242	0.240
17	Coal & petroleum products, n.e.c.	0.346	0.274	0.298	0.336	0.320	0.318
18	Basic chemicals	0.553	0.563	0.555	0.539	0.424	0.526
19	Pharmaceuticals	0.613	0.569	0.579	0.596	0.572	0.595
20	Fertilizers	0.557	0.554	0.557	0.554	0.549	0.574
21	Chemical products & preparations, n.e.c.	0.611	0.565	0.572	0.573	0.577	0.603
22	Plastics & rubber products	0.695	0.671	0.693	0.705	0.662	0.716
23	Logs & wood in the rough	0.778	0.573	0.670	0.700	0.798	0.808
24	Wood products	0.768	0.847	0.879	0.900	0.902	0.910
25	Pulp, newsprint, paper & paperboard	0.639	0.628	0.689	0.656	0.674	0.664
26	Paper & paperboard articles	0.671	0.731	0.792	0.768	0.708	0.730
27	Printed products	0.900	0.850	0.914	0.911	0.900	0.926
28	Textiles & leather products	0.827	0.843	0.847	0.821	0.802	0.816
29	Nonmetalic mineral products	0.820	0.802	0.820	0.827	0.832	0.852
30	Primary & semifinished base metal forms & shapes	0.682	0.655	0.660	0.642	0.687	0.690
31	Base metal products	0.816	0.824	0.830	0.813	0.834	0.854
32	Machinery	0.740	0.754	0.706	0.767	0.797	0.779
33	Electronic & electrical equipment & components	0.758	0.783	0.765	0.729	0.674	0.721
34	Motorized vehicles (including parts)	0.720	0.670	0.590	0.641	0.608	0.674
35	Transport equipment	0.760	0.761	0.779	0.778	0.806	0.829
36	Precision instruments & apparatus	0.756	0.799	0.824	0.786	0.714	0.802
37	Furniture, fixtures, lamps & lighting equipment	0.772	0.775	0.873	0.811	0.799	0.825
38	Miscellaneous manufactured products	0.779	0.776	0.793	0.738	0.764	0.888
39	Waste & scrap	0.000	0.000	0.000	0.000	0.000	0.000
40	Support Activities for Agriculture and Forestry	1.246	1.079	0.934	1.122	1.196	1.257
41	Support Activities for Mining	0.787	0.798	0.731	0.785	0.785	0.822
42	Utilities	0.473	0.451	0.475	0.495	0.459	0.490
43	Contract Construction	0.932	0.939	0.979	0.975	0.981	0.995
44	Support activities for printing	1.083	1.018	1.128	1.134	1.096	1.135
45	Wholesale Trade	0.860	0.836	0.858	0.855	0.851	0.875
46	Retail stores	0.889	0.848	0.893	0.872	0.903	0.906
47	Air Transportation	0.622	0.658	0.560	0.658	0.677	0.665
48	Rail Transportation	0.782	0.771	0.795	0.800	0.807	0.809
49	Water Transportation	0.642	0.588	0.425	0.648	0.657	0.645
50	Truck Transportation	0.909	0.842	0.881	0.878	0.860	0.884

Code	Industry	AR	OK	KS	MO	TX	RUS
51	Transit and Ground Passenger Transportation	0.939	0.867	0.970	0.917	0.911	0.920
52	Pipeline Transportation	0.691	0.673	0.743	0.758	0.759	0.712
53	Scenic, Sightseeing and Transportation Support	1.065	0.714	1.189	1.168	1.128	1.188
54	Postal Service	1.422	1.405	1.418	1.443	1.463	1.466
55	Couriers and Messengers	0.785	0.771	0.783	0.738	0.784	0.797
56	Warehousing and Storage	1.074	1.050	1.089	1.081	1.070	1.100
57	Publishing Industries (except Internet)	0.906	0.912	0.852	0.856	0.839	0.847
58	Motion Picture and Sound Recording Industries	0.811	0.791	0.822	0.804	0.777	0.822
59	Broadcasting (except Internet)	1.015	0.914	1.077	0.842	0.995	0.964
60	Telecommunications	0.558	0.573	0.569	0.570	0.576	0.577
61	Data Processing, Hosting and Related Services	0.658	0.646	0.656	0.639	0.649	0.654
62	Other Information Services	0.925	0.965	0.920	0.895	0.979	1.144
63	Monetary Authorities and Credit Intermediation	0.609	0.573	0.621	0.644	0.645	0.672
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.895	0.801	0.879	0.934	0.893	1.051
65	Insurance Carriers and Related Activities	0.807	0.784	0.848	0.799	0.803	0.806
66	Funds, Trusts, and Other Financial Vehicles	0.787	0.633	0.829	0.799	0.788	0.841
67	Real Estate	0.265	0.249	0.268	0.268	0.261	0.271
68	Rental and Leasing Services	0.684	0.781	0.821	0.821	0.789	0.798
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.196	0.123	0.151	0.147	0.096	0.146
70	Professional, Scientific, and Technical Services	0.991	0.949	1.024	0.994	1.033	1.032
71	Management of Companies and Enterprises	1.177	1.146	1.164	1.174	1.167	1.211
72	Administrative and Support Services	1.068	1.062	1.147	1.052	1.127	1.095
73	Waste Management and Remediation Services	0.812	0.801	0.821	0.822	0.827	0.837
74	Educational Services	1.055	1.037	1.040	1.090	1.110	1.151
75	Ambulatory Health Care Services	1.153	1.102	1.120	1.151	1.154	1.145
76	Hospitals	1.064	1.061	1.080	1.100	1.069	1.131
77	Nursing and Residential Care Facilities	1.123	1.118	1.151	1.141	1.151	1.179
78	Social Assistance	1.172	1.097	1.096	1.125	1.102	1.175
79	Performing Arts, Spectator Sports, and Related Industries	0.900	0.999	0.893	1.102	0.973	0.932
80	Museums, Historical Sites, and Similar Institutions	0.712	0.698	0.709	0.709	0.720	0.722
81	Amusement, Gambling, and Recreation Industries	0.990	0.858	0.968	0.827	1.013	0.956
82	Accommodation	0.857	0.860	0.852	0.883	0.864	0.887
83	Food Services and Drinking Places	0.871	0.850	0.856	0.892	0.895	0.919
84	Repair and Maintenance	0.882	0.893	0.874	0.917	0.894	0.938

Code	Industry	AR	OK	KS	MO	TX	RUS
85	Personal and Laundry Services	0.921	0.888	0.927	0.940	0.913	0.949
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	1.149	1.133	1.183	1.212	1.173	1.130
87	Private Households	1.634	1.609	1.638	1.639	1.658	1.661
88	Public Institutions	1.372	1.337	1.340	1.365	1.381	1.397
89	Noncomparable imports and non-sector accounts	0.000	0.000	0.000	0.000	0.000	0.000

Table 28 MKARNS MRSAM Proprietors' Income Multipliers

Code	Industry	AR	OK	KS	MO	TX	RUS
1	Live animals & fish	0.086	0.202	0.173	0.158	0.211	0.167
2	Cereal grains	0.060	0.345	0.316	0.253	0.374	0.265
3	Other agricultural products	0.070	0.712	0.500	0.420	0.760	0.544
4	Animal feed	0.122	0.111	0.089	0.101	0.142	0.133
5	Meat, fish, seafood & preparations	0.103	0.162	0.151	0.159	0.173	0.141
6	Milled grains & bakery products	0.142	0.162	0.170	0.153	0.191	0.158
7	Other foodstuffs and fats & oils	0.150	0.198	0.178	0.179	0.189	0.161
8	Alcoholic beverages	0.041	0.097	0.127	0.076	0.112	0.105
9	Tobacco products	0.000	0.047	0.000	0.028	0.075	0.042
10	Monument & building stone	0.045	0.107	0.090	0.079	0.114	0.096
11	Natural sands, gravel & crushed stone	0.066	0.133	0.117	0.107	0.139	0.127
12	Nonmetallic minerals, n.e.c.	0.076	0.133	0.113	0.098	0.134	0.101
13	Metallic ores & concentrates	0.040	0.086	0.000	0.055	0.095	0.062
14	Coal	0.090	0.140	0.119	0.097	0.143	0.108
15	Crude petroleum	0.101	0.107	0.135	0.134	0.096	0.158
16	Gasoline, aviation turbine fuel & fuel oils	0.046	0.069	0.065	0.066	0.054	0.068
17	Coal & petroleum products, n.e.c.	0.049	0.115	0.090	0.065	0.068	0.068
18	Basic chemicals	0.091	0.132	0.125	0.111	0.087	0.096
19	Pharmaceuticals	0.085	0.130	0.129	0.120	0.097	0.093
20	Fertilizers	0.081	0.129	0.127	0.115	0.109	0.100
21	Chemical products & preparations, n.e.c.	0.084	0.123	0.122	0.110	0.101	0.099
22	Plastics & rubber products	0.077	0.096	0.096	0.093	0.095	0.092
23	Logs & wood in the rough	0.065	0.644	0.971	0.160	0.182	0.212
24	Wood products	0.089	0.193	0.208	0.141	0.151	0.157
25	Pulp, newsprint, paper & paperboard	0.083	0.103	0.106	0.105	0.141	0.114
26	Paper & paperboard articles	0.074	0.101	0.103	0.110	0.126	0.119
27	Printed products	0.090	0.118	0.112	0.113	0.132	0.115
28	Textiles & leather products	0.085	0.110	0.108	0.106	0.116	0.116
29	Nonmetalic mineral products	0.076	0.114	0.110	0.109	0.123	0.106
30	Primary & semifinished base metal forms & shapes	0.084	0.098	0.091	0.086	0.106	0.093
31	Base metal products	0.079	0.127	0.138	0.117	0.164	0.122
32	Machinery	0.074	0.153	0.124	0.187	0.187	0.157

Code	Industry	AR	OK	KS	MO	TX	RUS
33	Electronic & electrical equipment & components	0.076	0.101	0.097	0.092	0.090	0.086
34	Motorized vehicles (including parts)	0.099	0.094	0.074	0.080	0.086	0.083
35	Transport equipment	0.088	0.094	0.092	0.090	0.097	0.095
36	Precision instruments & apparatus	0.077	0.199	0.214	0.219	0.307	0.186
37	Furniture, fixtures, lamps & lighting equipment	0.082	0.127	0.147	0.241	0.181	0.140
38	Miscellaneous manufactured products	0.090	0.180	0.198	0.142	0.242	0.160
39	Waste & scrap	0.000	0.000	0.000	0.000	0.000	0.000
40	Support Activities for Agriculture and Forestry	0.087	0.382	0.652	0.349	0.305	0.273
41	Support Activities for Mining	0.083	0.113	0.116	0.124	0.118	0.115
42	Utilities	0.044	0.099	0.069	0.069	0.116	0.086
43	Contract Construction	0.075	0.246	0.245	0.259	0.295	0.255
44	Support activities for printing	0.109	0.143	0.130	0.129	0.151	0.133
45	Wholesale Trade	0.055	0.134	0.128	0.128	0.160	0.122
46	Retail stores	0.060	0.190	0.168	0.155	0.193	0.151
47	Air Transportation	0.068	0.094	0.088	0.082	0.083	0.079
48	Rail Transportation	0.075	0.124	0.121	0.116	0.128	0.117
49	Water Transportation	0.070	0.102	0.416	0.076	0.082	0.098
50	Truck Transportation	0.064	0.240	0.213	0.222	0.236	0.202
51	Transit and Ground Passenger Transportation	0.081	0.173	0.169	0.172	0.235	0.172
52	Pipeline Transportation	0.098	0.506	0.120	0.117	0.426	0.431
53	Scenic, Sightseeing and Transportation Support	0.097	0.836	0.180	0.139	0.160	0.201
54	Postal Service	0.071	0.121	0.119	0.114	0.136	0.114
55	Couriers and Messengers	0.057	0.089	0.111	0.172	0.090	0.093
56	Warehousing and Storage	0.064	0.111	0.100	0.111	0.136	0.105
57	Publishing Industries (except Internet)	0.105	0.119	0.117	0.109	0.117	0.104
58	Motion Picture and Sound Recording Industries	0.106	0.146	0.147	0.151	0.152	0.133
59	Broadcasting (except Internet)	0.205	0.582	0.297	0.775	0.465	0.581
60	Telecommunications	0.055	0.100	0.080	0.100	0.102	0.093
61	Data Processing, Hosting and Related Services	0.064	0.106	0.089	0.071	0.093	0.084
62	Other Information Services	0.090	0.161	0.185	0.155	0.178	0.135
63	Monetary Authorities and Credit Intermediation	0.050	0.109	0.098	0.087	0.154	0.106
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.093	0.163	0.150	0.142	0.176	0.167
65	Insurance Carriers and Related Activities	0.062	0.134	0.125	0.134	0.137	0.105
66	Funds, Trusts, and Other Financial Vehicles	0.105	0.232	0.129	0.137	0.141	0.138
67	Real Estate	0.027	0.060	0.053	0.057	0.060	0.053
68	Rental and Leasing Services	0.078	0.210	0.331	0.236	0.342	0.302

Code	Industry	AR	OK	KS	MO	TX	RUS
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.031	0.023	0.027	0.027	0.021	0.028
70	Professional, Scientific, and Technical Services	0.080	0.228	0.228	0.240	0.259	0.234
71	Management of Companies and Enterprises	0.080	0.127	0.134	0.129	0.151	0.130
72	Administrative and Support Services	0.077	0.169	0.172	0.233	0.212	0.193
73	Waste Management and Remediation Services	0.071	0.138	0.136	0.135	0.159	0.139
74	Educational Services	0.077	0.141	0.141	0.130	0.164	0.134
75	Ambulatory Health Care Services	0.077	0.249	0.251	0.223	0.263	0.235
76	Hospitals	0.070	0.140	0.145	0.124	0.228	0.129
77	Nursing and Residential Care Facilities	0.069	0.140	0.122	0.128	0.165	0.133
78	Social Assistance	0.071	0.228	0.256	0.228	0.252	0.214
79	Performing Arts, Spectator Sports, and Related Industries	0.128	0.256	0.247	0.277	0.324	0.318
80	Museums, Historical Sites, and Similar Institutions	0.063	0.094	0.097	0.094	0.098	0.091
81	Amusement, Gambling, and Recreation Industries	0.085	0.113	0.130	0.100	0.152	0.117
82	Accommodation	0.110	0.137	0.158	0.134	0.156	0.135
83	Food Services and Drinking Places	0.069	0.171	0.174	0.138	0.165	0.140
84	Repair and Maintenance	0.077	0.301	0.392	0.321	0.413	0.334
85	Personal and Laundry Services	0.095	0.502	0.479	0.444	0.542	0.473
86	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.083	0.143	0.131	0.137	0.156	0.124
87	Private Households	0.072	0.119	0.117	0.111	0.136	0.112
88	Public Institutions	0.062	0.104	0.100	0.097	0.117	0.098
89	Noncomparable imports and non-sector accounts	0.000	0.000	0.000	0.000	0.000	0.000

Table 29 MKARNS MRSAM Household Income Multipliers

Code	Industry	AR	OK	KS	MO	TX	RUS
1	Live animals & fish	0.688	0.638	0.581	0.583	0.683	0.626
2	Cereal grains	0.661	0.796	0.743	0.674	0.867	0.720
3	Other agricultural products	0.833	1.306	0.992	0.861	1.432	1.151
4	Animal feed	0.635	0.615	0.523	0.527	0.664	0.655
5	Meat, fish, seafood & preparations	0.796	0.791	0.796	0.805	0.812	0.783
6	Milled grains & bakery products	0.779	0.846	0.792	0.777	0.853	0.810
7	Other foodstuffs and fats & oils	0.811	0.836	0.757	0.780	0.819	0.779
8	Alcoholic beverages	0.382	0.553	0.635	0.522	0.578	0.589
9	Tobacco products	0.000	0.279	0.000	0.208	0.390	0.255
10	Monument & building stone	0.633	0.663	0.672	0.651	0.778	0.721
11	Natural sands, gravel & crushed stone	0.886	0.870	0.890	0.894	0.924	0.927
12	Nonmetallic minerals, n.e.c.	0.727	0.720	0.724	0.716	0.753	0.740
13	Metallic ores & concentrates	0.439	0.442	0.000	0.381	0.460	0.452

Code	Industry	AR	OK	KS	MO	TX	RUS
14	Coal	0.774	0.770	0.775	0.764	0.798	0.783
15	Crude petroleum	0.610	0.558	0.661	0.698	0.533	0.580
16	Gasoline, aviation turbine fuel & fuel oils	0.304	0.275	0.298	0.330	0.272	0.282
17	Coal & petroleum products, n.e.c.	0.365	0.357	0.355	0.363	0.356	0.353
18	Basic chemicals	0.592	0.630	0.619	0.591	0.468	0.567
19	Pharmaceuticals	0.640	0.633	0.643	0.650	0.611	0.625
20	Fertilizers	0.595	0.620	0.623	0.610	0.603	0.613
21	Chemical products & preparations, n.e.c.	0.640	0.623	0.631	0.619	0.620	0.639
22	Plastics & rubber products	0.709	0.689	0.714	0.720	0.692	0.733
23	Logs & wood in the rough	0.990	1.138	1.548	0.782	0.899	0.933
24	Wood products	1.022	0.941	0.988	0.944	0.967	0.971
25	Pulp, newsprint, paper & paperboard	0.669	0.663	0.722	0.690	0.747	0.708
26	Paper & paperboard articles	0.688	0.750	0.809	0.793	0.763	0.772
27	Printed products	0.910	0.871	0.926	0.921	0.943	0.944
28	Textiles & leather products	0.835	0.854	0.862	0.836	0.838	0.846
29	Nonmetalic mineral products	0.835	0.820	0.839	0.842	0.873	0.869
30	Primary & semifinished base metal forms & shapes	0.703	0.678	0.679	0.658	0.725	0.711
31	Base metal products	0.834	0.855	0.877	0.839	0.915	0.887
32	Machinery	0.781	0.817	0.752	0.866	0.904	0.853
33	Electronic & electrical equipment & components	0.766	0.795	0.779	0.740	0.696	0.732
34	Motorized vehicles (including parts)	0.748	0.689	0.600	0.651	0.634	0.687
35	Transport equipment	0.771	0.769	0.788	0.782	0.823	0.838
36	Precision instruments & apparatus	0.803	0.903	0.945	0.914	0.945	0.902
37	Furniture, fixtures, lamps & lighting equipment	0.802	0.813	0.925	0.959	0.900	0.879
38	Miscellaneous manufactured products	0.807	0.864	0.902	0.796	0.927	0.954
39	Waste & scrap	0.000	0.000	0.000	0.000	0.000	0.000
40	Support Activities for Agriculture and Forestry	1.368	1.324	1.472	1.338	1.382	1.396
41	Support Activities for Mining	0.804	0.817	0.766	0.821	0.827	0.851
42	Utilities	0.498	0.494	0.491	0.508	0.530	0.524
43	Contract Construction	1.072	1.068	1.113	1.119	1.177	1.142
44	Support activities for printing	1.090	1.044	1.135	1.136	1.139	1.149
45	Wholesale Trade	0.876	0.865	0.890	0.883	0.928	0.905
46	Retail stores	0.959	0.931	0.960	0.925	1.008	0.961
47	Air Transportation	0.638	0.672	0.588	0.665	0.694	0.674
48	Rail Transportation	0.816	0.803	0.828	0.825	0.856	0.842
49	Water Transportation	0.651	0.629	0.787	0.653	0.675	0.675
50	Truck Transportation	0.957	0.977	0.994	0.998	1.010	0.991
51	Transit and Ground Passenger Transportation	1.042	0.932	1.031	0.983	1.055	0.994
52	Pipeline Transportation	1.054	1.090	0.780	0.791	1.104	1.062

Code	Industry	AR	OK	KS	MO	TX	RUS
53	Scenic, Sightseeing and Transportation Support	1.107	1.451	1.236	1.173	1.177	1.263
54	Postal Service	1.370	1.350	1.379	1.390	1.459	1.428
55	Couriers and Messengers	0.776	0.765	0.806	0.823	0.798	0.807
56	Warehousing and Storage	1.059	1.034	1.068	1.068	1.103	1.090
57	Publishing Industries (except Internet)	0.922	0.926	0.877	0.870	0.872	0.863
58	Motion Picture and Sound Recording Industries	0.859	0.846	0.880	0.866	0.851	0.869
59	Broadcasting (except Internet)	1.287	1.379	1.253	1.508	1.355	1.434
60	Telecommunications	0.592	0.603	0.586	0.604	0.622	0.609
61	Data Processing, Hosting and Related Services	0.675	0.675	0.672	0.636	0.679	0.670
62	Other Information Services	0.953	1.012	1.003	0.949	1.059	1.159
63	Monetary Authorities and Credit Intermediation	0.621	0.611	0.650	0.656	0.735	0.707
64	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.936	0.869	0.931	0.969	0.980	1.107
65	Insurance Carriers and Related Activities	0.840	0.821	0.878	0.840	0.861	0.827
66	Funds, Trusts, and Other Financial Vehicles	0.833	0.793	0.866	0.846	0.851	0.891
67	Real Estate	0.286	0.279	0.292	0.294	0.295	0.295
68	Rental and Leasing Services	1.087	0.894	1.056	0.962	1.049	1.012
69	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.213	0.132	0.161	0.158	0.107	0.158
70	Professional, Scientific, and Technical Services	1.112	1.058	1.136	1.116	1.189	1.155
71	Management of Companies and Enterprises	1.171	1.140	1.170	1.170	1.205	1.214
72	Administrative and Support Services	1.124	1.098	1.190	1.161	1.229	1.172
73	Waste Management and Remediation Services	0.860	0.842	0.866	0.863	0.905	0.888
74	Educational Services	1.070	1.049	1.065	1.094	1.166	1.165
75	Ambulatory Health Care Services	1.228	1.212	1.244	1.239	1.303	1.258
76	Hospitals	1.060	1.068	1.104	1.097	1.191	1.142
77	Nursing and Residential Care Facilities	1.135	1.119	1.144	1.137	1.204	1.188
78	Social Assistance	1.202	1.188	1.227	1.222	1.245	1.265
79	Performing Arts, Spectator Sports, and Related Industries	1.095	1.134	1.040	1.249	1.197	1.147
80	Museums, Historical Sites, and Similar Institutions	0.720	0.706	0.727	0.722	0.749	0.738
81	Amusement, Gambling, and Recreation Industries	1.008	0.866	0.990	0.832	1.066	0.973
82	Accommodation	0.901	0.899	0.917	0.919	0.933	0.929
83	Food Services and Drinking Places	0.910	0.914	0.934	0.927	0.972	0.962
84	Repair and Maintenance	1.121	1.082	1.163	1.129	1.214	1.169
85	Personal and Laundry Services	1.298	1.275	1.295	1.270	1.357	1.315
86	Religious, Grantmaking, Civic, Professional, and Similar	1.157	1.135	1.183	1.209	1.215	1.136

Code	Industry	AR	OK	KS	MO	TX	RUS
	Organizations						
87	**Private Households**	**1.557**	**1.525**	**1.573**	**1.560**	**1.636**	**1.601**
88	**Public Institutions**	**1.311**	**1.272**	**1.291**	**1.304**	**1.367**	**1.350**
89	**Noncomparable imports and non-sector accounts**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

IV MKARNS SURVEY, KEY INDUSTRIES, EXTENDED REACH OF OKLAHOMA'S WATERBORNE COMMERCE, AND POTENTIAL WATERWAY TRAFFIC ANALYSIS

IV.1 Survey of MKARNS Users

One of the features of this study is that a survey of MKARNS users was undertaken by researchers at Oklahoma State University—Caneday and Soltani (2014). Three groups of users were surveyed: recreation users, waterway users, and port operators. The survey results for the MKARNS recreation users are addressed later in this report in connection with the economic effects of recreation activities.

IV.1.1 MKARNS Users Survey

During preparation of the survey of port representatives, it became apparent that some additional information would be needed from businesses associated with the individual ports. In particular, the research principals agreed that specific information from these associated businesses was needed in three areas:

1. Percentage of a company's business that relied upon MKARNS;
2. Physical presence and space at one of the MKARNS ports; and
3. Ability of the company to conduct current business without services from MKARNS.

One-hundred-eighty-one responses were received from businesses associated with MKARNS ports. Clearly these were generated well beyond the direct email invitations and represent a "snowball" sampling of businesses directly or indirectly linked to the navigation system. The survey results are shown graphically below in Figures 35, 36, and 37.

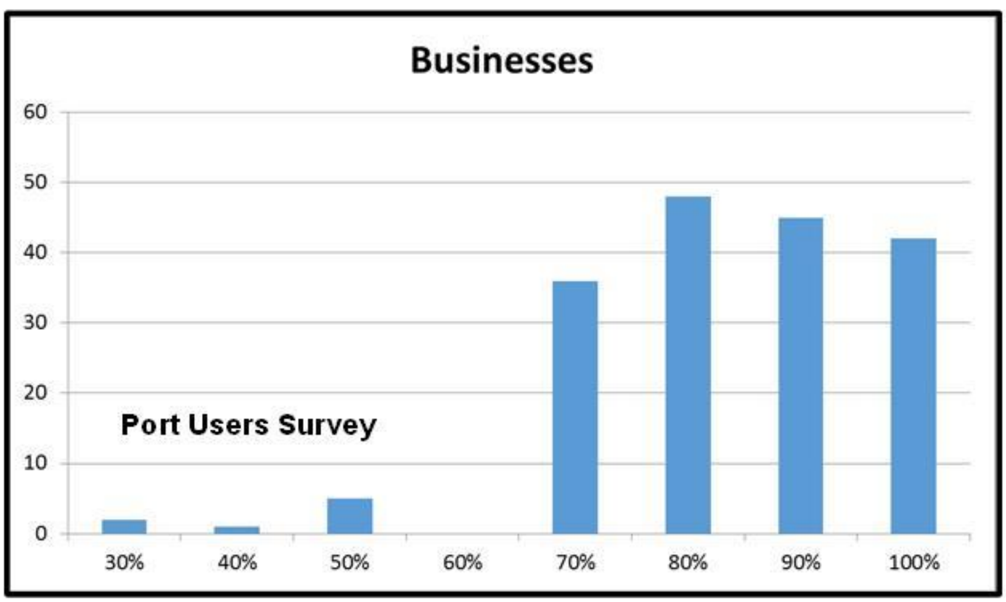

Figure 32 Percent of Businesses Relying upon the MKARNS

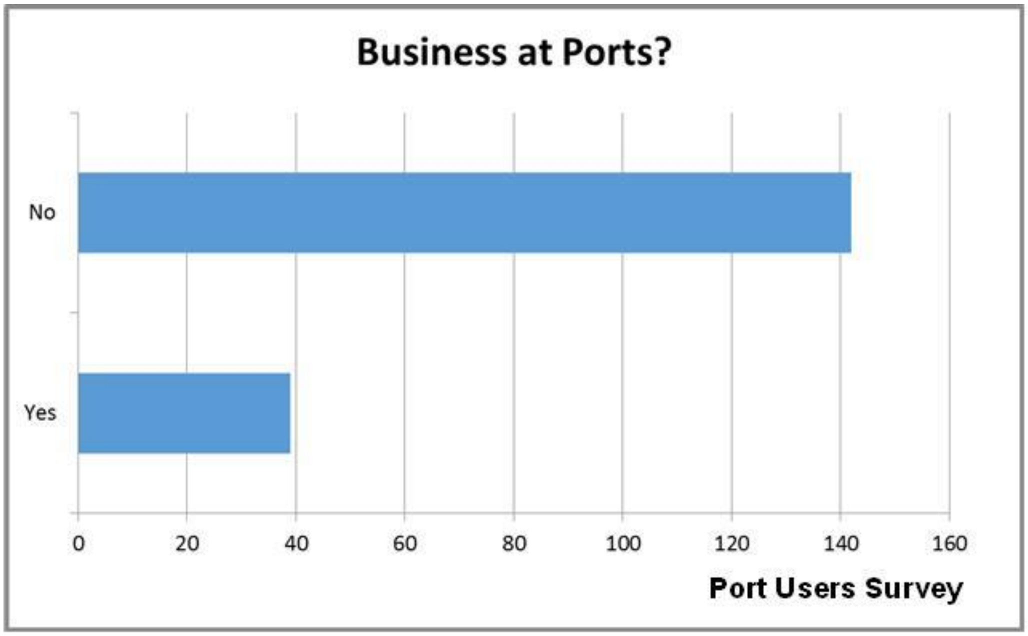

Figure 33 Businesses with Presence at MKARNS Ports

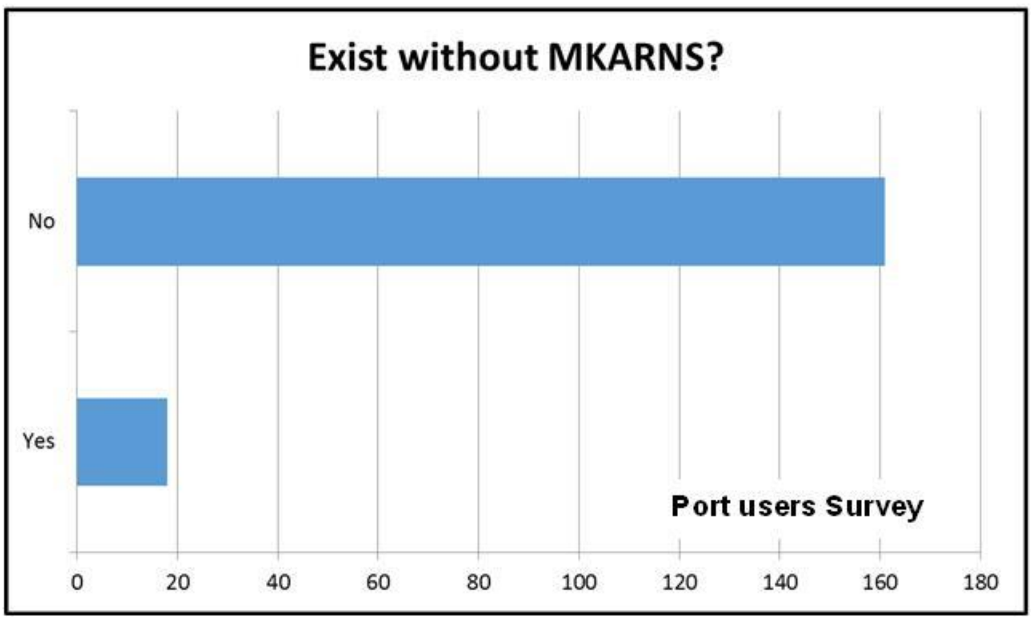

Figure 34 Can Business Operate without the MKARNS

IV.1.2 MKARNS Port Operators Survey

The port operators were asked a series of detailed questions that helped to define the types and levels of business activities that occur at the MKARNS ports. Of those survey instruments that were returned, five ports provided sufficient information to summarize for this report.

Table 30 provides some information concerning the business activity at the five ports shown. Table 30 gives the number of business establishments, number of persons employed at those businesses, and acreages used. On average, the MKARNS ports contain 25 business firms that employ 1,742 workers and require 896 acres to operate. Also on average over all five ports, each firm employed nearly 70 workers and required 36 acres to operate.

Table 30 Businesses, Employment, and Acreages Used[71]

	Reported in Survey			Average for Firms	
Port Name	**Employment**	**Acreage**	**Number**	**Employment**	**Acreage**
Harbor Industrial District Pine Bluff	230	177	10	23.0	17.7
Oakley	48	32	3	16.0	10.7
Port of Little Rock	2,603	1,417	27	96.4	52.5
Port of Muskogee	1,922	1,374	15	128.1	91.6
Tulsa Port	3,909	1,482	70	55.8	21.2
Total	8,712	4,481	125	69.7	35.8
Average for Ports	1,742	896	25		

Table 31 shows the discharged and loaded tonnages by type of cargo at the reporting ports. On average, a total of 620,460 tons of cargo were discharged, most of which were dry bulk (481,356 tons). A total of 748,515 tons of cargo were loaded, on average, at the MKARSN ports—dry bulk goods were the most common of the good loaded.

Table 31 Tons of Cargo by Type Discharged and Loaded at MKARNS Ports[72]

Commodity	Harbor Industrial District Pine Bluff	Oakley Port	Port of Little Rock	Port of Muskogee	Tulsa Port	Average
Tons Discharged						
Dry Bulk	64,200	1,350,000	150,000	337,579	505,000	481,356
Liquid Bulk	0	10,000	0	129,828	33,000	34,566
Break Bulk	0	0	284,200	176,476	18,000	95,735
Other (specify)	0	0	0	0	44,000	8,800
Total	64,200	1,360,000	434,200	643,883	600,000	620,457
Tons Loaded						
Dry Bulk	79,200	1,253,000	139,000	157,261	28,000	331,292
Liquid Bulk	0	10,000	0	141,014	981,000	226,403
Break Bulk	0	0	0	28,098	48,000	15,220
Other (specify)	0	0	0	0	878,000	175,600
Total	79,200	1,263,000	139,000	326,373	1,935,000	748,515

Table 32 shows the twelve most important commodities (in terms of tonnage) entering MKARNS ports—the largest tonnage was for fertilizes (code 22).

[71] Source: Port Operators Survey

[72] Source: Port Operators Survey

Table 32 Incoming Commodity Traffic by MKARNS Ports[73]

Code	Commodity	Harbor Industrial District Pine Bluff	Oakley Port	Port of Little Rock	Port of Muskogee	Tulsa Port	Total	Average
22	Fertilizers	20,000	1,100,000	125,000	51,036	200,000	1,496,036	498,679
32	Primary and semifinished base metal forms and shapes	24,000	0	284,000	176,476	0	484,476	242,238
19	Coal and petroleum products, NEC	0	330,000	0	105,398	0	435,398	290,265
13	Nonmetallic minerals, NEC	0	0	0	243,537	0	243,537	243,537
33	Base metal products	0	34,000	0	0	100,000	134,000	89,333
4	Animal feed	0	0	0	67,436	0	67,436	67,436
20	Basic chemicals	0	0	0	0	60,000	60,000	60,000
14	Metallic ores and concentrates	0	40,000	0	0	0	40,000	40,000
18	Fuel oils	0	0	0	0	30,000	30,000	30,000
12	Gravel and crushed stone	0	0	25,000	0	0	25,000	25,000
31	Nonmetallic minerals products	15,000	0	0	0	0	15,000	15,000
2	Cereal grains	3,500	0	0	0	0	3,500	3,500
25	Logs and wood in the rough	1,700	0	0	0	0	1,700	1,700

Table 33 shows the twelve most important commodities (in terms of tonnage) leaving MKARNS ports—the largest tonnage was for cereal grains (code 2).

Table 33 Outgoing Commodity Traffic by MKARNS Ports[74]

Code	Commodity	Harbor Industrial District Pine Bluff	Oakley Port	Port of Little Rock	Port of Muskogee	Tulsa Port	Total	Average
2	Cereal grains	3,500	800,000	0	0	0	803,500	535,667
18	Fuel oils	0	0	0	0	300,000	300,000	300,000
19	Coal and petroleum products, NEC	0	30,000	0	256,216	0	286,216	190,811
41	Waste and scrap	0	220,000	50,000	0	0	270,000	180,000
22	Fertilzers	20,000	0	0	0	170,000	190,000	126,667
12	Gravel and crushed stone	0	89,000	0	0	0	89,000	89,000
4	Animal feed	0	12,000	42,060	0	0	54,060	36,040
20	Basic chemicals	0	0	0	0	30,000	30,000	30,000
32	Primary and semifinished base metal forms and shapes	24,000	0	0	0	0	24,000	24,000
43	Mixed freight	0	0	0	0	20,000	20,000	20,000
3	Other agricultural products	15,000	0	0	0	0	15,000	15,000
31	Nonmetallic minerals products	15,000	0	0	0	0	15,000	15,000

[73] Source: Port Operators Survey

[74] Source: Port Operators Survey

Code	Commodity	Harbor Industrial District Pine Bluff	Oakley Port	Port of Little Rock	Port of Muskogee	Tulsa Port	Total	Average
25	Logs and wood in the rough	1,700	0	0	0	0	1,700	1,700

IV.2 Oklahoma's Extended Waterborne Traffic Reach Impacts

Oklahoma's businesses use the McClellan-Kerr Arkansas River Navigation System to either ship or receive a variety of commodities to and from fifteen (15) other states according to U.S. Waterborne Commerce Statistics Center (see Tables 34 to 37). The state names associated with the abbreviations shown and the commodities associated with the codes are given in Table 38.

According to the US Army Corps of Engineers waterborne commerce data, Oklahoma shipped 3.5 million tons of commodities to other locations in the U.S. during 2012. Louisiana was Oklahoma's largest destination (2.5 million tons).[75] The next six states with the outgoing tonnages are (in order) Alabama (179.4 thousand tons), Illinois (145.0 thousand tons), Texas (144.3 thousand tons), Tennessee (106.2 thousand tons), Arkansas (99.9 thousand tons), and Indiana (95.3 thousand tons).

Table 34 Oklahoma's 2012 Outgoing Waterborne Traffic (tons)[76]

State	1000	2100	2229	3100	3200	4349	4400	5155	5354	6168	8099	Total
AL	0	0	0	0	0	0	0	0	0	0	179,354	179,354
AR	0	0	0	0	0	0	0	0	0	0	99,861	99,861
IA	0	0	0	0	0	0	0	0	0	0	16,739	16,739
IL	0	0	0	0	0	0	0	0	0	0	144,962	144,962
IN	0	0	0	0	0	0	9,684	0	0	0	85,599	95,283
KY	0	0	0	0	0	0	8,421	0	0	0	51,208	59,629
LA	436,020	192,616	320,253	0	0	0	175,707	0	0	1,176,190	155,342	2,456,128
MN	0	0	0	0	0	0	0	0	0	0	32,072	32,072
MO	0	0	0	0	0	0	0	0	0	0	23,000	23,000
MS	0	0	0	0	0	0	0	0	0	0	59,687	59,687
OH	0	0	0	0	0	0	0	0	0	0	57,000	57,000
PA	0	0	0	0	0	0	0	0	0	0	0	0
TN	0	0	0	0	0	0	0	0	0	50,973	55,257	106,230
TX	0	0	106,902	0	0	0	0	0	0	0	37,414	144,316
WV	0	0	0	0	0	0	0	0	0	0	3,391	3,391

[75] We suspect that a large portion of this traffic is actually exports to foreign destinations. However, no official documentation of this suspicion is available.

[76] Source: U.S. Waterborne Commerce Statistics Center.

State	1000	2100	2229	3100	3200	4349	4400	5155	5354	6168	8099	Total
Total	436,020	192,616	427,155	0	0	0	193,812	0	0	1,227,163	1,000,886	3,477,652

Table 35 Oklahoma's 2008 to 2012 Average Annual Outgoing Waterborne Traffic (tons) [77]

State	1000	2100	2229	3100	3200	4349	4400	5155	5354	6168	8099	Total
AL	0	0	4,103	0	0	0	0	0	0	20,392	53,298	77,792
AR	0	0	0	0	0	0	2,125	0	0	0	45,866	47,991
IA	0	0	0	0	0	0	0	0	0	0	13,236	13,236
IL	0	0	1,534	0	0	0	0	0	0	0	123,865	125,399
IN	0	0	0	0	0	0	4,348	0	0	0	41,320	45,668
KY	0	0	0	0	0	0	2,821	0	0	0	61,658	64,479
LA	189,402	38,523	297,089	0	0	16,158	108,423	18,310	0	1,180,198	129,772	1,977,876
MN	0	0	0	0	0	0	0	0	0	0	17,814	17,814
MO	0	0	0	0	0	0	0	0	0	0	28,953	28,953
MS	0	0	0	0	0	0	0	0	0	0	71,596	71,596
OH	0	0	0	0	0	0	0	0	0	0	33,241	33,241
PA	0	0	0	0	0	0	0	0	0	0	7,707	7,707
TN	0	0	0	0	0	0	0	0	0	13,347	40,281	53,629
TX	0	0	31,050	0	0	0	2,476	0	0	0	36,872	70,398
WV	0	0	0	0	0	0	0	0	0	0	11,818	11,818
Total	189,402	38,523	333,775	0	0	16,158	120,193	18,310	0	1,213,938	717,297	2,647,597

According to the US Army Corps of Engineers waterborne commerce data, Oklahoma shipped 2.6 million tons of commodities to other locations in the U.S. during 2012. Louisiana shipped the largest tonnage to Oklahoma (1.8 million tons). The next six states with the incoming tonnages are (in order) Arkansas (177.8 thousand tons), Alabama (149.3 thousand tons), Mississippi (91.8 thousand tons), Tennessee (84.1 thousand tons), Kentucky (75.6 thousand tons), and Illinois (74.1 thousand tons).

Table 36 Oklahoma's 2012 Incoming Waterborne Traffic (tons) [78]

State	1000	2100	2229	3100	3200	4349	4400	5155	5354	6168	8099	Total
AL	0	0	0	0	0	0	0	0	116,304	0	32,954	149,258
AR	0	0	0	0	0	92,032	0	0	42,756	29,851	13,152	177,791
IA	0	0	0	0	0	0	0	0	0	7,987	0	7,987
IL	0	0	0	0	0	0	0	0	0	63,987	10,110	74,097

[77] Source: U.S. Waterborne Commerce Statistics Center.

[78] Source: U.S. Waterborne Commerce Statistics Center.

State	1000	2100	2229	3100	3200	4349	4400	5155	5354	6168	8099	Total
IN	0	0	35,056	0	0	0	0	0	0	0	29,048	64,104
KY	0	0	0	0	0	0	0	0	54,257	0	21,343	75,600
LA	0	0	0	1,408,521	24,057	28,353	0	0	73,915	96,922	146,803	1,778,571
MN	0	0	0	0	0	0	0	0	0	0	5,822	5,822
MO	0	0	0	0	0	0	0	0	0	0	66,981	66,981
MS	0	0	0	48,056	0	0	0	0	0	0	43,749	91,805
OH	0	0	0	0	0	0	0	0	0	0	6,270	6,270
PA	0	0	0	0	0	0	0	0	0	0	13,854	13,854
TN	0	0	0	0	0	0	0	0	0	76,165	7,927	84,092
TX	0	0	0	0	0	0	0	0	0	0	8,224	8,224
WV	0	0	0	0	0	0	0	0	0	0	27,316	27,316
Total	0	0	35,056	1,456,577	24,057	120,385	0	0	287,232	274,912	433,553	2,631,772

Table 37 Oklahoma's 2008 to 2012 Average Annual Incoming Waterborne Traffic (tons) [79]

State	1000	2100	2229	3100	3200	4349	4400	5155	5354	6168	8099	Total
AL	0	0	0	0	0	0	0	0	111,138	0	18,352	129,491
AR	0	0	0	0	0	45,324	0	0	8,551	29,221	92,092	175,188
IA	0	0	0	0	0	0	0	0	0	9,774	7,701	17,475
IL	0	0	0	0	0	0	0	0	0	77,628	41,357	118,985
IN	0	0	7,011	0	0	0	0	0	4,030	5,420	19,852	36,314
KY	0	0	0	0	0	0	0	0	47,686	1,289	32,882	81,857
LA	14,813	0	30,683	1,023,679	13,550	20,011	0	0	55,320	97,488	71,652	1,327,196
MN	0	0	0	0	0	0	0	0	0	0	7,465	7,465
MO	0	0	0	0	0	0	0	0	0	0	40,287	40,287
MS	0	0	0	38,886	0	0	0	0	949	7,045	20,468	67,348
OH	0	0	0	0	0	0	0	0	6,417	0	5,405	11,822
PA	0	0	0	0	0	0	0	0	0	0	22,801	22,801
TN	0	0	0	0	0	0	0	0	1,180	46,484	19,626	67,290
TX	0	0	0	4,735	0	0	0	0	0	0	35,735	40,470
WV	3,418	0	0	0	0	0	0	0	0	0	19,575	22,993
Total	18,231	0	37,694	1,067,299	13,550	65,334	0	0	235,272	274,349	455,252	2,166,981

[79] Source: U.S. Waterborne Commerce Statistics Center.

Table 38 States and Public Domain Commodities[80]

Abr	State
AL	Alabama
AR	Arkansas
IA	Iowa
IL	Illinois
IN	Indiana
KY	Kentucky
LA	Louisiana
MN	Minnesota
MO	Missouri
MS	Mississippi
OH	Ohio
PA	Pennsylvania
TN	Tennessee
TX	Texas
WV	West Virginia

Code	Public Domain Commodity Name
1000	Coal, Lignite, and Coal Coke
2100	Crude Petroleum
2229	Petroleum Products
3100	Chemical Fertilizers
3200	Chemicals excl. Fertilizers
4142	Lumber, Logs, Wood Chips
4349	Sand, Gravel, Shells, Clay, Salt and Slag
4400	Iron Ore, Iron, & Steel Scrap
4600	Non-Ferrous Ores and Scrap
5155	Primary Non-Metal Products
5354	Primary Metal Products
6168	Food and Food Products
7000	Manufactured Goods
8099	Unknown & Not Elsewhere Classified

IV.3 Identify Key Industries

Identifying the sectors associated with the outgoing traffic is relatively simple. The industries that produced the commodities shipped out are identified by the commodity codes. Unfortunately, the official waterborne commerce data for “state-to-state” flows are highly aggregated industrially (see Table 27). During 2012 only six of the commodity categories had tonnages. The single largest commodity shipment out of Oklahoma was Food and Food Products, code 6168 (1,227,163 tons). Table 3, which lists more specific commodity categories, indicates that food products like wheat, soybeans, and corn are among the most shipped commodities from the MKARNS to places elsewhere. Food products are followed by Unknown Products, code 8099 (1,000,886 tons), Coal and Coal Products, code 1000 (436,020 tons), Petroleum Products, code 2229 (427,155 tons), Iron Ore and Steel, code 4400 (193,812 tons), and Crude Petroleum, code 2100 (192,616 tons).

On the other hand, identifying the industries associated with the commodities entering Oklahoma from other places is not easy. These shipments represent commodities that are used by industries that produce other goods. We do not have data necessary to identify the specific purchasers of the waterborne cargo by industry.

IV.4 Potential Growth Opportunities for Waterborne Commerce

A simple way of thinking about how to identify potential waterborne commerce opportunities for the McClellan-Kerr Arkansas River Navigation System is to examine what

[80] Source: U.S. Waterborne Commerce Statistics Center.

kinds of products are currently hauled on the nation's waterways and then to analyzed why it isn't on the MKARNS. *Petroleum and petroleum products* account for more than one third, 34.2% of the total of the commodities that makeup U.S. domestic barge traffic shown in Figure 38. The next four waterborne commodities (order shown is in terms of tonnage) are *coal* (24.8%), *non-fuel crude material* (15.1%), *food and farm products* (10.3%), and *chemicals and related products* (9.5%).

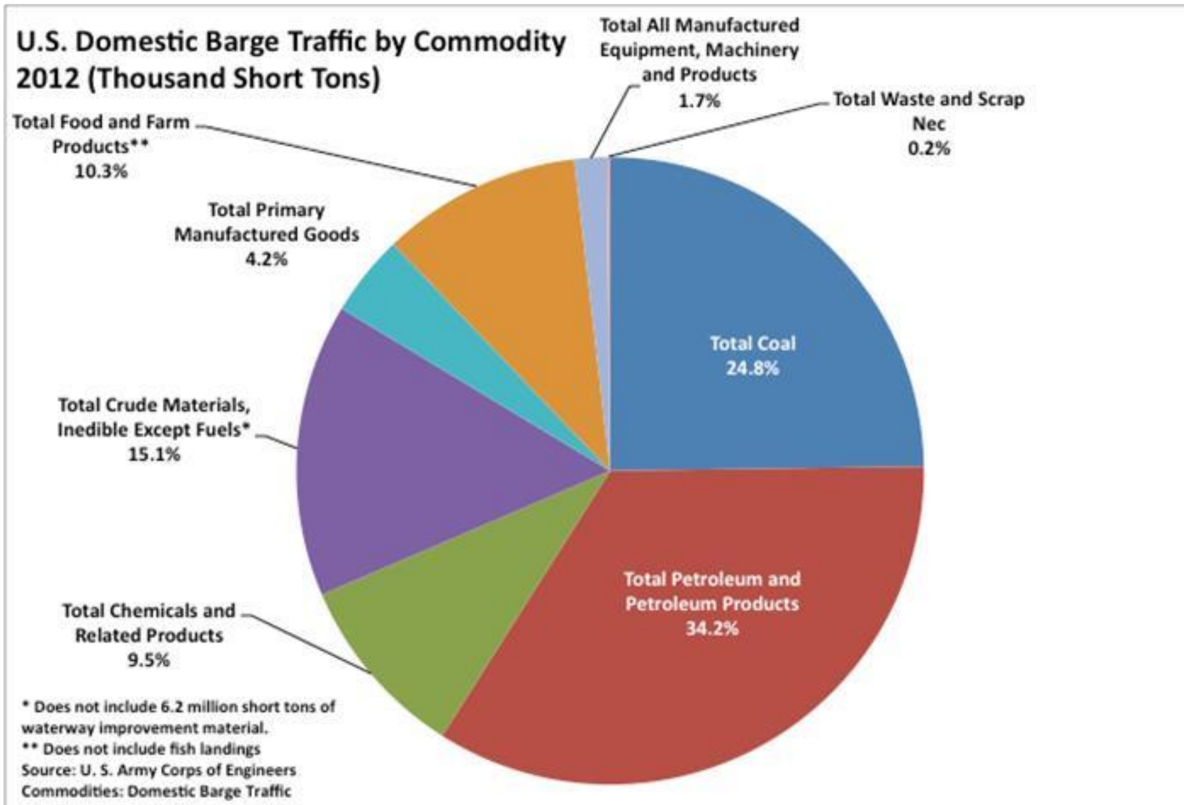

Figure 35 U.S. Domestic Barge Traffic by Commodity, 2012

Identifying the sectors associated with the outgoing traffic is relatively simple. The industries that produced the commodities shipped out are identified by the commodity codes. On the other hand, identifying the industries associated with the commodities entering Oklahoma from other places is not easy. These shipments represent commodities that are used by industries that produce other goods. We do not have data necessary to directly identify the specific purchasers of the waterborne cargo by industry.[81]

In order to identify industries that have potential for increased use of the MKARNS, domestic barge traffic for the United States was compared to industry employment in the counties surrounding the ports of Catoosa and Muskogee. The area under consideration

[81] Analytical techniques to identify new users of waterborne commodities and to measure their effective demands would require resources and time beyond those that were made available for this study. We recommend that such an analysis be undertaken.

approximately ranged from within 25 to around 100 miles of each port—a total of 51 counties representing four states (see Figure 39 and Table 39).

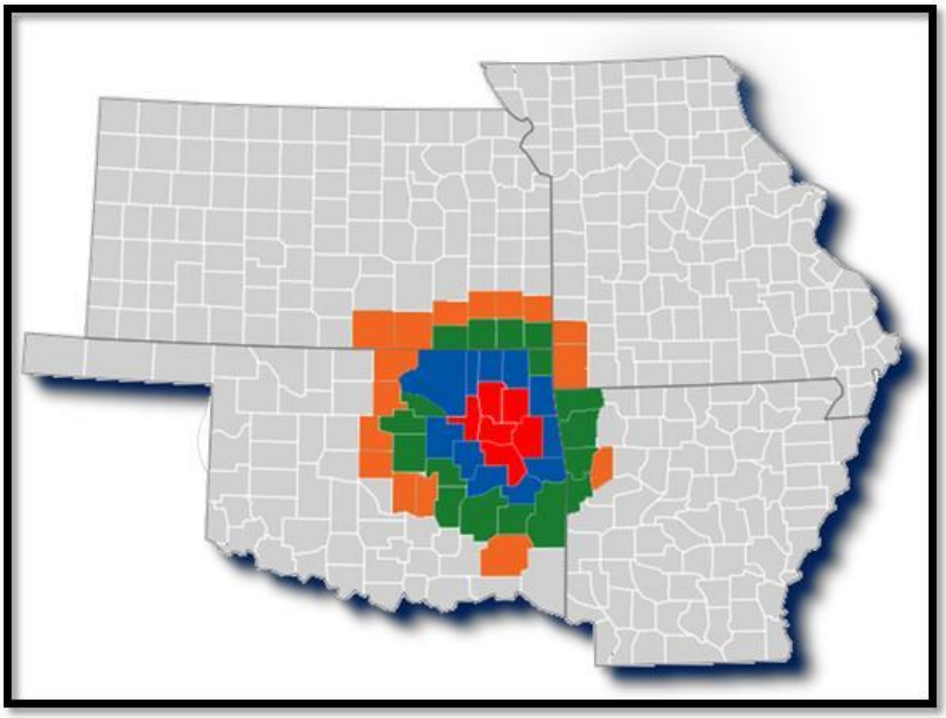

Figure 36 Counties Surrounding the Oklahoma Ports at Varying Distances

Table 39 Counties near Oklahoma River Ports

25 Miles	50 Miles	75 Miles	100 Miles
Oklahoma	**Oklahoma**	**Oklahoma**	**Oklahoma**
Cherokee	Adair	Hughes	Kay
Mayes	Craig	Latimer	Logan
Muskogee	Creek	Le Flore	Noble
Rogers	Delaware	Lincoln	Oklahoma
Tulsa	Haskell	Okfuskee	Pottawatomie
Wagoner	McIntosh	Ottawa	Pushmataha
	Nowata	Pawnee	Seminole
	Okmulgee	Payne	
	Osage	Pittsburg	
	Sequoyah		
	Washington		
		Kansas	**Kansas**
		Chautauqua	Cowley
		Cherokee	Crawford
		Labette	Elk

25 Miles	50 Miles	75 Miles	100 Miles
		Montgomery	**Neosho**
			Sumner
			Wilson
		Arkansas	**Arkansas**
		Benton	**Franklin**
		Crawford	
		Sebastian	
		Washington	
			Missouri
			Jasper
			McDonald
			Newton

The first step in identifying industries that have potential for growth in waterborne commerce was to narrow those under consideration to ones that are not time sensitive or location specific; industries that can take advantage of the savings generated by shipping via the waterways. Prior examination of the commodities transported via water shows that extraction, agriculture, and some manufacturing are heavily represented. Manufacturing industries included are those that may acquire raw materials, ship finished goods, or some combination by water. Industries of particular interest exhibited greater concentrations of employment in the region than that of the nation, indicating that these industries are exporting the portion of production that is not consumed locally. It is important to note that when examining percentage changes, industries with fewer total jobs may exhibit greater volatility due to smaller base numbers being changed while those with greater totals show more moderate percentage changes even with significant numbers of additions or subtractions. Examining the data by evaluating job growth provides indications of which industries likely to remain viable rather than declining.

The second step is to consider those industries that have significant numbers of employees and recent growth (say from 2008 to 2014). Industries that have small levels of employment locally and nationally may show high measures for exporting, but still be insignificant to the local and national economies. Even industries with large numbers of employees may not be attractive candidates for growth if employment has been declining. In examining the employment data for both the 25 and 100 mile radiuses, it becomes apparent that many of the industries that are the largest or exhibit noteworthy growth in the entire 100 mile radius area are also leaders in the core counties surrounding the ports (25 mile radius).

Industries of particular interest exhibited greater concentrations of employment in the region than that of the nation as demonstrated by Location Quotients[82] (LQs) greater than one—indicating that these industries are exporting the portion of production that is not consumed locally. This *Export Percentage*[83] represents the portion of total production leaving the area. Other criteria included significant numbers of employees and growth from 2008 to 2014. Industries that have small levels of employment locally and nationally may show high measures for exporting, but still be insignificant to the local and national economies. Even industries with large numbers of employees may not be attractive candidates for growth if employment has been declining. In examining the employment data[84] for both the 25 (six counties) and 100 (51 counties) mile radiuses, it becomes apparent that many of the industries that are the largest or exhibit noteworthy growth in the entire 51 county area are also leaders in the core six counties surrounding the ports.

The average rank order shown in Tables 40 and 41 indicate which industries within 25 and 100 miles (respectively) from the Ports of Catoosa and Muskogee) that have experienced the greatest growth rates in employment from 2008 to 2014 and have the highest export percentages.

Table 40 Potential MKARNS-Using Industries within a 25 Miles of the Ports of Catoosa and Muskogee

NAICS Code	Description	2014 Employment	2008 - 2014 Employment Growth	Rank	2014 Export Percentage	Rank	Average Rank
2123	Boiler, Tank, and Shipping Container Manufacturing	453	36.0%	5	92.6%	1	3
3331	Steel Product Manufacturing from Purchased Steel	3,439	166.3%	1	72.6%	7	4
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	523	161.5%	2	75.8%	6	4

[82] $LQ = \frac{e_i/e}{E_i/E}$ or $= \frac{e_i/E_i}{e/E}$, where e_i = Local employment in industry i, e = Total local employment, E_i = Reference area employment in industry i, and E = Total reference area employment.

[83] The export percentage is $(LQ - 1) \div LQ$. Positive percentages represent the portion of total production available for export; negative percentages are the amount of local use that must be met with imports.

[84] EMSI industry data have various sources depending on the class of worker. (1) For QCEW Employees, EMSI primarily uses the QCEW (Quarterly Census of Employment and Wages), with supplemental estimates from County Business Patterns and Current Employment Statistics. (2) Non-QCEW employee data are based on a number of sources including QCEW, Current Employment Statistics, County Business Patterns, BEA State and Local Personal Income reports, the National Industry-Occupation Employment Matrix (NIOEM), the American Community Survey, and Railroad Retirement Board statistics. (3) Self-Employed and Extended Proprietor classes of worker data are primarily based on the American Community Survey, Non-employer Statistics, and BEA State and Local Personal Income Reports. Projections for QCEW and Non-QCEW Employees are informed by NIOEM and long-term industry projections published by individual states.

NAICS Code	Description	2014 Employment	2008 - 2014 Employment Growth	Rank	2014 Export Percentage	Rank	Average Rank
3312	Agriculture, Construction, and Mining Machinery Manufacturing	703	36.3%	4	75.9%	5	4.5
3339	Cement and Concrete Product Manufacturing	5,475	46.3%	3	41.6%	10	6.5
3327	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	2,994	1.5%	10	82.7%	3	6.5
3328	Oil and Gas Extraction	1,091	1.7%	9	82.0%	4	6.5
3273	Other General Purpose Machinery Manufacturing	983	0.8%	11	84.2%	2	6.5
3334	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	2,410	30.7%	6	56.8%	9	7.5
2111	Coating, Engraving, Heat Treating, and Allied Activities	11,795	8.9%	8	57.9%	8	8
3324	Nonmetallic Mineral Mining and Quarrying	4,228	9.4%	7	16.9%	11	9

Table 41 Potential MKARNS-Using Industries within 100 Miles of the Ports of Catoosa and Muskogee

NAICS Code	Description	2014 Employment	2008 - 2014 Employment Growth	Rank	2014 Export Percentage	Rank	Average Rank
3324	Boiler, Tank, and Shipping Container Manufacturing	6,721	30.6%	4	82.9%	2	3
3312	Steel Product Manufacturing from Purchased Steel	2,196	83.0%	1	67.7%	6	3.5
2111	Oil and Gas Extraction	51,736	7.9%	8	84.9%	1	4.5
3331	Agriculture, Construction, and Mining Machinery Manufacturing	9,541	20.9%	5	68.1%	5	5
3111	Animal Food Manufacturing	2,868	8.2%	7	77.3%	3	5
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	908	66.3%	2	48.8%	8	5
3315	Foundries	2,860	50.9%	3	47.8%	9	6
3339	Other General Purpose Machinery Manufacturing	10,254	3.7%	10	68.9%	4	7
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	6,468	11.6%	6	26.3%	10	8
3271	Clay Product and Refractory Manufacturing	1,599	5.5%	9	62.6%	7	8
3328	Coating, Engraving, Heat Treating, and Allied Activities	2,053	3.4%	11	17.6%	11	11

Of the top six industries shown in Tables 40 and 41 (in terms of their average ranking) there are five in common: ordered by their NAICS codes, they are oil and gas extraction (2111);

pesticides, fertilizers, and other agricultural chemical products (3253); steel products from purchased steel (3312); boilers, tanks, and shipping containers (3324); and agriculture, construction, and mining machinery (3331). Cement and concrete products industry (3273) has the sixth highest average ranking of those industries within 25 miles of the Ports of Catoosa and Muskogee and animal foods (3111) has the fourth highest average ranking of those industries within 100 miles of the two ports.

Particular candidate industries to expand waterborne transportation on the MKARNS should be based on evaluations of multiple criteria, such as employment levels, growth prospects, and export potential. We do not imply that the six industries discussed here (or even the industries shown in Tables 33 and 34) are the only industries that should be considered as providing potential waterway commerce. Greater detail including data by 25-mile graduations is available in Appendix D.

IV.5 Thoughts on the Panama Canal Expansion

Since its opening in 1914, the Panama Canal has been a major connecting link between the Pacific and Atlantic Oceans. Freight volumes passing through the Canal have increased continuously over the years. However, the Canal`s capacity has become strained. It has been estimated that the canal could reach its maximum capacity around 2012. After that the canal would start to inefficiently handle freight demand—waiting times for freight to pass through the Canal would increase and the quality of service would decline. Longer waiting times and lower service quality are likely to contribute to congestion on the Panama Canal and, as a result, would lead to a decline in the Canal`s competitiveness (Kim, Anderson, and Wilson, 2014).

The Canal's expansion project began in the year 2007 and is expected to be completed in 2015. The expansion project will add one new lane and two lock facilities at each end of the canal lane. After construction the canal`s capacity will be doubled and the new lane will be able to handle mega size container vessels and/or dry bulk vessels. The additional capacity is expected to shift cargo volume between Asia and the U.S. from West Coast ports to East/Gulf Coast ports.

The Panama Canal expansion is a major topic of discussion because the expansion of the canal is expected to significant impact on international trade routes, port facilities, freight distribution systems, and the U.S maritime and intermodal systems.

The inland waterway system in the United States has about 12,000 miles of commercially navigable waters and is composed of rivers, waterways, canals, and locks and dams. Barges and towboats operate on the system and carry about 15% of the nation's domestic freight (IWR, 2012). U.S. inland waterways are some of the most advanced and extensive in the world. Much of nation's the early economic development and population settlement patterns were greatly influenced by the system of interior waterways. The inland waterways work in a complementary, multi-modal fashion with the nation's highway and railway systems. Many of the nation's coastal ports are located on or connected to inland waterways (see Figure 40).

Figure 37 Inland Waterway and Coastal Port Connections

The inland waterway system basically are connected to three primary coastal port areas in terms of foreign exports and imports: from Baton Rouge to the Gulf in South Louisiana; the port of Mobile, AL; and the port of Portland, OR. The expansion of the Panama Canal is important to ports in Louisiana and Mobile Bay for two main reasons. One, these ports handle large quantities of bulk commodities that are exported from the U.S. (for example, grains) through the Panama Canal. One of the kinds of impacts that may occur due to the Canal expansion is a shift in the ports that handle exported bulk commodities and a possible significant increase in bulk export tonnages (EDRGI, 2013). Two, increased utilization of the nation's inland waterways could prove to be a cost-effective alternative to both truck and rail.

One of the major advantages that waterways have over both truck and rail is that waterway transport is not limited by either highway weight restrictions or rail clearance limitations. This can make water transport a more cost-efficient method of moving cargo (especially heavy and hazardous materials). Even though a relatively small proportion of the nation's overall freight tonnage is transported on inland waterways, barge transport is a primary means of hauling goods to particular areas of the country (especially for long distance movements for bulk commodities that are coming from or to places near inland waterways).

The Panama Canal expansion could create transportation cost reductions that may affect the movement of cargo for several reasons. For example, EDRGI (2013) note that reductions in sea going transportation costs out of Gulf ports (due to larger, more efficient bulk ships) may reduce aggregate costs of exporting bulk goods—such as grain using the Mississippi River route rather than by rail through Pacific ports. Therefore, exports of bulk commodities would increase on the Mississippi River and decrease on rail routes to West Coast ports. We presume this increase in export traffic on the Mississippi River could also mean greater export volume coming from the MKARNS. In addition, the lower transport costs due to the Panama Canal expansion could even expand overall export trade from the U.S., not just create competitive differentials between U.S. port areas.

There are several limitations that private and public interests need to address in order for inland waterway users to take advantage of these positive beneficial effects of the Panama Canal expansion. The first limitation is the conditions of the port infrastructure at both the origin (for exports) and destination (imports) of the shipments. This is especially true for the deep water ports, but it is also applicable to ports on the inland waterways (such as at Little Rock, AR or the Port of Catoosa, OK). Not having the right equipment or facilities at a port could be a critical issue for a shipper in deciding whether water transportation should be used. The second limitation is the reliability of the nation's lock and dam structures. The reliability is linked to interconnected highway and rail systems in determining the overall performance of transportation networks. The aging system of U.S. locks and dams have experienced increases in outages during the last few decades due to scheduled and unscheduled lock repairs. Such lock outages increase delays and related costs. Disruption in waterway services may induce carriers to seek alternative modes of transport if the delays are frequent and last long enough.

V ECONOMIC VALUATION METHODOLOGY

V.1 The Role of Waterways in the Economy

Waterways are vital resources that have multiple functions. Foremost, waterways provide an attractive method of transporting goods. On a ton-mile basis, barge transportation is well known as the cheapest mode to haul commodities. In addition, waterways can provide a variety of other valuable services. For example, hydropower generating facilities are often included as part of the locks and dams built to enhance navigation on the waterways. Structures and flow regimes that are used to maintain and control channel depths for navigation can also help in lessening flooding events and, as a result, mitigating their damage effects on affected populations and properties. Waterways are an important source of water supply for drinking, for commercial and industrial uses, and for irrigation. Waterways and the reservoirs that are often built are attractive for many recreation opportunities—fishing, boating, camping, hunting, sight-seeing, hiking, etc. And, important environmental benefits can be gained when appropriate and effective mitigation facilities are put in place and actions are implemented such as improving fish and wildlife habitat or species protection.

Water resources are fundamental and critical to regional economic development. The availability of well integrated transportation networks often defines how that region can compete, what types of goods will be available as inputs for local industries, what types of goods and services will be reasonable for local sectors to produce. An improvement in the transportation system of a region can change the production costs of many goods and services produced in the region and can provide the benefited region with a competitive advantage in regional, national, and international markets. Transportation of goods on the inland waterway system occurs because this mode of transportation provides the lowest cost means of movement for such heavy and bulky goods as grain, grain mill products, lumber, paper products, chemicals, petroleum, coal, stone, iron, and steel. When a new waterway is opened, the reduction in transportation costs reduces the cost of producing other goods. Reductions in transport costs make indigenous industries more competitive, thereby leading to firm expansions. The firms are able to lower costs and participate in new markets. This helps to increase region output, employment, and income.

The unique feature of these functions is that their benefits are, in one form or another, valued in terms of efficiency gains or cost savings. The complicating factor in evaluating the regional economic effects of these cost savings is that improvements in these activities (i.e., reductions in transportation costs) affect both industrial producers and final consumers (i.e., households, governments and foreign residents). How one analyzes and computes the regional economic impacts of project functions that generate system-wide efficiencies is not as straightforward as for project-related spending. Much goes on between regions of an economic system, between firms within regions, and within the firms themselves. Some effects are compensating while others are complementary, however, they all occur approximately during the same timeframe.

An improvement in the transportation systems of a region can change the production costs of many goods and services produced in the region and can provide the benefited region with a competitive advantage in regional, national, and international markets (see Figure 41 below). Transportation of goods on the inland waterway system occurs because this mode of transportation provides the lowest cost means of movement for such heavy and bulky goods as grain, grain mill products, lumber, paper products, chemicals, petroleum, coal, stone, iron, and steel. When a new waterway is opened, the reduction in transportation costs reduces the cost of producing other goods. Reductions in transport costs make indigenous industries more competitive, thereby leading to firm expansions. The firms are able to lower costs and participate in new markets. This helps to increase region output, employment, and income.

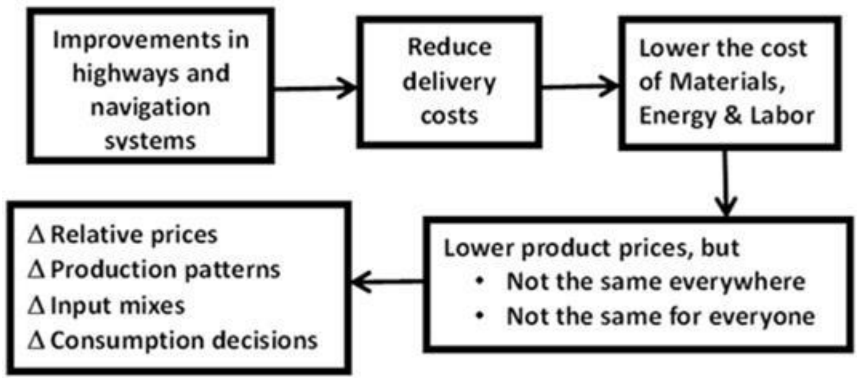

Figure 38 Effects of Transportation Improvements

The basic ideas that have to be addressed while analyzing and computing regional economic impacts of cost savings efficiencies are illustrated below using the example of an improvement in transportation infrastructure. The premise of transportation cost savings is that improvements in navigation systems reduce the delivery costs of capital, materials, and energy inputs used by firms, as well as, the transportation costs to deliver the products produced. A transportation improvement will directly reduce the cost of the flow of goods and services between two regions ***A*** and ***B***. Such delivery cost reductions, *ceteris paribus*, should be reflected in lower factor and product costs. In addition, one should also expect indirect systems interactions that will spread quite readily within and between regions depending on the competitiveness of the economic system (i.e., between regions ***A*** and ***C*** and between regions ***B*** and ***C***). Factor cost reductions themselves should lead to lower production costs. Lower production costs in some firms relative to others should lead, in a competitive industry, to relative price changes for their goods and services. These changes in relative prices, in turn, should cause some goods and services to be consumed more, and others less. This chain of events is likely to change trading patterns among firms and, thus, between regions. It would also be expected to alter the factor mix in production processes within firms (i.e., technological change).

Using a simple two-region model of interregional trade for a single commodity (e.g., coal, electronic components, etc.) we can examine the basic principle of how transportation cost savings affects multiple regional economies (Bressler and King, 1978, pp. 87-89). Ideally in a competitive world, we would expect that the prices for the commodity to be the same everywhere. However, due to region-specific conditions and characteristics regional variations in the prices of commodities are common. However, suppose there is a transportation-related impediment that could be overcome with an improvement in the transportation infrastructure between regions ***A*** and ***B***.[85] Due to "non-optimal" release schedules, an interregional price differential (or transfer cost) exists between the commodities prices in regions ***A*** and ***B*** (i.e., $\boldsymbol{P_B^*} - \boldsymbol{P_A^*}$). For example, this price differential may represent the cost of "light loading" vessels to overcome shallow clearance depths due to low water releases. This price differential represents the cost savings of improving navigation on the MKARNS. After the transportation improvement measures have been implemented, the market for the commodity will tend toward a new equilibrium price somewhere between $\boldsymbol{P_A^*}$ and $\boldsymbol{P_B^*}$ (raising the price in region *A* and lowering the price in region ***B***). Assuming supply and demand curves don't shift in reaction to the price changes, exports will increase in region ***A*** and imports will increase in region ***B***. Producers in region ***A*** will benefit from the transportation improvement (due to the increased exports) while consumers will have less of the commodity to consume (again, due to increased exports). On the other hand, consumers in region ***B*** reap greater benefits due to cheaper imports but producers will suffer losses (again, due to more imports of the commodity). The volume of goods will increase due to the lower cost of transportation (i.e., an increase in exports in region *A* and an increase in imports for region ***B***).

From a general equilibrium point of view, a decrease in transportation costs due to transport improvements will generate widespread effects in a variety of sectors within a region (Rietveld, 1989). In areas that experience transportation cost reductions, the cost reductions not only reduce production costs for exported goods but also reduce the cost of imported products. When the price of imported goods declines consumers and producers will tend to substitute the imported products for the relatively more expensive domestically produced goods. Even in areas that do not benefit from transportation cost reductions (i.e., suffer transportation cost increases like region ***B***), the more expensive imported goods will cause local consumers and producers to use the more relatively more expensive imported goods less intensively and the less expensive domestic products more intensively.

Transportation cost reductions cause further complications because of intermediate goods deliveries—goods that are used to produce other goods (e.g., the steel used to produce cars). Reductions in the transportation cost of the intermediate products will affect the prices of local goods and services and will alter the mix of goods and services used by producers. In addition, there will also be an expansive effect on local production.

V.2 The Economic Effects of Water Resource Development

Water resources investments generate three types of regional economic impacts. First, some activities involve the direct expenditure of funds—like construction, operations, and

[85] Such infrastructure improvements might include, among many others, deepening the navigation channel, better water flow regimes, or wider and deeper locks.

recreation. The regional economic consequences of these types of activities are easily evaluated using commercially available economic impact software. Second, water resources generate system efficiencies. For example, if improvements are made in navigation channel, like deepening the MKARNS, then we can expect that transporting commodities on the waterway will be cheaper and more efficient (lower transportation rates). Or, generating electricity by hydropower—because a lock and dam has a generating unit on-site—is often cheaper and environmentally "cleaner" than electricity produced from alternative fuel sources. These types of water resource-related activities create modeling complications that are incompatible with any of the standard and commercially available regional economic impact software programs. Third, recent innovations in the evaluation of national and regional economic effects of water resources infrastructure investments have focused on the effects the investments have on resource costs—i.e., the prices of labor, energy, and materials—that producers use in the economy.

V.2.1 Effects of Project-Related Expenditure Changes

To understand how regional economic effects are generated and, in turn, estimated, it is important to review their economic context. The simplest economic context for the regional economic effects to be understood is in terms of an input-output accounting framework. In addition to showing the interrelationships among industries within an economy, the input-output accounts have the fundamental information required, when combined with several key assumptions, to provide useful and powerful analytic tools for estimating the regional economic development effects from the design, construction, and operation of water resource investments, activities, and projects, as well as, the purchase of goods and services by people enjoying recreational activities. The assumptions required to estimate the regional economic effects of spending related to Corps' projects are: (1) Each industry produces a single output; and (2) The relationship between output and required inputs are proportional (i.e., linear), fixed, and constant. There is no possibility for economies of scale and for changes in the input-to-output relationships due to changes in output prices, input costs, tax structures, or shipping costs. Combining the above assumptions with the input-output accounts, we can create a simple model of the economy which will provide an estimate of the industrial production that is required directly and indirectly (along with induced income changes) in order for goods and services to be sold to the economy's final consumers (including the Corp's purchases and recreational spending).

Following the input-output model development of Miller and Blair (2009), the input-output accounts can be easily restated and summarized in the form of a simple equation,

[3] $$\boldsymbol{X} = \boldsymbol{AX} + \boldsymbol{Y},$$

Where $\boldsymbol{X}$ is a vector of industrial output levels, $\boldsymbol{A}$ is a matrix of direct interindustry production requirements for goods and services (per dollar of output), and $\boldsymbol{Y}$ is a vector of industrial final demand levels. Assuming the direct production requirements are linear, fixed and constant, output levels can be solved for final demand levels by a simple manipulation of equation [3]; i.e.,

[4] $$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{Y}.$$

The matrix $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is the table of direct and indirect (if households are included) requirements to meet industrial demand levels ($\boldsymbol{Y}$).

The effects of changes in spending (either by the Corps—for construction, operations, maintenance, and major rehabilitation—or by people involved with recreational activities) are computed by posing a vector of changes in purchases ($\Delta\boldsymbol{Y}$) in equation [4] to derive a vector of changes in industrial requirements necessary to meet the changes in purchases ($\Delta\boldsymbol{X}$), or

[5] $$\Delta\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\Delta\boldsymbol{Y}.$$

Employment and income effects are simply computed by applying the appropriate industry-specific employment and income per output ratios to the industry-specific output changes **(**$\Delta\boldsymbol{X}$) of equation [5]. There are several commercially available software choices that can estimate the regional economic effects of water resources spending-related activities, including RIMS II, IMPLAN, and REMI.

V.2.2 Effects of Transportation Cost Changes

The spending effects just discussed do not consider (by assumption) the effects that occur due to system efficiencies brought about by infrastructure investments such as Corps waterway developments. Nothing in the standard input-output accounts or the subsequent standard model solution (equations [4] or [5]) is able to address the economic expansion effects resulting from the efficiencies of improved water resources—i.e., transportation, water supply, hydropower, or flood protection benefits. For example, the standard input-output solution, above, is incapable of estimating the economic impacts that can occur because of reductions in transportation or production costs. A reduction in costs in the delivery or production of commodities creates a type of "substitution" effect which conventional regional economic impact models fail to capture. In fact, the effects of cost reductions are ruled out by assumption. This substitution effect plays a crucial role in determining the technical and trading patterns in an economy both temporally and spatially. These types of changes also have industrial repercussions that can be measured in terms of output (sales), employment, and income.

Much of the restrictive nature of the assumptions underlying the standard version of the input-output model can be overcome by totally differentiating equation [3] and then solving for changes in output levels with respect to changes in technological and trading patterns and with respect to changes in final demand (Robinson, 1990); i.e.,

$$\begin{aligned}
&\Delta\boldsymbol{X} = \Delta\boldsymbol{A}\boldsymbol{X} + \boldsymbol{A}\Delta\boldsymbol{X} + \Delta\boldsymbol{A}\Delta\boldsymbol{X} + \Delta\boldsymbol{Y} \\
&\Delta\boldsymbol{X} - \boldsymbol{A}\Delta\boldsymbol{X} - \Delta\boldsymbol{A}\Delta\boldsymbol{X} = \Delta\boldsymbol{A}\boldsymbol{X} + \Delta\boldsymbol{Y} \\
&(\boldsymbol{I} - \boldsymbol{A} - \Delta\boldsymbol{A})\Delta\boldsymbol{X} = \Delta\boldsymbol{A}\boldsymbol{X} + \Delta\boldsymbol{Y}
\end{aligned}$$

[6] $$\Delta\boldsymbol{X} = \underbrace{(\boldsymbol{I} - \boldsymbol{A} - \Delta\boldsymbol{A})^{-1}\Delta\boldsymbol{A}\boldsymbol{X}}_{\textbf{Intermediate Demand Change}} + \underbrace{(\boldsymbol{I} - \boldsymbol{A} - \Delta\boldsymbol{A})^{-1}\Delta\boldsymbol{Y}}_{\textbf{Final Demand Change}}$$

Equation [6] is the most general solution to the input-output model (in contrast to the more restrictive standard version, equation [5], above). This can be easily seen by assuming $\Delta\boldsymbol{A} = \boldsymbol{0}$. Not only does this solution account for those effects due to changes in project-related spending, but it also evaluates those effects resulting from reductions in transport costs. Comparing equations [5] and [6] indicates that the more general input-output solution is more complex than the standard approach. However, this additional complexity permits a much higher degree of flexibility and applicability for the model. Evaluating the effects of transportation improvements or the operations of a river system (such as the MKARNS) requires consideration of two types of effects caused by the efficiency gains from the river system or its improvements, i.e., (1) the effects of changes in technological and trading patterns of interindustry transactions due to efficiencies and relative price changes ($\Delta\boldsymbol{AX}$) and (2) the effects of changes in final demand due to changes in relative price changes ($\Delta\boldsymbol{Y}$).

Liew and Liew (1985) developed a practical production function approach, called the multiregional variable input-output (MRVIO) model, that makes changes in the technical coefficients of input-output models depend on changes in such cost items as transportation costs, wage rates, and service price of capital, and the relative prices on inputs and outputs. This is accomplished by exploiting the duality between production and price frontiers. The price frontiers are solved and expressed in terms of input elasticities, wage rates, the service price of capital, transportation costs, tax rates, technical progress parameters, and quantities of commodities. These equilibrium prices then determine the equilibrium multiregional input-output technical, trade, and primary input coefficients. As a consequence, changes in such costs as transporting commodities induces price changes which, in turn, alters the purchasing patterns of commodities throughout the economic system. The methodology of the MRVIO model works based on maximizing “system-wide” profits (revenues minus business costs) which are constrained to be simultaneously consistent with technical production requirements (production functions) and with consumption balances. Price relationships with changes in factor costs (labor, financial, transportation costs, and technological conditions) are derived by solving the detailed and complex system of mathematical equations of the MRVIO model. Changes in multiregional technical coefficients expressed in terms of changes in output-to-input price ratios, the inverse of changes in transportation costs, and underlying technical factors. These are also derived directly from the model’s mathematical optimization solution.

V.2.3 Effects of Infrastructure Productivity Changes

In addition to these water resources-savings effects, there are also broader induced productivity effects generated by water resources investments. The basic premise is that transportation improvements reduce the costs of capital, materials, energy, and even labor inputs used by firms, as well as, the transportation costs to deliver the products produced. One should also anticipate indirect systems interactions that spread quite readily within and between industries and regions depending on the competitiveness of the economic system. Factor cost reductions themselves should lead to lower production costs. Lower production costs in some firms relative to others should lead, in a competitive industry, to relative price changes for their goods and services. These changes in relative prices, in turn, should cause some goods and services to be consumed more, and others less. This chain of events is likely to change trading patterns among firms and, thus, between regions. It would also be expected to alter the factor mix in production processes within firms (i.e., technological change).

The great majority of studies analyzing the transportation infrastructure productivity effects have ignored these resource cost effects in their models and estimation procedures.[86] Kelejian and Robinson (2000) specifically analyzed the productivity effects of resource cost effects due to infrastructure investment, simultaneously, for both navigation and highway capital investments. One result of their investigation was the development of industry-specific navigation capital investment final demand elasticity estimates. An industrial final demand elasticity of navigation capital investment is the percentage change in final demand for a sector due to a one-percent (1%) change in navigation capital investment. They also evaluated the short- and long-run effects of navigation capital investments. The methodology employed by Kelejian and Robinson (2000) is to conjoin an econometrically estimated model of resource prices (for labor, energy, and materials) in relation to transportation infrastructure capital investments (i.e., highways and navigation) with a variable input-output (VIO) model of the U.S. economy. Kelejian and Robinson (2006) further refined their econometric resource price model to state economies, which can be then conjoined with a state-level MRVIO model.

V.2.4 Effects from Commodities Which Benefit from Water Resource Projects

Another type of regional economic effect that has been proposed and, in a large number of cases, implemented, are the regional economic effects of produced commodities hauled by tow boat operators on the communities and localities where they are produced. In some sense, these studies claim a "dependency" on the river or waterway. Can or should the performance (i.e., production levels) of the firms and industries which use our nation's waterways and ports and their related indirect effects (induced too) as possible performance measures of its activities? In other words, can we count the direct, indirect, and induced effects (i.e., impacts) of the coal mines that happen to ship their products via waterways and harbors as additional effects of water resource-related activities (as if the commodities could not be hauled by another means of transportation)?

These production effects are easy to compute and use the methodology and procedures described above (see the spending effects section). However, equation [3] indicates that changes in industrial production (i.e., $\Delta\boldsymbol{X}$) occur due to changes in final demand ($\Delta\boldsymbol{Y}$). It is important to note that the commodities hauled on the MKARNS are goods like coal, grain, gravel and sand, petroleum, and basic metal products. These commodities are intended for further processing (called intermediate goods) and, except for exports, are not generally consumed by final demand. Depending on the geographic perspective of the regional economic effects analysis, the production of goods and services will either be sold to intermediate demand

[86] The resource cost effects of transportation infrastructure development and the consequences of ignoring them for infrastructure productivity modeling are further discussed by Dalenberg and Partridge (1997), Haughwout (1998), and Kelejian and Robinson (2000).

or to final demand. It is inappropriate to count the extent to which the production of these goods is sold to intermediate demand. Only that part of the effects which is related to production sold to final demand **(**ΔY; e.g., exports) are counted appropriately as legitimate regional economic effects of water resource-related activities.

How does this discussion relate to the MKARNS activities? The answer is found in the manner in which projects and activities affect the production levels of the commodities shipped on the MKARNS or through the ports. It would take a large leap of faith or a large stretch of the imagination to consider that the production grain hauled on the MKARNS depends solely on the use of the existence of the MKARNS—i.e., the commodities cannot be hauled by another available mode of transport. Even if there are short-term capacity restrictions for other modes of transportation, it is likely that the number of rail cars or trucks could increase or that the rail and highway infrastructure could be enhanced in the intermediate- and long-term.[87] The usual way to think of how the water resources activities and projects effect the production of goods and services is through related transportation cost changes. These cost changes provide competitive advantages and disadvantages for the firms that produce and consume the commodities that use the waterways and ports. These advantages/disadvantages should translate into price changes for those commodities and the firms which use them to produce other goods and services. However, this "story" has already been told above in the discussion of the savings effects. *As a consequence, attempting to attribute the regional economic effects much beyond those associated with MKARNS-related cost and subsequent price reduction effects or due to the induced productivity effects is inappropriate.*

V.3 User Guide for the MKARNS MRVIO Spreadsheet Calculator

Many economists use the Input-Output (IO) model for impact analysis as a result of the easy, user friendly nature of the model. Yet, the IO model has a major drawback –its inability to take into account the change of price or cost change effect on output. This flaw is due to the IO model's inability to allow any input substitution in the model. In the IO model, output is determined in the quantity equation whereas prices from the model are determined by the cost equation. By not allowing substitution within the model, the model does not accurately depict profits maximizing behaviors of firms. For if a price or cost change occurs, the firm will switch to a cheaper alternative. In the IO model output is impacted by input price, yet; the model fails to account for the "dichotomy that exists between the price and quantity" (Liew and Liew, 1988). Economists began looking for a model that incorporated how business would react to price changes within the model which led to the creation of the Multiregional Variable Input – Output (MRVIO) Model.

The MRVIO model differs from the IO model in that the MRVIO model captures the optimizing behavior of firms by allowing firms to respond to changes in price and cost. The

[87]However, the related traffic congestion and environmental effects of significantly increasing the number of rail cars and trucks on the current system of the nation's highways and rail-lines could make this possibility rather socially and politically undesirable.

MRVIO model is able to fully capture the "optimizing behavior" of firms since the model is derived from "basic duality between the production frontier and price frontier" (Liew and Liew, 1985). By including the duality between production and price function, MRVIO model is able to trace the firm ability to substitute which the IO model was unable to do. Additional benefit of the MRVIO model is the ability to incorporate changes in transportation cost.

The MRVIO model treats a change in transportation cost as a substitution effect. This substitution effect will impact the regional technical and trade coefficient. How does a change in transportation cost affect the technical coefficient for a region? An improvement makes the delivery cost to transport on the waterway cheaper. This transportation improvement reduces not only delivery cost of inputs used by firms; this improvement also reduces the transportation cost to products produced (Liew and Liew, 1985). The improvement creates a reduction in delivering all goods and services in the region, thus leading to trickle- down effect lowering the factor and production cost, ceteris paribus. Reductions in waterway delivery costs lead to other modes of transportation lowering their delivery cost as well to compete causing major change in price within the market as more firms lower their price to remain competitive. Robinson (2013) explained in great detail how this reduction in delivery impacts the regional technological coefficient.

> "Factor cost reductions themselves should lead to lower production costs. Lower production costs in some firms relative to others should lead, in a competitive industry, to relative price changes for their goods and services. These changes in relative prices, in turn, should cause some goods and services to be consumed more, and others less. This chain of events is likely to change trading patterns among firms, and, thus, between regions. It would also be expected to alter the factor mix in production process within firms (i.e., technological change)."

Under the IO model, the regional technical coefficient is fixed "regardless of changes in output prices, input costs, or transportation costs" (Liew and Liew, 1985). As a result of this assumption, the IO model cannot measure the firm ability to substitute, whereas, the MRVIO model is able to incorporate the firm ability to substitute making the regional technical coefficient endogenous to the MRVIO model.

The MRVIO model shows a firm's quest to maximize profit guides every decision the firm makes on output, input mix, employment, income, and trade structure. The MRVIO make all the variables listed above price-sensitive subject to change when business costs change, thus; the model truly captures the profit maximizing behavior of firms. In additional to the MRVIO model's ability to measure impact of the MKARNS River, the model can measure the impact of the river in terms of "industrial outputs, interregional trade flows, and industrial transaction" (Liew and Liew, 1985).

In order to obtain a comprehensive and precise economic impact of the regional benefits of the MKARNS to the citizens of Oklahoma and Arkansas, as well as, other neighboring states (Kansas and Missouri) this project will incorporate the techniques used by Liew and Liew in their multiregional variable input–output (MRVIO) model. MRVIO model determines the changes in the regional technical coefficients of the input-output model that are subject to changes to transportation cost, wage rate, service price of capital and relative price changes on inputs and outputs. Liew and Liew (1985) used the duality between the production and price frontier which allows for the ability to determine input elasticities, wage rate, service price of capital, transportation costs, tax rates, technical advancement, and changes in quantity by solving the price frontier. Using the equilibrium price to calculate the equilibrium technical and input coefficient, we can determine how changes in cost will affect changes in price thus influencing purchasing quantity of the commodity. Maximizing the profits of firms (revenues minus business costs) and constraining the profits to be subject to technical constraints of the production function so that any changes in costs (transportation costs, labor, and technological) can be solved through mathematical computation of the MRVIO model.

VI ECONOMIC VALUE OF THE MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM

VI.1 What are the "With" and "Without" Conditions?

For the purpose of our study of the economic value of the Oklahoma portion of the McClellan-Kerr Arkansas Navigation System, we define the Oklahoma portion of the MKARNS to consist of the navigation channel from the Port of Catoosa to where it flows into the State of Arkansas.[88] This includes the seven projects that are managed by the Tulsa District Office of the U.S. Army Corps of Engineers shown in Table 42.[89] In addition, we also consider in our economic value study of the MKARNS the supporting functions of those upstream Tulsa District projects shown in Table 43.

The economic value of an existing activity or project is commonly determined by evaluating the consequences of ceasing the activity or project. In the terms used by the Corps of Engineers the "with" condition is for the Corps of Engineers to continue maintaining the existing state of the MKARNS. The so-called "without" condition is the hypothetical state of shutting down the McClellan-Kerr Arkansas Navigation System. This will mean that the functions performed by the MKARNS (shown in Table 42) will no longer be continued. These functions include such activities as navigation, hydropower, recreation, water supply, and flood control. However, it is assumed that the Corps will continue the maintenance and operations of the functions performed at the projects shown in Table 43 (i.e., that formally supported the MKARNS).

Specifically the navigation, hydropower, and recreation functions of the MKARNS will cease because it is expected that the navigation channel will be lowered to a "river" level by simply leaving the locks open. This will mean that the MKARNS' reservoirs will also be lowered.

Water supply is not an authorized function of the MKARNS. People are currently allowed to use the available water in the MKARNS for such purposes as irrigation (essentially by putting a pipe or hose in the waterway), however, if the water levels drop too low the Corps will not manage the MKARNS to maintain water supplies. As a result, because the MKARNS has no authorized water supply function we will not consider any economic effects of reduced water supplies due to the closure of the MKARNS. People will still be able to put hoses and pipes in the "Arkansas River". Water supply is an authorized function of the reservoirs upstream of the MKARNS and they will be maintained in the hypothetical event of closing the MKARNS.

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[88] This includes the section of the Verdigris River that connects the Port of Catoosa to the Arkansas River.

[89] See Appendix E for descriptions of the MKARNS projects managed by the Tulsa District of the US Army Corps of Engineers.

Table 42 McClellan-Kerr Arkansas River Navigation System and Related Corps-Managed Projects[90]

Tulsa District MKARNS Project	Navigation	Hydro Power	Water Supply	Flood Control	Recreation	Fish & Wildlife
Arkansas River Bank Stabilization and Channel Rectification, OK	X			X		
Chouteau Lock and Dam (#17)	X				X	X
Newt Graham Lock and Dam (#18)	X				X	X
Robert S. Kerr Lock and Dam (#15) and Reservoir	X	X			X	
Robert S. Kerr Marine Terminal	X					
Sans Bois Navigation Channel	X					
W. D. Mayo Lock and Dam (#14)	X					
Webbers Falls Lock and Dam (#16) and Reservoir	X	X				

Flood control is a function that is also performed by the upstream reservoirs (projects Table 42). This function is controlled by a river gage that measures water flow located at Fort Smith on the Arkansas side of the Oklahoma/Arkansas border. It is expected that this function will continue whether the MKARNS exists or not.

Table 43 MKARNS-Related Corps-Managed Projects[91]

Other Tulsa District Navigation Projects	Navigation	Hydro Power	Water Supply	Flood Control	Recreation	Fish & Wildlife
Big and Little Sallisaw Creeks Navigation Project, OK	X					
Poteau River Navigation Project, OK and AR	X					
Copan Lake (1)			X	X	X	X
Eufaula Lake	X	X	X	X		
Fort Gibson Lake		X		X		
Grand Lake O' the Cherokees (Pensacola Dam)		X		X		
Hulah Lake (2)			X	X		
Kaw Dam (3)		X	X	X	X	X
Keystone Lake	X	X	X	X		X
Lake Hudson (Markham Ferry Dam)		X		X		

[90] Source: Tulsa District. 2003. *Tulsa District Civil Works Projects Pertinent Data Sheets*. Tulsa, OK: Tulsa District, U.S. Army Corps of Engineers (November).

[91] (1) Copan Lake has a water quality function, (2) Hulah Lake has water conservation and low-flow regulation functions, (3) Kaw Lake has a water quality function, and (4) Wister Lake also has low-flow augmentation, water conservation & sedimentation functions. Functions marked with a red X have MKARNS supporting purposes. Source: Tulsa District. 2003. *Tulsa District Civil Works Projects Pertinent Data Sheets*. Tulsa, OK: Tulsa District, U.S. Army Corps of Engineers (November).

Other Tulsa District Navigation Projects	Navigation	Hydro Power	Water Supply	Flood Control	Recreat ion	Fish & Wildlife
Oologah Lake	X		X	X	X	X
Tenkiller Ferry Lake		X		X		
Wister Lake (4)			X	X		

We will evaluate the economic value of the MKARNS in the following sections the losses of MKARNS'

- Hydroelectric power capacity,
- Corps of Engineers operations and maintenance expenditures,
- Port activities,
- Shippers activities,
- Private sector waterway infrastructure investment expenditures,
- Transportation benefits,
- Recreational opportunities, and
- Environmental benefits

The economic impact results that follow are computed using the MKARNS MRSAM model. Please note that the base year for the model is 2011. This means that to use the MKARNS MRSAM model appropriately a user should make sure that monetary input values are expressed in terms of 2011 price levels (base year prices). The monetary impact results that the model generates will also be expressed in 2011 prices. All monetary input values that shown below are expressed in 2011 prices to be consistent with what data are entered into the model (unless otherwise noted). However, all of the monetary impact values that shown below have been re-valued in terms of 2015 prices for the readers' convenience.

VI.2 Loss of MKARNS Hydroelectric Power

The McClellan-Kerr Arkansas River Navigation System has hydroelectric power 170,000 kW capacity installed at Robert S. Kerr and Webber Falls Reservoirs (see Table 44). In 2012 they generated 395 million kWh of net energy. Based on the total possible hours of operations (8,760 hours), the facilities operate at a 45.1% capacity rate.

Table 44 MKARNS Hydropower Conversion Factor Calculations[92]

Project	Fiscal Year On-Line Date	Installed Capacity (kW) (1)	Estimated Annual Energy[2] (millions kWh) (2)	2012 Actual Net Energy (Millions kWh)	Cost Assigned to Power[3]	Total Project Cost (3)	% Cost Assigned to Power
Robert S. Kerr and Webber Falls	1971 & 74	170,000	672	395	$140,735,888	$267,771,507	52.6%
hours of operation	N/A	3,953	45.1%	N/A	N/A	N/A	N/A
hours in a year	N/A	8,760	45.1%	N/A	N/A	N/A	N/A
Oklahoma Electricity Price (4)	$0.0754	per kWh					
Retail Value of Electricity	$50,641,920	dollars					

If the hydropower plants at the Robert S. Kerr and Webbers Falls Reservoirs were shut down due to the closure of the MKARNS it is assumed that their equivalent power capacities would need to be replaced.[93] Table 45 shows operating characteristics and costs for five types of natural gas plants according to the U.S. Energy Information Administration.

Table 45 Natural Gas Power Plant Capital and Operating Cost Characteristics[94]

		Conventional CC (CCC)	Advanced CC (ACC)	Advanced CC with CCS (ACC w CCS)	Conventional CT (CCT)	Advanced CT (ACT)
Plant Character-istics	Nominal Capacity (MW)	620	400	340	85	210
	Heat Rate (Btu/kWh)	7,050	6,430	7,525	10,850	9,750
Plant Costs (2012 dollars)	Overnight Capital Cost ($/kW)	$917	$1,023	$2,095	$973	$676
	Fixed O&M Cost ($/kW-yr)	$13.17	$15.37	$31.79	$7.34	$7.04
	Variable O&M Cost ($/MWh)	$3.60	$3.27	$6.78	$15.45	$10.37

[92] (1) Installed capacity at hydroelectruic power plants at Robert S. Kerrt and Webber Falls reservoirs. (2) For each of the 24 projects in Southwestern's marketing area, a planning study was conducted by the U.S. Army Corps of Engineers prior to construction to forecast the quantity of energy that could be produced under average hydrological conditions. The term "Estimated Annual Energy" used in the table above represents the quantity of this forecasted energy on an annual basis. (3) Includes construction work in progress with plant in service less contributions in aid of construction. (4) Energy Information Administration, U.S. Department of Energy. Source: Southwestern Power Administration 2012 Annual Report

[93] For the purposes of analysis in this report we only consider the replaced of the equivalent power capacity not more. That is, we don't consider larger plant capacities to accommodate future growth.

[94] Source: Energy Information Administration. U.S. Department of Energy.

The problem with Table 45 is that the different types of natural gas plants come in different sizes, heat rates, and capacity rates. Table 46 shows the equivalent plant sizes (PS needed) needed to hydroelectric power plants on the MKARN—that is, in order to generate 395 million kWh of net energy per year. The equivalent natural gas plants and their generation capacities are provided in the "right-hand" side of Table 43.

Table 46 Natural Gas Power Plant Equivalencies to MKARNS Hydropower[95]

	Conventional Combined Cycle	Advanced Combined Cycle	Advanced CC with CCS	Conventional Combustion Turbine	Advanced Combustion Turbine
Nominal Capacity (MW)	620	400	340	85	210
Heat Rate (Btu/kWh)	7,050	6,430	7,525	10,850	9,750
Overnight Capital Cost ($/kW)	$917	$1,023	$2,095	$973	$676
Capacity Factor	87	87	87	30	30
Potential (mill kWh)	4,725	3,048	2,591	223	552
Capacity (kW)	620,000	400,000	340,000	85,000	210,000
Plant Size Factor	0.0836	0.1296	0.1524	1.7683	0.7157
Plant Size Needed	51,829	51,829	51,829	150,304	150,304

The overnight capital costs represent the total costs to build a new power plant. The "variable" and "fixed" operations and maintenance (O&M) costs are the operation costs of a plant. Because these costs will be paid over time, the future payments need to be discounted in terms of "today's" dollars and "annualized" to reflect annual payment equivalents. We expect that a new power plant has an expected life of 30 years and that the construction costs will be financed over that expected period. We also expect that the construction costs will be financed using a "bond" mechanism, such as a corporate or municipal bond. Table 47 shows corporate, municipal, and Treasury bond rates for varying maturity dates. Note that the "20-year" corporate bond yield is 3.41%. The trend in these bond yields are increasing but at dimensioning rates. The currently used discount rate used by the U.S. Army Corps of Engineers is 3.375%. This appears to approximate what the corporate bond yield would be if the yields were extended to 30 years in Table 47. Therefore, we use the Corps' discount rate to approximate the appropriate bond rate in our analyses of natural gas plant construction and O&M costs.

[95] Note: Overnight capital costs in 2012 price levels.

Table 47 Boned Rate Comparisons by Maturity Dates[96]

Year	Corporate	Municipal	Treasury
2	0.79%	0.53%	0.47%
3	N/A	N/A	0.91%
5	1.71%	1.27%	1.55%
10	3.17%	2.15%	2.24%
20	3.41%	3.00%	N/A
30	N/A	N/A	2.95%

The “left-hand” side of Table 48 shows the construction and O&M costs for the five types of natural gas power plants considered herein. The discounted construction costs are shown in total and its equivalent “annualized” costs. The annualized construction costs reflect what the electricity customers would be charged annually (over a 30-year period) to finance the new power plant.

Table 48 Natural Gas Plant Costs Equivalent to MKARNS Hydropower Plants[97]

	Conventional Combined Cycle	Advanced Combined Cycle	Advanced CC with CCS	Conventional Combustion Turbine	Advanced Combustion Turbine	Conventional Hydroelectric
Capacity (kW)	51,829	51,829	51,829	150,304	150,304	170,000
Energy (million kWh)	395	395	395	395	395	395
Overnight Cap Cost ($/kW)	$917	$1,023	$2,095	$973		$2,936
Fixed O&M Cost ($/kW)	$13.17	$15.37	$31.79	$7.34	$7.04	$14.13
Variable O&M Cost ($/MWh)	$3.60	$3.27	$6.78	$15.45	$10.37	$0.00
Total Overnight Capital Costs ($mill)	$47.5	$53.0	$108.6	$146.2	$101.6	N/A
Annualized Overnight Capital Costs ($mill)	$2.6	$2.9	$6.0	$8.1	$5.6	N/A
Total Fixed O&M Cost ($mill)	$0.68	$0.80	$1.65	$1.10	$1.06	$2.40
Total Variable O&M Cost ($mill)	$1.42	$1.29	$2.68	$6.10	$4.10	$0.00
Total Annual Cost ($mill)	$2.10	$2.09	$4.33	$7.21	$5.15	$2.40

[96] Source: KCG BondPoint, A Division of KCG Americas LLC. Copyright © 2013 KCG Holdings Inc. Reported by ABC News Network.

[97] Note: Monetary values in 2012 price levels.

Table 49 adjusts these cost estimates for inflation and restates them in terms of 2011 price levels.

Table 49 Total and Annualized Natural Gas Plant Costs[98]

Type of Power Plant	Total Overnight Capital Costs		Total Fixed O&M Cost	Total Variable O&M Cost	Total Annual Cost
	Total	Annualized			
Conventional Combined Cycle	**$46.7**	**$2.6**	**$0.67**	**$1.40**	**$2.07**
Advanced Combined Cycle	**$52.1**	**$2.9**	**$0.78**	**$1.27**	**$2.05**
Advanced CC with CCS	**$106.7**	**$5.9**	**$1.62**	**$2.63**	**$4.25**
Conventional Combustion Turbine	**$143.7**	**$8.0**	**$1.08**	**$5.99**	**$7.08**
Advanced Combustion Turbine	**$99.8**	**$5.5**	**$1.04**	**$4.02**	**$5.06**
Conventional Hydroelectric	**N/A**	**N/A**	**$2.36**	**$0.00**	**$2.36**

VI.2.1 Economic Comparison of MKARNS Hydroelectric Power Generation versus Natural Gas Power Generation

Table 49 provides the basic information necessary to carry out the impact assessments so that the economic effects of operating the MKARNS hydroelectric power generation facilities with those of an equivalent natural gas power plant. The economic effects of the natural gas power plant will depend on which of the available technologies will be used. For the purpose of the analysis here, we assume that the new natural gas power plant will use an advanced combined cycle technology. This also happens to be the “least cost” method in terms of total annual operating costs that has a slightly higher total construction cost than the conventional combined cycle technology.

In his 2007 dissertation, Joe Marriott provides detailed estimates of normalized production requirements for various types of electricity power generation methods (e.g., coal, natural gas, hydropower, solar, etc.). We updated his estimates to reflect 2011 prices and to have consistent commodity classifications with the MKARNS MRSAM model. Commodity expenditures necessary to compute the economic effects of generating electricity by either hydropower or natural gas (using the MKARNS MRVIO spreadsheet program) are calculated by multiplying the total annual operations and maintenance costs for hydropower and the advanced combined cycle natural gas generation (Table 49) by the respective normalized operations and maintenance costs for hydropower and natural gas generation (Table 50).

[98] Note: Monetary values in millions of 2011 dollars.

Table 50 Normalized Operations and Maintenance (O&M) and Construction Costs per Mission Dollars of Output (2011 prices)[99]

Code	Commodity Input	Hydropower O&M	Natural Gas O&M	Natural Gas Construction Costs
15	Crude petroleum	$0	$77,134	$0
16	Gasoline, aviation turbine fuel and fuel oils	$0	$6,931	$55,258
17	Coal and petroleum products, NEC	$315	$23	$1,624
18	Basic chemicals	$74	$10	$0
21	Chemical products & preparations, NEC	$247	$17	$0
22	Plastics & rubber products	$176	$13	$3,499
23	Logs & wood in the rough	$381	$26	$0
24	Wood products	$44	$4	$0
25	Pulp, newsprint, paper & paperboard	$658	$44	$0
26	Paper and paperboard articles	$638	$46	$0
27	Printed products	$773	$50	$0
29	Nonmetalic mineral products	$826	$52	$2,423
30	Primary and semifinished base metal forms and shapes	$810	$53	$36,605
31	Base metal products	$793	$51	$16,839
32	Machinery	$25	$3	$4,913
33	Electronic and electrical equipment and components	$270	$19	$0
34	Motorized vehicles (including parts)	$0	$2	$6,498
37	Furniture, fixtures, lamps and lighting equipment	$42	$4	$0
38	Miscellaneous manufactured products	$921	$57	$0
42	Utilities	$14	$1	$8,866
43	Contract construction	$9,295	$613	$1,782
44	Support activities for printing	$0	$2	$0
45	Wholesale trade	$12,224	$808	$0
46	Retail stores	$432	$28	$6,223
47	Air transportation	$571	$40	$0
48	Rail transportation	$1,718	$114	$7,368
49	Water transportation	$0	$0	$7,368
50	Truck transportation	$0	$0	$3,684
51	Transit and ground passenger transportation	$2,248	$148	$13,732
52	Pipeline transportation	$262	$15	$0
53	Scenic, sightseeing and transportation support	$0	$9,645	$0
54	Postal Service	$451	$36	$7,368
55	Couriers and messengers	$5,209	$351	$7,368
56	Warehousing and storage	$0	$3	$0
57	Publishing industries (except internet)	$7,022	$467	$18,545
58	Motion picture and sound recording industries	$2,310	$151	$6,249

[99] Source: Joe Marriott Dissertation (2007).

Code	Commodity Input	Hydropower O&M	Natural Gas O&M	Natural Gas Construction Costs
59	Broadcasting (except internet)	$0	$1	$2,272
60	Telecommunications	$62	$6	$24,641
61	Data processing, hosting and related services	$135	$12	$37,984
63	Monetary authorities and credit intermediation	$97	$6	$0
64	Securities, commodity contracts and other financial investments and related activities	$11,230	$743	$7,368
65	Insurance carriers and related activities	$3,090	$202	$127,604
66	Funds, trusts, and other financial vehicles	$410	$26	$0
67	Real estate	$492	$30	$0
68	Rental and leasing services	$2,011	$127	$3,405
69	Lessors of nonfinancial intangible assets (except copyrighted works)	$16,822	$1,110	$3,684
70	Professional, scientific and technical services	$1,915	$126	$3,712
71	Management of companies and enterprises	$6,369	$420	$0
72	Administrative and support services	$226	$15	$291
73	Waste management and remediation services	$0	$2	$0
74	Educational services	$139	$8	$0
75	Ambulatory health care services	$0	$4	$0
76	Hospitals	$0	$5	$0
77	Nursing and residential care facilities	$1,224	$71	$3,684
78	Social assistance	$5,127	$339	$1,357
79	Performing arts, spectator sports and related industries	$101	$7	$9,308
80	Museums, historical sites and similar institutions	$515	$31	$0
81	Amusement, gambling and recreation industries	$639	$46	$0
84	Repair and maintenance	$996	$65	$873
85	Personal and laundry services	$0	$1	$822
86	Religious, grantmaking, civic, professional and similar organizations	$35	$3	$448
EC	Employee compensation	$208,379	$208,550	$498,994
OVA	Other value added	$691,238	$691,079	$57,344
	Total Purchases	$1,000,000	$1,000,000	$1,000,000

Tables 51 and 52 show the regional summaries of the economic effects of generating electricity by hydropower and natural gas (advanced combined cycle). We will not show the impacts by industry for either of these two cases given the small magnitude of the impacts shown above (i.e., respective magnitudes are not likely to be very informative).

Table 51 MKARNS Hydroelectric Power Generation Impacts[100]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$3,595	11	$628	$872	$281	$1,781
Arkansas	$33	0	$9	$6	$1	$16
Oklahoma	$831	6	$219	$205	$40	$463
Power Plant	$2,360	2	$311	$562	$225	$1,098
Kansas	$37	0	$10	$7	$1	$18
Missouri	$55	0	$15	$11	$2	$28
Texas	$280	2	$64	$82	$12	$158
Rest of US	$643	4	$172	$153	$24	$349
US Total Impact	$4,239	14	$799	$1,025	$305	$2,129

Table 52 Natural Gas Advanced Combined Cycle Power Generation Impacts[101]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$3,231	9	$547	$800	$258	$1,604
Arkansas	$20	0	$5	$4	$1	$9
Oklahoma	$681	5	$167	$176	$35	$379
Power Plant	$2,051	2	$270	$489	$196	$954
Kansas	$35	0	$7	$6	$1	$15
Missouri	$41	0	$11	$8	$1	$20
Texas	$403	2	$86	$117	$23	$227
Rest of US	$521	3	$138	$120	$21	$279
US Total Impact	$3,752	12	$684	$921	$279	$1,883

The economic loss to Oklahoma due to shutting down the MKARNS hydroelectric facilities is the difference between the economic effects of the hydroelectric power generation (Table 52) and the economic effects of the natural gas power generation (Table 51). Since the hydropower impacts on the State of Oklahoma are larger than those generated by natural gas, there appears to be a net loss of economic activity associated with the loss of the MKARNS hydropower plants. However, this net economic loss is due to considering the advanced combined cycle natural generation technology to replace the hydropower plants. There would be a net economic gain had we chosen the conventional combustion turbine natural gas generating technology (due to higher total annual O&M costs). However, the construction costs for the conventional combustion turbine technology is almost three times higher than for the advance combined cycle technology (i.e., $143.7 million as compared with $52.1 million, respectively in Table 46).

[100] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[101] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

VI.2.2 Comparison of Natural Gas Plant Construction versus Its Opportunity Cost

Table 49 indicates that the total overnight capital costs for an advanced combined cycle natural gas power plant that is equivalent to the current MKARNS hydroelectric facilities is $52.1 million. This figure represents an amount of money that will generate economic effects of some size. However, it also is an amount of money that will have to be paid back by the power company's customers in terms of higher utility rates.

Table 53 Economic Impacts of Construction an Advanced Combined Cycle Power Plant[102]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$56,987	310	$12,785	$12,900	$1,864	$27,549
Arkansas	$845	5	$191	$151	$28	$369
Oklahoma	$45,873	247	$10,062	$10,252	$1,423	$21,737
Kansas	$965	6	$242	$199	$31	$472
Missouri	$1,307	8	$339	$267	$46	$652
Texas	$7,998	44	$1,951	$2,031	$337	$4,319
Rest of US	$18,162	100	$4,913	$4,157	$696	$9,766
US Total Impact	$75,149	410	$17,697	$17,057	$2,560	$37,315

Table 54 Household Income Impacts Forgone due to Constructing a New Advanced Combined Cycle Power Plant[103]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$93,581	654	$24,007	$23,105	$4,678	$51,790
Arkansas	$1,811	12	$431	$317	$56	$804
Oklahoma	$64,522	482	$16,942	$16,179	$3,429	$36,550
Kansas	$2,813	19	$699	$529	$89	$1,317
Missouri	$4,283	27	$1,167	$833	$157	$2,157
Texas	$20,152	114	$4,768	$5,247	$947	$10,962
Rest of US	$40,767	231	$10,895	$9,064	$1,588	$21,548
US Total Impact	$134,348	885	$34,902	$32,169	$6,266	$73,338

We do not include the construction impacts as part of the economic value of the MKARNS because they represent both a source of economic gain (construction activity impacts) and also a source of economic loss (the foregone household income) of about the same magnitudes—e.g., there are about 475 full and part-time jobs separating the economic effects of foregone income (Table 54) and construction impacts (Table 53).

[102] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[103] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

VI.2.3 Net Economic Losses Due to Changes in Electric Power Generation

The loss of hydropower generation capacity on the Oklahoma portion of the MKARNS is estimated to decrease the nation's business sales annually by $134.8 million (in 2015 prices): see Table 55. The loss in contribution to the nation's gross domestic product (GDP) is $73.6 million and gross business operating surplus is $32.3 million after all other expenses have been paid (i.e., rents, dividends, interest, and profits). Oklahoma's portion of the MKARNS is responsible for 890 of the nation's full and part-time jobs and for $35.0 million in employee compensation. Business taxes and license fees total $6.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $93.9 million in business sales, $52.0 million in GDP, 655 full and part-time jobs, $24.1 million in employee compensation, $23.2 million in gross business operating surplus, and $4.7 million in business taxes. The State of Oklahoma also shares in the economic value: $65.0 million in business sales, $36.8 million in GDP, 480 full and part-time jobs, $17.0 million in employee compensation, $16.3 million in gross business operating surpluses, and $3.5 million in business taxes.

Table 55 Net Losses Due to Changes in Electricity Generation Capacity[104]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$93,945	655	$24,088	$23,177	$4,701	$51,967
Arkansas	$1,823	12	$435	$319	$57	$811
Oklahoma	$64,981	484	$17,036	$16,280	$3,462	$36,779
Kansas	$2,815	19	$701	$530	$89	$1,320
Missouri	$4,297	28	$1,171	$836	$158	$2,164
Texas	$20,029	113	$4,746	$5,212	$936	$10,893
Rest of US	$40,889	232	$10,929	$9,097	$1,592	$21,617
US Total Impact	$134,834	887	$35,017	$32,274	$6,293	$73,584

VI.3 Economic Losses of Public and Private Sector Expenditures

Closing the MKARNS will mean reductions in private and public waterway-related spending in Oklahoma. The US Army Corps of Engineers spends money annually to operate and maintain the MKARNS that will no longer be needed without the MKARNS. Private port and cargo shipping activities will cease if the MKARNS closes. In addition, private sector interests make substantial annual investments to enhance their infrastructure.

VI.3.1 Loss of Corps Operations and Maintenance Expenditures

The Tulsa District of the U.S. Army Corps of Engineers currently spends about $10.4 million annually to keep the MKARNS operational (including dredging activities).[105] It is

[104] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[105] Person communications with Dr. Edwin Rossman (USACE, Tulsa District).

estimated that $7.4 million are used to purchase needed goods and services and about $3.1 million are used to pay labor.[106] Table 56 shows the discounted and annualized operations and maintenance expenditures by type of commodity purchased.

Table 56 Tulsa Corps District Annualized MKARNS O&M Expenditures[107]

Code	Commodity	Corps O&M Expenditures
7	Other foodstuffs and fats & oils	$180
11	Natural sands, gravel & crushed stone	$197
16	Gasoline, aviation turbine fuel & fuel oils	$600
30	Primary & semifinished base metal forms & shapes	$206
31	Base metal products	$711
35	Transport equipment	$163
43	Contract Construction	$1,482
68	Rental and Leasing Services	$497
70	Professional, Scientific, and Technical Services	$343
72	Administrative and Support Services	$643
84	Repair and Maintenance	$1,011
88	Public Institutions	$1,311
5001	Employee Compensation	$3,147
	Total	$10,489

The loss of the annual Corps District's operations and maintenance expenditures in the Oklahoma due to the closure of the MKARNS is estimated to decrease the nation's business sales annually by $33.7 million (in 2015 prices): see Table 57. The loss in contribution to the nation's gross domestic product (GDP) is $18.3 million and gross business operating surplus is $7.3 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 230 of the nation's full and part-time jobs and for $9.9 million in employee compensation. Business taxes and license fees total $1.4 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $24.5 million in business sales, $13.5 million in GDP, 180 full and part-time jobs, $7.3 million in employee compensation, $5.3 million in gross business operating surplus, and $1.0 million in business taxes. The State of Oklahoma also shares in the economic value: $16.6 million in business sales, $9.4 million in GDP, 130 full and part-time jobs, $5.2 million in employee compensation, $3.5 million in gross business operating surpluses, and $0.7 million in business taxes.

[106] These cost figures have been discounted (at a 3.75% rate) over a 50-year period and then annualized.

[107] Notes: Tulsa District receives $10 million annually for MKARNS O&M. Funds are discounted over a 50 year period using a 3.375% discount rate. Monetary values in thousands of 2011 dollars. Source: Tulsa District, U.S. Army Corps of Engineers.

Table 57 Tulsa Corps District's O&M Impacts[108]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$24,533	178	$7,225	$5,298	$1,003	$13,525
Arkansas	$594	4	$136	$102	$18	$256
Oklahoma	$16,596	131	$5,240	$3,460	$680	$9,380
Kansas	$599	4	$146	$114	$19	$278
Missouri	$834	5	$219	$160	$29	$408
Texas	$5,910	34	$1,484	$1,461	$257	$3,203
Rest of US	$9,211	51	$2,457	$2,009	$348	$4,814
US Total Impact	$33,743	229	$9,682	$7,307	$1,351	$18,339

VI.3.2 Loss of Private Sector Investment Expenditures

Oklahoma's private sector waterborne commerce interests (e.g., ports, shippers, etc.) have made substantial investments in waterway capital infrastructure (equipment and facilities) since the inception of the MKARNS—approximately $5 billion in total since 1971 (see Table 58).

Table 58 Oklahoma Private Sector Waterways Investment Expenditures[109]

Calculation Assumptions	Value
Total private capital expenditures	$5,000,000
Current Year	2014
Year MKARNS opened	1971
Number of years	43
Discount Rate	3.375%
Annual Discounted Private Sector Expenditures	**Value**
Total annual expenditures	$222,027
Expenditures for structures (8%)	$17,762
Expenditures for equipment (92%)	$204,265

If we assume that these monies were invested over time (43 years) at a 3.375% discount rate then the annualized equivalent investment is $222 million. We assume that this type of investment will be continued into the future annually. Using the latest Annual Capital Expenditure Survey (U.S. Census Bureau) split between water transportation sector capital expenditures for structures (8%) and equipment (92%) is typical for the MKARNS in Oklahoma

[108] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[109] Note: The split between structures and equipment based on the 2011 and 2012 average structures/equipment capital expenditure ratio for water transportation. Monetary values in thousands of dollars. Source: 2012 Annual Capital Expenditure Survey. Census Bureau, U.S. Department of Commerce.

then approximately $17.8 million will be spent annually for structure improvements and $204.3 million will be spent for the purchase of new equipment.

The latest capital expenditure flow data were published in relation to the 1997 Benchmark National Input-Output Table (U.S. Bureau of Economic Analysis, 2003). These data allow us to distribute the capital structures and equipment expenditures to the commodities of the MKANRS MRSAM model (Table 59).

Table 59 Oklahoma's Water Transportation Capital Expenditures[110]

Code	MKARNS Model Commodity	Value
28	Textiles and leather products	$45
31	Base metal products	$2,707
32	Machinery	$9,341
33	Electronic and electrical equipment and components	$76,373
34	Motorized vehicles (including parts)	$4,597
35	Transport equipment	$79,254
37	Furniture, fixtures, lamps and lighting equipment	$1,447
44	Support activities for printing	$17,762
45	Wholesale trade	$12,643
46	Retail stores	$4,793
47	Air transportation	$775
48	Rail transportation	$95
50	Truck transportation	$604
57	Publishing industries (except internet)	$1,170
70	Professional, scientific, and technical services	$10,385
89	Noncomparable imports and non-sector accounts	$35
	Commodity Total	$222,027

The loss of the annual Corps District's operations and maintenance expenditures in the Oklahoma due to the closure of the MKARNS is estimated to decrease the nation's business sales annually by $629.5 million (in 2015 prices): see Table 60. The loss in contribution to the nation's gross domestic product (GDP) is $291.5 million and gross business operating surplus is $112.3 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 3,110 of the nation's full and part-time jobs and for $158.5 million in employee compensation. Business taxes and license fees total $20.7 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $272.7 million in business sales, $124.6 million in GDP, 1,480 full and part-time jobs, $67.4 million in employee compensation, $47.9 million in gross business operating surplus, and $9.4 million in business

[110] Note: Does not include structures, in 1997 there were none. Investment expenditures (in thousands of dollars) have been converted to 2011 price levels and recoded to the MKARNS sectors. Source: Meade, Douglas S.; Stanislaw J. Rzeznik; and Darlene C Robinson-Smith. 2003. "Business Investment by Industry in the U.S. Economy for 1997." Survey of Current Business (November), pp. 18-70.

taxes. The State of Oklahoma also shares in the economic value: $129.2 million in business sales, $61.6 million in GDP, 820 full and part-time jobs, $33.6 million in employee compensation, $23.3 million in gross business operating surpluses, and $4.8 million in business taxes.

Table 60 Loss of Private Sector Investment Expenditure Impacts[111]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$272,743	1,475	$67,403	$47,850	$9,391	$124,644
Arkansas	$9,593	49	$2,151	$1,348	$239	$3,737
Oklahoma	$129,247	818	$33,564	$23,263	$4,771	$61,598
Kansas	$17,441	80	$3,935	$2,289	$409	$6,634
Missouri	$25,424	112	$5,961	$3,442	$639	$10,042
Texas	$91,038	416	$21,791	$17,508	$3,334	$42,633
Rest of US	$356,738	1,630	$91,116	$64,438	$11,299	$166,853
US Total Impact	$629,482	3,105	$158,519	$112,288	$20,690	$291,497

VI.3.3 Loss of Transportation Services

Closing the McClellan-Kerr Arkansas River Navigation System will impact the loss of transportation services that are currently performed by ports and barge operations on the MKARNS. River ports perform many activities and services. This section discusses these economic losses that would be expected in the event that the MKARNS closes. The economic effects of port activities are related to the nature of the commodities being handled—specifically whether they are liquid bulk, break bulk, or dry bulk. We grouped the break bulk traffic with the dry bulk. Discounted and annualized cargo port costs per ton of cargo for various port-related activities by cargo type are given in Table 61. Incoming and outgoing waterborne traffic are shown in Tables 62 and 63. Multiplying the costs per ton by the respective tonnages provides estimates of the direct value of the port activities in Oklahoma.

Table 61 Discounted and Annualized Port Activity Costs by Type of Cargo per Ton[112]

Type of Cargo	IMPLAN	Dry Bulk and Other (2011 prices)	Liquid Bulk (2011 prices)
Short Haul Trucking	335	$17.37	$24.55
Long Haul Trucking	335	$35.57	$57.35

[111] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[112] Note: Weighted averages do not include liquid bulk traffic from port survey. Values have been discounted and annualized over a 50 year period. Discount rate is 3.375%. Source: USACE Navigation Investment Model, Sample Data from the Ohio River System (Landon, 2010). Landon, Buddy, Navigation Planning Center, personal communication with IWR) on July 16, 2010. Taken from the Institute for Water Resources (IWR). 2011. *RECONS MODEL Methodology Manual: Stemming-From Effects of USACE Programs and Infrastructure*. Alexandria, VA: U.S. Army Corps of Engineers (October).

Type of Cargo	IMPLAN	Dry Bulk and Other (2011 prices)	Liquid Bulk (2011 prices)
Rail	333	$5.69	$7.25
Barge	334	$1.50	$1.50
Port Services	338	$3.15	$26.23
Fuel	115	$2.80	$2.88
Warehousing	340	$0.55	$27.27
Security	387	$0.86	$7.04
Lodging	411	$0.09	$0.09
Supplies	319	$0.07	$0.22
Total		$67.65	$154.39

Table 62 Oklahoma's 2012 Incoming Waterborne Traffic[113]

Code	Commodity	From	Tons
2229	Petroleum Products	RUS	35,056
3100	Chemical Fertilizers	LA	1,408,521
3100	Chemical Fertilizers	RUS	48,056
3200	Chemicals excl. Fertilizers	LA	24,057
4349	Sand, Gravel, Shells, Clay, Salt and Slag	AR	92,032
4349	Sand, Gravel, Shells, Clay, Salt and Slag	LA	28,353
5354	Primary Metal Products	AR	42,756
5354	Primary Metal Products	LA	73,915
5354	Primary Metal Products	RUS	170,561
6168	Food and Food Products	AR	29,851
6168	Food and Food Products	LA	96,922
6168	Food and Food Products	RUS	148,139
8099	Unknown & Not Elsewhere Classified	AR	13,152
8099	Unknown & Not Elsewhere Classified	LA	146,803
8099	Unknown & Not Elsewhere Classified	MO	66,981
8099	Unknown & Not Elsewhere Classified	RUS	198,393
8099	Unknown & Not Elsewhere Classified	TX	8,224
	Total		2,631,772

Table 63 Oklahoma's 2012 Outgoing Waterborne Traffic[114]

Code	Commodity	To	Tons
1000	Coal, Lignite, and Coal Coke	LA	436,020
2100	Crude Petroleum	LA	192,616
2229	Petroleum Products	LA	320,253
2229	Petroleum Products	TX	106,902

[113] Source: U.S. Waterborne Commerce Statistics Center.

[114] Source: U.S. Waterborne Commerce Statistics Center.

Code	Commodity	To	Tons
4400	Iron Ore, Iron, & Steel Scrap	LA	175,707
4400	Iron Ore, Iron, & Steel Scrap	RUS	18,105
6168	Food and Food Products	LA	1,176,190
6168	Food and Food Products	RUS	50,973
8099	Unknown & Not Elsewhere Classified	AR	99,861
8099	Unknown & Not Elsewhere Classified	LA	155,342
8099	Unknown & Not Elsewhere Classified	MO	23,000
8099	Unknown & Not Elsewhere Classified	OK	6,308
8099	Unknown & Not Elsewhere Classified	RUS	685,269
8099	Unknown & Not Elsewhere Classified	TX	37,414
	Total		3,483,960

Using the MKARNS MRVIO software program (and treating the costs as commodity demand changes), we computed the economic effects stemming from the port activities (see Table 64). The loss of port activities (i.e., expenditures) in the Oklahoma due to the closure of the MKARNS is estimated to decrease the nation's business sales annually by $1.0 billion (in 2015 prices). The loss in contribution to the nation's gross domestic product (GDP) is $400.9 million and gross business operating surplus is $180.5 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 5,070 of the nation's full and part-time jobs and for $195.2 million in employee compensation. Business taxes and license fees total $25.2 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $534.4 million in business sales, $144.6 million in GDP, 2,320 full and part-time jobs, $57.1 million in employee compensation, $79.1 million in gross business operating surplus, and $8.4 million in business taxes. The State of Oklahoma also shares in the economic value: $387.3 million in business sales, $69.6 million in GDP, 1,440 full and part-time jobs, $17.9 million in employee compensation, $48.5 million in gross business operating surpluses, and $3.3 million in business taxes.

Table 64 Port Activity Impacts[115]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$534,446	2,324	$57,108	$79,137	$8,359	$144,604
Arkansas	$5,720	37	$1,416	$964	$169	$2,549
Oklahoma	$387,324	1,437	$17,853	$48,508	$3,268	$69,629
Kansas	$4,884	29	$1,187	$869	$147	$2,204
Missouri	$7,413	44	$1,920	$1,445	$259	$3,624
Texas	$129,104	777	$34,732	$27,351	$4,516	$66,598
Rest of US	$483,885	2,749	$138,133	$101,329	$16,868	$256,329
US Total Impact	$1,018,331	5,073	$195,241	$180,465	$25,227	$400,933

[115] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

Even though the MKARNS ports considered in this report are all located in Oklahoma and even though the port activities also occur in Oklahoma, we note that the largest regional economic effects are expected to occur in the rest of the U.S. However, the State of Oklahoma port activity impacts are nearly as large as those for the rest of the nation. Nearly 1,440 full and part-time jobs in Oklahoma depend on Oklahoma's port activities. Much smaller impacts are expected in the States of Arkansas, Kansas, Missouri, and Texas (approximately 890 full and part-time jobs). In addition, a little more than 5,070 full and part-time jobs also depend on Oklahoma's port activities nation-wide.

Computing the economic effects of shipper activities is somewhat more complex. Some of the shippers' activities involve cargo handling related to loading and loading commodities on and off barges. These activities occur at or very near the ports in Oklahoma. As a consequence, the economic effects of the cargo handling activities are computed in a manner similar to those of the port activities. That is, one multiplies the per ton cargo handling costs (shown on the "right-hand" side of Table 65) by the total tonnages loaded on or off barges (Tables 62 and 63). Then, these resulting costs are entered into the MKARNS MRVIO software program as industry demand changes. The economic effects are then computed.

On the other hand, shippers incur "line haul" or transportation-related costs. The trouble is, how do we attribute the shipping activities to location? For example, part of the trips occur in Oklahoma (incoming and outgoing), part in Arkansas, and part elsewhere. We decided to attribute the water line haul costs to the origin of the traffic movements. Oklahoma gets credit for all of the water line haul costs for those movements starting in Oklahoma. Water line haul costs attributed to places other than Oklahoma are calculated by multiplying the water line haul costs per ton (Table 65) by the respective tons of incoming waterborne traffic (Table 62). Similarly, water line haul costs attributed to Oklahoma are calculated by multiplying the water line haul costs per ton (Table 65) by the respective tons of outgoing waterborne traffic (Table 63). The economic impacts of the water line costs by region directly affected are computed by entering the water line haul costs as an industry demand change for water transportation (MKARNS model sector number 49).

Table 65 Discounted and Annualized Shipper Costs per Ton (2011 prices)[116]

Commodity	Water Line Haul Costs (IMPLAN 334)	Loading, Unloading, & Handling Costs (IMPLAN 338)
Ores and Minerals	**$27.33**	**$5.33**
Coal	**$7.86**	**$4.47**

[116] Note: Costs are expressed in dollars per ton ($/ton). Values have been discounted and annualized over a 50 year period. Discount rate is 3.375%. Source: USACE Navigation Investment Model, Sample Data from the Ohio River System (Landon, 2010). Landon, Buddy, Navigation Planning Center, personal communication with IWR) on July 16, 2010. Taken from the Institute for Water Resources (IWR). 2011. *RECONS MODEL Methodology Manual: Stemming-From Effects of USACE Programs and Infrastructure*. Alexandria, VA: U.S. Army Corps of Engineers (October).

Commodity	Water Line Haul Costs (IMPLAN 334)	Loading, Unloading, & Handling Costs (IMPLAN 338)
Petroleum	**$42.66**	**$2.83**
Crude Petroleum	**$67.50**	**$1.64**
Aggregates	**$7.54**	**$2.73**
Graines	**$13.46**	**$5.94**
Chemicals	**$58.78**	**$2.97**
Iron and Steel	**$19.85**	**$8.81**
All Commodities	**$19.63**	**$4.62**

The loss of shippers' cargo handling activities and their water line haul costs (i.e., expenditures) in the Oklahoma portion of the MKARNS are estimated to decrease the nation's business sales annually by $1.5 billion (in 2015 prices): see Table 66. The loss in contribution to the nation's gross domestic product (GDP) is $747.9 million and gross business operating surplus is $323.5 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 8,970 of the nation's full and part-time jobs and for $378.3 million in employee compensation. Business taxes and license fees total $46.1 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $784.0 million in business sales, $391.2 million in GDP, 4,910 full and part-time jobs, $191.4 million in employee compensation, $176.8 million in gross business operating surplus, and $23.0 million in business taxes. The State of Oklahoma also shares in the economic value: $577.2 million in business sales, $287.8 million in GDP, 3,700 full and part-time jobs, $140.9 million in employee compensation, $131.4 million in gross business operating surpluses, and $15.4 million in business taxes.

Table 66 Shippers' Economic Impacts[117]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$783,979**	**4,912**	**$191,439**	**$176,847**	**$22,954**	**$391,240**
Arkansas	**$40,365**	**267**	**$10,184**	**$6,608**	**$1,078**	**$17,871**
Oklahoma	**$577,178**	**3,702**	**$140,923**	**$131,422**	**$15,412**	**$287,757**
Kansas	**$16,298**	**101**	**$3,943**	**$3,215**	**$508**	**$7,665**
Missouri	**$36,768**	**226**	**$9,408**	**$7,154**	**$1,144**	**$17,706**
Texas	**$113,370**	**617**	**$26,981**	**$28,448**	**$4,812**	**$60,241**
Rest of US	**$693,124**	**4,057**	**$186,854**	**$146,698**	**$23,113**	**$356,665**
US Total Impact	**$1,477,102**	**8,969**	**$378,293**	**$323,545**	**$46,067**	**$747,905**

[117] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

VI.3.4 Total Economic Loss of Public and Private Sector Waterway Spending

Closing the MKARNS will mean reductions in private and public waterway-related spending in Oklahoma. The US Army Corps of Engineers spends money annually to operate and maintain the MKARNS that will no longer be needed without the MKARNS. Private port and cargo shipping activities will cease if the MKARNS closes. In addition, private sector interests make substantial annual investments to enhance their infrastructure. The loss of the private and public expenditures on the Oklahoma portion of the MKARNS is estimated to decrease the nation's business sales annually by $3.2 billion (in 2015 prices): see Table 67. The loss in contribution to the nation's gross domestic product (GDP) is $1.5 billion and gross business operating surplus is $623.6 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 17,380 of the nation's full and part-time jobs and for $741.7 million in employee compensation. Business taxes and license fees total $93.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $1.6 billion in business sales, $674.0 million in GDP, 8,890 full and part-time jobs, $323.2 million in employee compensation, $309.1 million in gross business operating surplus, and $41.7 million in business taxes. The State of Oklahoma also shares in the economic value: $1.1 billion in business sales, $428.4 million in GDP, 6,090 full and part-time jobs, $197.6 million in employee compensation, $206.7 million in gross business operating surpluses, and $24.1 million in business taxes.

Table 67 Losses Due to Reductions in Private and Public Waterway Expenditures[118]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$1,615,700**	**8,888**	**$323,174**	**$309,131**	**$41,707**	**$674,012**
Arkansas	**$56,273**	**356**	**$13,887**	**$9,023**	**$1,503**	**$24,413**
Oklahoma	**$1,110,345**	**6,088**	**$197,581**	**$206,652**	**$24,131**	**$428,364**
Kansas	**$39,221**	**213**	**$9,211**	**$6,487**	**$1,083**	**$16,781**
Missouri	**$70,439**	**387**	**$17,508**	**$12,201**	**$2,071**	**$31,780**
Texas	**$339,423**	**1,845**	**$84,988**	**$74,768**	**$12,919**	**$172,675**
Rest of US	**$1,542,958**	**8,488**	**$418,560**	**$314,475**	**$51,628**	**$784,662**
US Total Impact	**$3,158,658**	**17,376**	**$741,734**	**$623,606**	**$93,335**	**$1,458,675**

VI.4 Loss of Transportation Benefits

One of the vital functions of the MKARNS is that it provides a cheaper, alternative mode of transportation as compared to rail and truck. In 2013 the Inland Navigation Center of Expertise for updated water vs. all-land transportation savings. The Center reported Land-Water savings of $15.00 per ton in 2013 price levels. For this Economic Update, given the stability of the types of commodities over time, the Little Rock Corps District calculated a ratio of the 2013 Land-Water savings to the 2003 Land-Water savings ($15.00 / $9.75 = 1.538) and

[118] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

applied that ratio to the Land-NCDA-12 savings (1.538 x 10.60) to get updated Land-NCDA-12 savings equaling $16.30.[119] We adjusted these transportation cost savings to reflect 2011 price levels (see Table 68). We also applied the same updating factor to the 2003 costs savings per ton values for each commodity.

Table 68 Transportation Cost Savings per Ton for the MKARNS (2011 prices)[120]

Commodity	Land/Water Savings	Land NCDA-12
Farm Products	$17.32	$19.76
Metals	$19.36	$20.16
Coal	$23.36	$26.03
Crude Petroleum	$14.52	$15.78
Non-Metallic Minerals	$6.28	$6.67
Forest Products	$13.83	$14.74
Industrial Products	$15.25	$15.29
Agricultural Products	$24.81	$27.02
Petroleum Products	$18.98	$19.59
Others	$26.15	$26.06
Commodity Total	$14.52	$15.78

The District expects that with normal flows, an economic recovery, and the expansion of the Panama Canal with more tonnage through New Orleans, a 1.6% growth is a reasonable assumption. Table 69 shows the annualized net present value factors for one dollar invested at various growth and discount rates for a 50-year period.

Table 69 Annualized Net Present Values of a Dollar Invested at Various Growth and Discount Rates of 50 Years[121]

Discount Rate	Growth Rate 1.0%	1.3%	1.6%	2.0%	2.5%	3.0%
2.00%	$1.250	$1.342	$1.442	$1.591	$1.807	$2.061
2.75%	$1.232	$1.316	$1.408	$1.545	$1.742	$1.972
3.375%	$1.218	$1.296	$1.382	$1.509	$1.690	$1.902
3.50%	$1.215	$1.293	$1.377	$1.502	$1.681	$1.889

119 Please note that the “Land-Water” savings represents the current 9-foot MKARNS navigation channel and the “Land-NCDA-12” savings represents a 12-foot MKARNS navigation channel.

120 Note: Commodity total used for crude petroleum. Source: Little Rock District. 2013. McClellan-Kerr Arkansas River Navigation Study: Economic Update. Little Rock, AR: U.S. Army Corps of Engineers (May).

121 Note: Author's computations.

3.75%	**$1.210**	**$1.285**	**$1.367**	**$1.488**	**$1.661**	**$1.862**
4.50%	**$1.194**	**$1.264**	**$1.339**	**$1.449**	**$1.607**	**$1.788**
5.00%	**$1.185**	**$1.250**	**$1.321**	**$1.425**	**$1.573**	**$1.743**

The MKARNS MRVIO Spreadsheet Calculator computes the regional economic effects of transportation cost changes due to transportation improvement, deterioration, or stoppage (in the case of shutting down the MKARNS) using percentage changes in transportation costs, not the transportation savings provided in Table 70. The percentage changes in transportation costs are computed by dividing the transportation cost changes (in 2011 price levels), shown above, by the respective trade flow values from the MKARNS model's database. Care should be given to match up the commodity-specific, region-to-region transportation cost changes with the corresponding commodity-specific, region-to-region trade flows. It should be noted that the trade flow data are in millions of dollars and the transportation cost changes are in thousands of dollars. In several cases, the resulting percentage changes in transportation costs are unusually large. There are several reasons for this. One, the model's trade flow data are consistent with the base year of the model (2011) and the transportation cost changes are based on the latest available Corps of Engineers state-to-state waterborne commerce data. The Corps waterborne traffic data are somewhat volatile from year to year. Two, the commodity classifications in Table 68 are more aggregated than are the MKARNS MRIO model's commodity classifications. This means that the savings data have to be "split" between several of the model's commodity classifications. Three, updating the savings data was based on an adjustment of the total savings, not the individual commodity values (as was done by the Tulsa Corps District Office). As a result, adjustments had to be made to the trade flow values to be more consistent with the commodity savings data (i.e, we averaged the trade flows for those specific commodities that were problematic).

Table 70 Annualized Net Present Value of MKARNS Water Transportation Savings (2011 and 2015 prices)[122]

Code	Commodity	From	To	2011 Prices	2015 Prices
14	Coal	OK	RUS	$13,925	$14,861
15	Crude petroleum	OK	RUS	$3,823	$4,080
17	Coal & petroleum products, n.e.c.	OK	TX	$2,774	$2,961
17	Coal & petroleum products, n.e.c.	OK	RUS	$8,311	$8,870
13	Metallic ores & concentrates	OK	RUS	$5,129	$5,473
2	Cereal grains	OK	RUS	$28,548	$30,467
3	Other agricultural products	OK	RUS	$106	$113
4	Animal feed	OK	RUS	$568	$607
38	Miscellaneous manufactured products	OK	AR	$3,569	$3,809
38	Miscellaneous manufactured products	OK	OK	$225	$241

[122] Note: Savings values are expressed in thousands of dollars. Savings in 2015 prices were adjusted from 2011 prices using the GDP deflator.

Code	Commodity	From	To	2011 Prices	2015 Prices
38	Miscellaneous manufactured products	OK	MO	$822	$877
38	Miscellaneous manufactured products	OK	TX	$1,337	$1,427
38	Miscellaneous manufactured products	OK	RUS	$30,046	$32,066
17	Coal & petroleum products, n.e.c.	RUS	OK	$910	$971
20	Fertilizers	RUS	OK	$12,512	$13,353
18	Basic chemicals	RUS	OK	$191	$203
22	Plastics & rubber products	RUS	OK	$39	$42
11	Natural sands, gravel & crushed stone	AR	OK	$176	$187
11	Natural sands, gravel & crushed stone	RUS	OK	$54	$58
12	Nonmetallic minerals, n.e.c.	AR	OK	$571	$609
12	Nonmetallic minerals, n.e.c.	RUS	OK	$176	$188
29	Nonmetalic mineral products	AR	OK	$44	$47
29	Nonmetalic mineral products	RUS	OK	$14	$15
30	Primary & semifinished base metal forms & shapes	AR	OK	$1,061	$1,133
30	Primary & semifinished base metal forms & shapes	RUS	OK	$6,068	$6,476
31	Base metal products	AR	OK	$70	$75
31	Base metal products	RUS	OK	$401	$428
2	Cereal grains	AR	OK	$53	$57
2	Cereal grains	RUS	OK	$438	$468
4	Animal feed	AR	OK	$709	$757
4	Animal feed	RUS	OK	$5,821	$6,212
7	Other foodstuffs and fats & oils	AR	OK	$227	$242
7	Other foodstuffs and fats & oils	RUS	OK	$1,862	$1,987
38	Miscellaneous manufactured products	AR	OK	$470	$502
38	Miscellaneous manufactured products	OK	OK	$225	$241
38	Miscellaneous manufactured products	MO	OK	$2,394	$2,555
38	Miscellaneous manufactured products	TX	OK	$294	$314
38	Miscellaneous manufactured products	RUS	OK	$12,338	$13,168
	Total			$146,302	$156,139

Another issue with transportation cost changes generated from Oklahoma to the Rest of the U.S. The great majority of the percentage cost changes is based on waterborne traffic that goes to Louisiana and are for commodities that are, in reality, exported to foreign customers. Unfortunately, the Corps' waterborne commerce data do not show foreign exports originating from Oklahoma. The foreign exports from Oklahoma are shown going to Louisiana and then exported from Louisiana. We assumed that the waterborne commodity flows from Oklahoma to the Rest of the U.S. are foreign exports. We further assumed that world commodity markets are very competitive and that transportation cost increases (such as from Oklahoma due to the closure of the MKARNS) will for the firms that produce the exported commodities to either absorb the cost increases or spread them among their domestic customers. A third assumption we made was that the Oklahoma producing firms will spread the subject transportation cost changes among their domestic customers equally ("everyone gets equal treatment").

If the MKARNS closed it is expected that transportation costs will rise for those commodities currently hauled on the waterway having to switch to more expensive modes of transportation. Based on 2012 traffic data it is estimated that transportation costs will rise by $156.1 million (2015 prices): see Table 71.[123] Higher transportation costs are estimated to decrease the nation's business sales annually by $677.4 million (Table 68). The contribution to the nation's gross domestic product (GDP) is $443.8 million and gross business operating surpluses is $130.6 million after all other expenses have been paid. Oklahoma's portion of the MKARNS is responsible for 2,370 of the nation's full and part-time jobs and for $135.2 million in employee compensation. Business taxes and license fees total $21.8 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $37.7 million in business sales, $18.5 million in GDP, 170 full and part-time jobs, $8.1 million in employee compensation, $8.9 million in gross operating surplus, and $1.5 million in business taxes. The State of Oklahoma also shares in the economic value: $9.9 million in business sales, $4.9 million in GDP, 50 full and part-time jobs, $2.0 million in employee compensation, $2.4 million in gross business operating surpluses, and $490 thousand in business taxes.

Table 71 Economic Losses of Transportation Cost Savings of the MKARNS in Oklahoma[124]

Region	Sales	Employment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$37,723**	**169**	**$8,080**	**$8,875**	**$1,519**	**$18,474**
Arkansas	**$3,800**	**19**	**$707**	**$684**	**$96**	**$1,488**
Oklahoma	**$9,897**	**49**	**$1,953**	**$2,429**	**$485**	**$4,867**
Kansas	**$866**	**3**	**$153**	**$162**	**$25**	**$340**
Missouri	**$2,907**	**14**	**$622**	**$703**	**$120**	**$1,445**
Texas	**$20,254**	**84**	**$4,645**	**$4,895**	**$793**	**$10,334**
Rest of US	**$483,575**	**2,205**	**$127,109**	**$121,755**	**$20,326**	**$269,190**
US Total Impact	**$521,298**	**2,374**	**$135,189**	**$130,629**	**$21,846**	**$287,664**
Transport Savings	**$156,139**	**0**	**$0**	**$0**	**$0**	**$156,139**
US Impact + Savings	**$677,437**	**2,374**	**$135,189**	**$130,629**	**$21,846**	**$443,803**

VI.5 Loss of Recreational Use of MKARNS[125]

USACE maintains traffic counters at several access points. In addition, locations with campground hosts and fee collection requirements include fairly accurate visitation counts

[123] Note that the increases in transportation costs due to closing the MKARNS are included

[124] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[125] This section is largely exerted from Caneday and Soltani (2014).

through fiscal 2012. Table 72 reports the most recent visitation numbers for specific MKARNS locations as documented by USACE.

Table 72 Recreation Sites and Reported Visitation from USACE[126]

Recreation Site	Reported Visitation
Afton Landing Recreation Area (Chouteau L&D)	**32,167**
Tullahassee Loop Recreation Area (Chouteau L&D)	**21,826**
Three Forks Harbor (Webbers Falls L&D)	**205,796**
Brewers Bend Recreation Area (Webbers Falls L&D)	**52,678**
Summers Ferry (Robert S. Kerr L&D)	**9,618**
Vian Creek (Robert S. Kerr L&D)	**4,249**
Webbers Falls City Park (Robert S. Kerr L&D)	**32,064**
Gore Landing (Robert S. Kerr L&D)	**21,263**
Applegate Cove Recreation Area (Robert S. Kerr L&D)	**34,902**
Short Mountain Cove Recreation Area (Robert S. Kerr L&D)	**18,061**
Cowlington Point Recreation Area (Robert S. Kerr L&D)	**26,611**
Total at these developed sites	**459,235**

For context, the Tulsa District of the U.S. Army Corps of Engineers reported over 16 million recreational visits at its various facilities during fiscal 2012. This number has been quite consistent over a five-year span from 2007 through 2012. USACE sites included in their accounting are most numerous on lakes such as Lake Tenkiller, Fort Gibson, Lake Texoma, and Lake Eufaula, but numerous smaller lakes are also included. The MKARNS sites receive fewer visitations than the higher profile sites on some of the larger lakes. As a result, the MKARNS corridor may comprise about 5% of the total recreational visits within the Tulsa District.

[126] Source: U.S. Army Corps of Engineers, Tulsa District.

Table 73 Recreation Sites and Estimated Visitation[127]

Recreation Site	Estimated Visitation
Rogers Point Public Use Area (Newt Graham L&D)	23,800
Highway 33 Landing (Newt Graham L&D)	3,650
Bluff Landing Recreation Area (Newt Graham L&D)	54,400
Bluegill Point Public Use Area (Newt Graham L&D)	2,800
Goodhope Ramp Public Use Area (Newt Graham L&D)	2,800
Coal Creek Public Use Area (Chouteau L&D)	7,600
Pecan Park Recreation Area (Chouteau L&D)	1,600
Spainard Creek Recreation Area (Webbers Falls L&D)	48,300
Highway 10 Landing (Webbers Falls L&D)	4,850
Cherokee Nation Park (Robert S. Kerr L&D)	51,700
Dam Site (Robert S. Kerr L&D)	10,300
Fisherman's Landing (Robert S. Kerr L&D)	14,600
Keota Landing (Robert S. Kerr L&D)	3,100
Little Sanbois Creek (Robert S. Kerr L&D)	900
Sequoyah National Wildlife Refuge (Robert S. Kerr L&D)	63,200

Several sites along MKARNS do not have the traffic counters or campground hosts which formalized the reported recreational visits in Table 73. As a result, a variety of methods were necessary to estimate recreational visitation to these locations. These methods included:

- Conversations with local managers as at Rogers Point, operated by the City of Catoosa, and Sequoyah National Wildlife Refuge, operated by the U.S. Fish and Wildlife Service, and Cherokee Nation representatives for Cherokee Nation Park.
- Conversations were held with on-site hosts as at Bluff Landing Recreation Area and Spainard Creek Recreation Area and USACE representatives at the various Locks and Dams. Observation of use patterns, number of occupants per vehicle, and vehicle counts at locations such as Highway 33 Landing, Highway 10 Landing, and Coal Creek.

These estimates of visitation at the dispersed locations along MKARNS show an annual recreation visitation of 293,600 people. Some of these locations such as Sequoyah National Wildlife Refuge draw from a significant distance. Other locations like Bluff Landing Recreation Area rely upon a more localized market from Broken Arrow and Tulsa. Other locations such as Highway 33 Landing and Highway 10 Landing attract recreation visitors because of the intersection of highways with the waters of the navigation channel. Others such as Little Sanbois Creek or Keota Landing draw from a limited, rural population in close proximity to the residence of the respective recreation visitors.

[127] Source: Observation and Estimation.

VI.5.1 Survey Response from Recreational Visitors

A Survey of Visitor Expenditure along MKARNS was developed based upon the expenditure categories and codes utilized in the IMPLAN model. This survey had been used in numerous prior studies by the principal investigator. An identical research protocol had been utilized during the summer 2012 at campgrounds throughout the USACE – Tulsa District. In the 2012 research effort, rangers and personnel from USACE encouraged campground hosts to directly recruit respondents. As a result, a much greater response rate was achieved during 2012 than was true in 2014. These responses from 2012 were utilized to supplement the 2014 responses. Since the attendance data from the USACE was also from 2012, these responses are considered to be valid and reliable.

A grand total of 469 responses were received from the combined 2012 and 2014 efforts. Of these respondents, 61 were generated during the 2014 research effort and 399 were products of the 2012 research effort. Among these total respondents, 91 identified themselves as day visitors to MKARNS, meaning they did not spend a night within the MKARNS corridor. Three-hundred-seventy-eight (378) respondents indicated they spent at least one night in the MKARNS corridor and therefore were considered to be overnight visitors.

As reported, these day visitors may have been local residents or transients, indicated by the fact that some of the day visitors to MKARNS had spent one or more nights in lodging outside the MKARNS corridor. However, their visit to MKARNS was limited to some portion of one day. With an average party size of 2.34 persons per group, it is more valuable to examine the expenditures per person per day on a visit to the MKARNS corridor. These expenditures are reported in Table 74.

Table 74 Expenditures of Day Visitors per Person per Day[128]

Spending Categories	Within five miles of the MKARNS corridor	More than five miles from the MKARNS corridor
Lodging (IMPLAN codes 411 & 412)		
Lodge, cabins, hotels, motels, B&B rental homes	$44.23	$6.57
Campground fees (including hook-ups)	$4.11	$1.16
Food and Beverage (IMPLAN codes 324 & 413)		
Restaurants, bars, take-out food/drinks from restaurants	$5.51	$6.99
Groceries, drinks, take-out food/drinks not from restaurants	$1.72	$7.60
Transportation (IMPLAN codes 326 & 338)		
Gas and oil for auto, boat, RV, etc.	$2.48	$15.76
Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$4.34	$2.02
Local transportation (e.g., bus, taxi, cab, etc.)	$0.00	$0.00
Recreation (IMPLAN codes 403, 406 through 410)		

[128] Note: Based on survey respondents.

Admissions and fees (e.g., golf green fees, stables, etc.)	**$2.15**	**$0.97**
Sporting goods (e.g., boat equipment, fishing gear, etc.)	**$1.82**	**$2.72**
Casino gambling	**$0.00**	**$0.48**
Other expenses (IMPLAN codes 327 & 328)		
Clothing	**$0.73**	**$0.95**
Souvenirs (e.g., Maps, books, mugs, etc.)	**$1.99**	**$1.58**
How many people were in your party on this trip?	**2.34**	**2.34**
How many nights did you spend in the MKARNS corridor on this trip?	**0**	**0**

A typical trip to MKARNS for a day of fishing, boating, hunting, or other recreation leads to an expenditure of $69.09 per person within five miles of the MKARNS corridor for that trip's activities. However, among those who were truly day visitors and not spending a night on their trip, the expenditure was $24.86. In addition, the average day visitor spent $46.81 outside the MKARNS corridor, with the largest expenditures being for lodging and transportation.

There are few opportunities for certain types of expenditures within the MKARNS corridor including lack of local public transportation and casinos. In addition, few grocery stores or department stores are available within five miles of the MKARNS corridor. Based upon the responses from the day visitors in this survey, the average expenditure for a day's recreational visit by one person to MKARNS was $108.41 of which $86.75 was spent at a distance of five miles or more from the corridor while $21.66 was spent within the navigation corridor.

In the same manner, overnight recreation visitors along the MKARNS responded to the survey. These overnight visitors reported having spent at least one night within five miles of the MKARNS corridor and may have spent additional nights on their recreational visit outside of the MKARNS corridor.

Within the MKARNS corridor, lodging options vary by provider and by location. Campgrounds are located directly on the navigation corridor or on adjacent lakes and creeks. A few private lodges, cabins, motels and rental properties are located along the corridor, particularly in the vicinity of Robert S. Kerr Reservoir or near the cities of Muskogee, Webbers Falls, Gore and Vian. Greenleaf State Park is directly across Highway 10 from Highway 10 Landing and offers campgrounds and cabins operated by the state of Oklahoma.

As would be expected for an overnight recreational visit, the largest categories of expenditure for these respondents were lodging, food from restaurants, and transportation expenses such as fuel. Average spending for an overnight visit to one of the recreational sites along MKARNS was $650.30 per group. These overnight recreational visitors reported an average party size of 4.97 persons and an average visit length of 2.43 nights. The longest reported visit to a location within the MKARNS corridor was 11 nights, although the principal investigator recognized that some recreational vehicles remained in campsites for the entire summer.

Party size for recreational visitors also varied with the largest responding party being 65 persons. This is likely to have been an organized travel club that is known to have utilized one of the campgrounds on Robert S. Kerr Reservoir. As a result, the average party size was 4.97 persons with a standard deviation of 8.27. It should also be noted that it is quite common to observe a recreational vehicle like a travel trailer on a campsite with two or more vehicles associated with that one site. It is also common to see a recreational vehicle on a campsite with one or more tents also located on the campsite. As a result, the party size reflects the perception of the respondent. A more accurate reflection of expenditures by overnight guests is reported in Table 75. The data in this table reflect the average expenditure of an overnight visitor per person per day.

Table 75 Expenditures of Overnight Visitors per Person per Day[129]

Expenditure Categories	Within five miles of the MKARNS corridor	More than five miles from the MKARNS corridor
Lodging (IMPLAN codes 411 & 412)		
Lodge, cabins, hotels, motels, B&B rental homes	$22.75	$2.56
Campground fees (including hook-ups)	$0.27	$0.01
Food and Beverage (IMPLAN codes 324 & 413)		
Restaurants, bars, take-out food/drinks from restaurants	$4.29	$4.56
Groceries, drinks, take-out food/drinks not from restaurants	$1.29	$2.98
Transportation (IMPLAN codes 326 & 338)		
Gas and oil for auto, boat, RV, etc.	$2.60	$3.08
Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$1.31	$0.37
Local transportation (e.g., bus, taxi, cab, etc.)	$0.01	$0.00
Recreation (IMPLAN codes 403, 406 through 410)		
Admissions and fees (e.g., golf green fees, stables, etc.)	$1.46	$0.96
Sporting goods (e.g., boat equipment, fishing gear, etc.)	$1.22	$0.40
Casino gambling	$0.25	$1.12
Other expenses (IMPLAN codes 327 & 328)		
Clothing	$0.37	$0.62
Souvenirs (e.g., Maps, books, mugs, etc.)	$0.79	$0.57
How many people were in your party on this trip?	4.97	4.97
How many nights did you spend in the MKARNS corridor on this trip?	2.43	2.43

These overnight visitors spent an average of $53.85 per person per day on a recreational visit to MKARNS. Of those expenditures, $36.62 was expended within five miles of the MKARNS corridor with the largest portion of that expenditure ($23.02) being for lodging.

[129] Note: Based on survey respondents.

Similarly, these recreational visitors who spent at least one night within the MKARNS corridor also spent an average of $17.23 per person outside of the corridor.

Based upon the responses provided by actual visitors to the MKARNS corridor, the following spending patterns have been documented:

- Recreational day trips to MKARNS showed an average party size of 2.34 persons per group;
- A recreational day trip to MKARNS produces an expenditure of $191.37 per group within five miles of the MKARNS corridor;
- These recreational day trips lead to an expenditure of $69.09 per person within five miles of the MKARNS corridor;
- A recreational day trip to MKARNS produces an expenditure of $129.65 per group beyond five miles from the MKARNS corridor;
- These recreational day trips lead to an expenditure of $46.80 per person beyond five miles from the MKARNS corridor;
- A recreational day trip to MKARNS leads to an expenditure of $115.89 per person;
- Recreational overnight trips to MKARNS showed an average party size of 4.97 persons per group and an average of 2.43 nights per visit;
- A recreational overnight trip to MKARNS produces an expenditure of $442.20 per group within five miles of the MKARNS corridor;
- These recreational overnight trips to MKARNS lead to an expenditure of $36.61 per person per day within five miles of the MKARNS corridor;
- A recreational overnight trip to MKARNS produces an expenditure of $208.08 per group beyond five miles from the MKARNS corridor;
- These recreational overnight trips to MKARNS lead to an expenditure of $17.23 per person per day beyond five miles from the MKARNS corridor;
- A recreational overnight trip to MKARNS produces an expenditure of $53.85 per person per day.

VI.5.2 Economic Impact of Recreation along MKARNS

The USACE documents 459,235 recreational visitors at the 11 more developed recreation sites along MKARNS. The principal investigator for this project utilized a variety of sources to estimate recreational visitation at 15 of the lesser developed recreation sites not included on the USACE report. As a result, the estimated visitation at these public access locations is 293,600 persons annually. The USACE estimates that 80% of visitation to its sites in the Tulsa District is day use with 20% of recreational visits being overnight use. As a result, Table 76 presents the visitation patterns between day visitors and overnight visitors along MKARNS.

Table 76 Visitation Patterns along the MKARNS

Visitation	Day visitors	Overnight visitors	Total visitors
USACE reports	367,388	91,847	459,235
PI estimates	234,880	58,720	293,600
Totals	602,268	150,567	752,835

Using the visitation patterns and the expenditure patterns for these visitors, it is possible to estimate the total expenditure of recreational visitors utilizing public access locations along MKARNS. Table 77 reports the recreation expenditures by day and overnight visitors within the immediate MKARNS corridor, beyond five miles from the corridor, and the total direct expenditure. The total estimated direct recreational expenditure generated by visits to public access locations along MKARNS is almost $78 million annually.

Table 77 Recreation Expenditures along the MKARNS[130]

	Day Visitors	Overnight Visitors
Number of Visitors	**602,268**	**150,567**
Spending per visitor: Within 5 miles of MKARNS	**$69.09**	**$36.61**
Beyond 5 miles from MKARNS	**$46.80**	**$17.23**
Total spending: Within 5 miles of MKARNS	**$41,611**	**$5,512**
Beyond 5 miles from MKARNS	**$28,186**	**$2,594**
Total Spending on the MKARNS in Oklahoma	**$69,797**	**$8,107**

The Caneday and Soltani (2014) analysis utilized the Money Generation Model Version 2 (MGM2) (http://35.8.125.11/mgm2_new/MGM2web.htm) to assess economic impact in recreation settings in Oklahoma. While this project was based on IMPLAN, MGM2 is also developed on IMPLAN. Although recreation was not – and is not – the primary purpose for the McClellan Kerr Arkansas River Navigation System, recreation is clearly an important economic, social, cultural, and personal component of MKARNS.

Closing the MKARNS would reduce recreational visitation in Oklahoma. Subsequently, recreation spending in Oklahoma is expected to reduce business sales by $105.6 million, $43.5 million in GDP, 2,120 full and part-time jobs, $19.0 million in employee compensation, $20.5 million in gross business operating surpluses, and $3.1 million in business taxes (2015 prices): see Table 78.

Table 78 Economic Impacts of Recreation Expenditures along the MKARNS[131]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
Oklahoma	**$105,589**	**2,123**	**$19,863**	**$20,524**	**$3,112**	**$43,498**

[130] Note: Spending is categorized according to where the expenditures are made, not the where the visitors are coming from.

[131] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

Please note that the impacts shown in Table 78 are probably overstated because people have other alternative recreation sites within the State of Oklahoma that could be used in if the MKARNS and its reservoirs were to be closed. As a result, the recreation related impact should be considered “gross” not net impact estimates. However, we will include these impacts as among the economic value of the MKARNS in Oklahoma for the sake of the argument that people who visit MKARNS recreation sites would go outside Oklahoma to partake their recreation experiences if the MKARNS sites were not available.

VI.6 Summary of the Economic Losses due to Closing the MKARNS

The prior subsections addressed the individual components of the economic value of the McClellan-Kerr Arkansas River Navigation System. The total economic loss due to closing the MKARNS is equal to the economic impacts due to

- Loss due to closing the hydropower plants,
- Minus the gain of opening and operating a replacement natural gas generation facility,
- Plus the loss of Corps MKARNS O&M expenditures,
- Plus the loss of port activities,
- Plus the loss of shippers operations,
- Plus the loss of private sector waterway infrastructure investment spending,
- Plus the loss of transportations benefits,
- Plus the loss of recreation opportunities, and
- Plus the environmental damages.

The economic value of the McClellan-Kerr Arkansas River Navigation System is the sum total of all the economic losses due to closing the MKARNS. Closing the MKARNS is estimated to decrease the nation’s business sales annually by $4.1 billion (in 2015 prices): see Table 79. The contribution to the nation’s gross domestic product (GDP) is $2.0 billion and gross business operating surpluses of $807.0 million. Oklahoma’s portion of the MKARNS is responsible for 22,760 of the nation’s full and part-time jobs and for $931.8 million in employee compensation. Business taxes and license fees total $124.6 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $2.0 billion in business sales, $744.5 million in GDP, 11.840 full and part-time jobs, $375.2 million in employee compensation, $361.7 million in gross operating surplus, and $51.0 million in business taxes. The State of Oklahoma also shares in the economic value: $1.2 billion in business sales, $470.0 million in GDP, 6,620 full and part-time jobs, $216.6 million in employee compensation, $225.4 million in gross business operating surpluses, and $28.1 million in business taxes.

Table 79 Economic Losses of Closing the MKARNS[132]

Region	Sales	Employment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$1,852,957	11,836	$375,205	$361,707	$51,039	$744,452
Arkansas	$167,486	2,510	$34,892	$30,550	$4,768	$26,712
Oklahoma	$1,185,222	6,620	$216,569	$225,362	$28,078	$470,009
Kansas	$42,901	235	$10,065	$7,179	$1,196	$18,440
Missouri	$77,642	428	$19,300	$13,740	$2,349	$35,389
Texas	$379,706	2,042	$94,379	$84,875	$14,648	$193,902
Rest of US	$2,067,423	10,925	$556,598	$445,327	$73,546	$1,075,470
US Total Impact	$3,920,380	22,761	$931,803	$807,033	$124,585	$1,819,922
Transport Savings	$156,139	0	$0	$0	$0	$156,139
US Impact + Savings	$4,076,519	22,761	$931,803	$807,033	$124,585	$1,976,061

VI.7 Loss of MKARNS Environmental and Fuel Benefits

Two key indicators of the value the McClellan-Kerr Arkansas River Navigation System (MKARNS) are fuel savings and lower carbon dioxide (CO_2) emissions created by hauling commodities via the waterway (by barge) rather than by the competing rail and highway modes (Figure 41).[133]

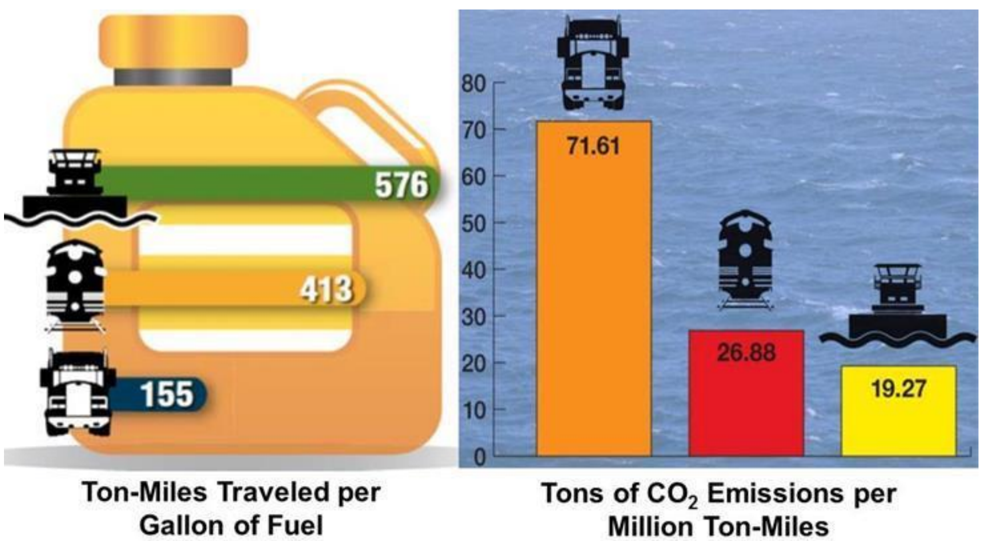

Figure 39 Fuel Efficiency and CO2 Emissions per Ton-Mile Comparisons by Transport Mode

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[132] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[133] C. James Kruse, Annie Protopapas, Leslie E. Olson, and David H. Bierlin. 2009. *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*. Houston, TX: Center for Ports and Waterways, Texas Transportation Institute. Prepared for the Maritime Administration, U.S. Department of Transportation and the National Waterways Foundation (March).

VI.7.1 What is a Metric Ton of Carbon Dioxide?

Carbon dioxide is a naturally occurring chemical compound of two oxygen atoms covalently bonded to a single carbon atom. It is a gas at standard temperature and pressure and exists in Earth's atmosphere in this state, as a trace gas at a concentration of 0.039 percent by volume.[134] Plants, algae, and cyanobacteria absorb carbon dioxide, light, and water to produce carbohydrate energy for themselves and oxygen as a waste product. Carbon dioxide is produced by combustion of coal or hydrocarbons, the fermentation of liquids and the breathing of humans and animals. It is also emitted from volcanoes, hot springs, geysers and other places where the earth's crust is thin. CO_2 is found in lakes at depth under the sea and commingled with oil and gas deposits. The environmental effects of carbon dioxide are of significant interest. In the earth's atmosphere, it acts as a greenhouse gas which plays a major role in global warming and anthropogenic climate change. Also a major source of ocean acidification is CO_2 which dissolves in water forming carbonic acid, which is a weak acid, because CO_2 molecule ionization in water is incomplete.

A metric ton of carbon dioxide is more appropriately interpreted as a volume, not a weight.[135] The density of CO_2 in its pure form is 0.1234 pounds per cubic foot—so one pound of CO_2 fills about 8.1 cubic feet of space (approximately a cube that is 2 feet on each side). One ton (2,000 pounds) of CO_2 would fill about 16,200 cubic feet—a cube that is around 25.3 feet on each side or a weather balloon with a diameter of 31.4 feet.

VI.7.2 MKARNS Environmental and Fuel Benefits

Two key indicators of the value the McClellan-Kerr Arkansas River Navigation System (MKARNS) are fuel savings and lower carbon dioxide (CO_2) emissions created by hauling commodities via the waterway (by barge) rather than by the competing rail and highway modes.[136] Barges are known to use fuel more efficiently than either rail or truck. Every gallon of fuel used by barges will haul a ton of cargo 576 miles, while rail will haul the same ton 413 miles and truck will haul the same ton 155 miles. In addition, barges also generate fewer CO2 emissions than either rail or trucks. For every million ton-miles, barges generate 19.3 metric tons of CO2 gases, while rail emits 26.9 metric tons and trucks generate 71.6 metric tons.[137]

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[134] Wikipedia definition. *http://en.wikipedia.org/wiki/Carbon_dioxide*

[135] Gelvin Stevenson. The Green Economy. *The Magazine for the New Economy* (*http://thegreeneconomy.com/what-is-a-carbon*).

[136] C. James Kruse, Annie Protopapas, Leslie E. Olson, and David H. Bierlin. 2009. *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*. Houston, TX: Center for Ports and Waterways, Texas Transportation Institute. Prepared for the Maritime Administration, U.S. Department of Transportation and the National Waterways Foundation (March).

[137] A metric ton of carbon dioxide is more appropriately interpreted as a volume, not a weight.[137] The density of CO_2 in its pure form is 0.1234 pounds per cubic foot—so one pound of CO_2 fills about 8.1 cubic feet of space (approximately a cube that is 2 feet on each side). One ton (2,000 pounds) of CO_2 would fill

The MKARNS provides significant fuel savings and reduces substantial environmental emissions (in terms of carbon dioxide) as compared with other possible modes of transportation. The Oklahoma portion of the MKARNS carried approximately 6.1 million short tons and 12.5 billion ton-miles of freight during 2012.[138] This required the use of about 19.3 million gallons of fuel and a little more than 241.4 thousands of metric tons of CO_2 were emitted during the transport on the MKARNS (Table 80). We estimate that fuel use and CO_2 emissions would be 40 percent higher if the MKARNS waterway freight traffic were hauled by rail and 270 percent higher if trucks had been used. However, the latter comparison is a bit skewed in that truck transportation is not often the competing mode for barge traffic.

Table 80 Environmental Impacts of MKARNS Waterborne Commerce[139]

	Conversion Factors*		Based on 2012 MKARNS Traffic	
Mode	**Ton-miles per gallon**	**Metric tons of CO2 emissions per million ton-miles**	**Fuel Used (millions of gallons)**	**CO2 Emissions (metric tons)**
Barge	**576**	**19.3**	**21.7**	**241,396**
Rail	**413**	**26.9**	**30.3**	**336,453**
Truck	**155**	**71.6**	**80.7**	**895,541**

Table 81 Traffic Mode Equivalence[140]

Mode	**Capacity**	**2012 MKARNS Traffic**	**Number Required**
Barge	**1,500**	**6,116**	**4,077**
Rail Car	**109**	**6,116**	**55,915**
Truck	**25**	**6,116**	**244,629**

In addition, a standard barge on the MKARNS is estimated to be able to hold 1,500 short tons of dry-bulk commodities. It is estimated that 4,077 barges were required to transport the

about 16,200 cubic feet—a cube that is around 25.3 feet on each side or a weather balloon with a diameter of 31.4 feet.

[138] A ton of cargo hauled by barge travels approximately 2,045 miles, on average, per trip based on the US Federal Highway Administration's (2009) *Freight Analysis Framework 3* data for 2015.

[139] Note: Fuel use and CO2 emissions are based on 2012 MKARNS traffic for Oklahoma. *C. James Kruse, Annie Protopapas, Leslie E. Olson, and David H. Bierlin. 2009. *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*. Houston, TX: Center for Ports and Waterways, Texas Transportation Institute. Prepared for the Maritime Administration, U.S. Department of Transportation and the National Waterways Foundation (March).

[140] Note: Capacity is the tons hauled by one barge, rail car, or truck. 2012 MKARNS traffic is in thousands of tons. Number required is the number of barges, rail cars, or truck needed to haul the 2012 MKARNS traffic.

6.1 million tons of waterborne traffic on the MKARNS during 2012. It is also estimated that it would take 13.7 rail cars and 60 trucks to hold the same volume of commodities as one barge. This would mean that approximately 55,915 rail cars and 2 trucks would be needed to haul the same cargo that was carried on the MKARNS during 2012 via barges (Table 81).

VII ECONOMIC IMPACT OF DEEPENING THE MCCLELLAN-KERR NAVIGATION SYSTEM CHANNEL

In August 2005 the U.S. Army Corps of Engineers Districts at Little Rock, Arkansas and Tulsa, Oklahoma completed two major studies that justified enhanced maintenance and improvements of the MKARNS and ensured compliance with national environmental regulations.[141] The "preferred" plan of the U.S. Army Corps of Engineers for the McClellan-Kerr Arkansas River Navigation System (MKARNS) consists of three basic activities:

1) **Navigation Channel Maintenance**: The ongoing operation and maintenance of the existing 9-foot navigation channel on the MKARNS, entails the use of "river training structures" (dikes, revetments, and weirs) as well as periodic dredging at some locations within the navigation channel. Since the completion of the system in 1971, some approved dredged material disposal sites have reached capacity and new disposal sites are required to continue channel maintenance activities. Additionally, the construction of new river training structures would facilitate the maintenance of the 9-foot navigation channel.

2) **Flow Management**: Sustained high flows on the MKARNS have adversely influenced the safety and efficiency of commercial navigation operations and have resulted in flood damages along the river. The reliability and predictability of river flows affect navigation traffic utilization of the MKARNS.

3) **Navigation Channel Depth**: Commercial navigation is not at optimum productivity within the MKARNS since its 9-foot navigation channel limits towboat loads compared to the Lower Mississippi River's authorized 12-foot channel.

VII.1 Costs of MKARNS 12-Foot Channel Deepening and Oklahoma's Portion

The 2005 MKARNS Feasibility Report indicates that total cost of the MKARNS project is $166.4 million and about half of that cost will occur from project activities in Arkansas. The 2005 MKARNS Feasibility Report considers a combination of flow management, dredging, and training structures (dikes and jetties) in order to achieve and maintain a 12-foot navigation channel in the McClellan-Kerr Arkansas River Navigation System (MKARNS). Note that the MKARNS project cost here is as was published in 2005 and does not reflect the most current cost estimate shown earlier ($183 million in 2013 prices and about $185 million in 2015 prices).

[141] Little Rock and Tulsa Districts. 2005. *Final Environmental Impact Statement: Arkansas River Navigation Study*. Little Rock, AR and Tulsa, OK: U.S. Army Corps of Engineers (August). Little Rock and Tulsa Districts. 2005. *Final Feasibility Study: Arkansas River Navigation Study Arkansas and Oklahoma McClellan-Kerr Arkansas River Navigation System*. Little Rock, AR and Tulsa, OK: U.S. Army Corps of Engineers (August).

Purpose here is to evaluate the cost of a "channel deepening" option for the MKARNS based on the available detailed 2005 MKARNS project cost estimates. Table 82 shows the construction-related costs of the 12-foot channel deepening option from the 2005 MKARNS Feasibility Report.[142] All monetary values are in constant 2004 dollars. A column has been added which contains Oklahoma's percentage of total MKARNS project costs for each line item listed. As provided, 45.3 percent of the total implementation costs occur in the Arkansas portion of the MKARNS (refer to the line immediately below the line numbered 31—Contract Administration). The total implementation cost of the Arkansas portion of the MKARNS project is $68.2 million. Not included are interest charges during the construction period (i.e., an additional $7 to $7.5 million). As a result, the total cost of implementing the MKARNS project as it is designed is about $75.2 to $75.7 million for the Arkansas portion. Also not included are any annual operations and maintenance costs ($821.6 thousand).

Table 82 Cost Shares of Deepening the MKARNS[143]

Cost Category	MKARNS System	Oklahoma Portion	Oklahoma Percentage
Construction Costs	**$150,482**	**$82,303**	**54.7%**
Dredging, rock removal & disposal areas	**$59,983**	**$43,323**	**72.2%**
Dikes & jetties	**$50,388**	**$18,558**	**36.8%**
Demolition & Lock Pin Guide Walls	**$4,202**	**$0**	**0.0%**
Real Estate, Disposal Areas & Mitigation	**$14,647**	**$10,445**	**71.3%**
Planning, Design & Contract Administration	**$20,773**	**$9,592**	**46.2%**
Investment by Ports	**$488**	**$385**	**79.0%**
Annual Operations & Maintenance Costs	**$2,549**	**$848**	**33.3%**
Dredging	**$1,773**	**$648**	**36.6%**
Mitigation & monitoring	**$0**	**$0**	**0.0%**
Dikes & jetties	**$384**	**$200**	**52.1%**
Locks, Design & Administration	**$392**	**$0**	**0.0%**

Again, it should be noted that the costs in Table 82 include the costs of river training structures (dikes and jetties). If we just consider the dredging-related costs (i.e., dredging, mitigation, and real estate costs) then the implementation cost is $20.9 million without interest

[142]Table 82 includes exerted columns for the 12-channel option from the MKARNS Project Cost spreadsheet, "*Combined Cost Estimate 02 25 05 w Code of Accounts.xslx*", provided by Dr. Edwin J. Rossman (Chief, Planning Branch, Planning and Environmental Analysis and Compliance Division, Tulsa District, U.S. Army Corps of Engineers). This spreadsheet is supplied as an attachment to the sending e-mail.

[143] Note: Cost figures are in thousands of 2004 dollars. Percentages are author's calculations. Source: Little Rock and Tulsa Districts. 2005. Arkansas River Navigation Study Arkansas and Oklahoma McClellan-Kerr Arkansas River Navigation System: Final Feasibility Report. Little Rock, AR and Tulsa, OK: U.S. Army Corps of Engineers (August).

charges during construction.[144] Interest charges during construction are approximately $2 million. This means that the total implementation costs of just dredging is about $23 million with annual operations and maintenance costs of $456.9 thousand.

However, the above, dredge-only costs figures do not account for additional costs that would be expected if the dikes and jetties are not installed. Such costs increases would include additional annual operations and maintenance (O&M) dredging because of increases in sediment related to bed and bank erosion. Due to the additional annual O&M dredging, additional dredged material disposal costs would increase and additional disposal areas would have to be acquired to accommodate the increased volume of dredged material. Greater mitigation efforts will need to be undertaken due to increase annual O&M dredging activities—thus increasing mitigation costs. One of the purposes of river training structures is to help keep the navigation channel where it is supposed to be. There will be a greater likelihood that the MKARNS channel might move without the river training structures. This would further increase mitigation costs.

VII.2 Economic Effects of Deepening the MKARNS Navigation Channel

There are three parts to estimating the economic impacts of deepening the MKARNS navigation channel an additional three feet. First, the Corps of Engineers will spend additional monies in order to operate and maintain the deeper navigation channel. Second, the additional three feet of navigation channel adds to the existing transportation benefits created by the existing nine feet. Third, the money spent to deepen the MKARNS navigation channel represents a public investment in the nation's waterway infrastructure.

VII.2.1 Operations and Maintenance Spending Economic Effects of Deepening the MKARNS Navigation Channel

The Army Corps of Engineers is expected to spend $848 thousand (2004 prices) annually to keep the MKARNS operational in Oklahoma, according to the 2005 MKARNS Feasibility Report. The annualized value of this expenditure over 50 years is approximately $1.4 million (in 2011 prices).[145] Table 83 shows the discounted and annualized operations and maintenance expenditures by type of commodity purchased.

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[144] These items include Dredging and Rock Removal (line 09.01.16), Dredged Material Disposal Areas (line 09.01.20), Real Estate – Dredge Material Disposal Areas (line 01), and Mitigation (line 06).

[145] We assumed that MKARNS traffic will grow at 1.6% annually and a 3.375% discount rate. We used a GDP deflator to update price levels from 2004 to 2011.

Table 83 Annualized MKARNS of Additional O&M Expenditures for a Deepened Navigation Channel[146]

Code	Commodity	Corps O&M Expenditures
7	Other foodstuffs and fats & oils	$23
11	Natural sands, gravel & crushed stone	$26
16	Gasoline, aviation turbine fuel & fuel oils	$78
30	Primary & semifinished base metal forms & shapes	$27
31	Base metal products	$92
35	Transport equipment	$21
43	Contract Construction	$192
68	Rental and Leasing Services	$64
70	Professional, Scientific, and Technical Services	$44
72	Administrative and Support Services	$83
84	Repair and Maintenance	$131
88	Public Institutions	$170
5001	Employee Compensation	$408
	Total	$1,359

Table 84 provides the regional economic impacts of Tulsa District's O&M expenditures. The State of Oklahoma gets about two-thirds of the economic impacts generated nationally by the Corps O&M expenditures in Oklahoma.

Table 84 O&M Expenditure Impacts of Deepening the MKARNS Navigation Channel[147]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$3,544	26	$1,044	$765	$145	$1,954
Arkansas	$86	1	$20	$15	$3	$37
Oklahoma	$2,398	19	$757	$500	$98	$1,355
Kansas	$86	1	$21	$16	$3	$40
Missouri	$120	1	$32	$23	$4	$59
Texas	$854	5	$214	$211	$37	$463
Rest of US	$1,331	7	$355	$290	$50	$695
US Total Impact	$4,875	33	$1,399	$1,056	$195	$2,649

[146] Notes: Tulsa District receives $10 million annually for MKARNS O&M. Funds are discounted over a 50 year period using a 3.375% discount rate. Monetary values in thousands of 2011 dollars. Source: Tulsa District, U.S. Army Corps of Engineers.

[147] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

VII.2.2 Transportation Benefits Economic Effects of Deepening the MKARNS Navigation Channel

The additional three feet of navigation channel adds to the existing transportation benefits created by the existing 9 feet. The additional transportation savings created by the additional three feet of navigation channel (i.e., from 9 feet to 12 feet) are shown in Table 85.

Table 85 Annualized Transportation Savings from Deepening the MKARNS Navigation Channel an Additional Three Feet[148]

Code	Commodity	From	To	2011 Prices	2015 Prices
14	Coal	OK	RUS	$1,589	$1,695
15	Crude petroleum	OK	RUS	$333	$356
17	Coal & petroleum products, n.e.c.	OK	TX	$89	$95
17	Coal & petroleum products, n.e.c.	OK	RUS	$267	$285
13	Metallic ores & concentrates	OK	RUS	$213	$227
2	Cereal grains	OK	RUS	$4,026	$4,296
3	Other agricultural products	OK	RUS	$15	$16
4	Animal feed	OK	RUS	$51	$54
38	Miscellaneous manufactured products	OK	AR	-$12	-$13
38	Miscellaneous manufactured products	OK	OK	-$1	-$1
38	Miscellaneous manufactured products	OK	MO	-$3	-$3
38	Miscellaneous manufactured products	OK	TX	-$5	-$5
38	Miscellaneous manufactured products	OK	RUS	-$103	-$110
17	Coal & petroleum products, n.e.c.	RUS	OK	$29	$31
20	Fertilizers	RUS	OK	$771	$823
18	Basic chemicals	RUS	OK	$12	$13
22	Plastics & rubber products	RUS	OK	$0	$0
11	Natural sands, gravel & crushed stone	AR	OK	$11	$12
11	Natural sands, gravel & crushed stone	RUS	OK	$3	$4
12	Nonmetallic minerals, n.e.c.	AR	OK	$35	$38
12	Nonmetallic minerals, n.e.c.	RUS	OK	$11	$12
29	Nonmetalic mineral products	AR	OK	$3	$3
29	Nonmetalic mineral products	RUS	OK	$1	$1
30	Primary & semifinished base metal forms & shapes	AR	OK	$44	$47
30	Primary & semifinished base metal forms & shapes	RUS	OK	$252	$269
31	Base metal products	AR	OK	$3	$3
31	Base metal products	RUS	OK	$17	$18

[148] Note: Savings values are expressed in thousands of dollars. Savings in 2015 prices were adjusted from 2011 prices using the GDP deflator.

Code	Commodity	From	To	2011 Prices	2015 Prices
2	Cereal grains	AR	OK	$8	$8
2	Cereal grains	RUS	OK	$62	$66
4	Animal feed	AR	OK	$63	$68
4	Animal feed	RUS	OK	$521	$556
7	Other foodstuffs and fats & oils	AR	OK	$20	$22
7	Other foodstuffs and fats & oils	RUS	OK	$167	$178
38	Miscellaneous manufactured products	AR	OK	-$2	-$2
38	Miscellaneous manufactured products	OK	OK	-$1	-$1
38	Miscellaneous manufactured products	MO	OK	-$8	-$9
38	Miscellaneous manufactured products	TX	OK	-$1	-$1
38	Miscellaneous manufactured products	RUS	OK	-$42	-$45
	Total			$8,438	$9,005

Table 86 Economic Impacts of Deepening the MKARNS Navigation Channel an Additional Three Feet[149]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$2,481	11	$517	$603	$116	$1,236
Arkansas	$134	1	$33	$22	$4	$59
Oklahoma	$857	4	$153	$211	$49	$413
Kansas	$64	0	$11	$13	$2	$26
Missouri	$134	1	$27	$31	$5	$63
Texas	$1,293	5	$293	$326	$56	$675
Rest of US	$27,457	127	$7,311	$6,924	$1,164	$15,400
US Total Impact	$29,938	137	$7,828	$7,528	$1,280	$16,636
Transport Savings	$9,006	0	$0	$0	$0	$9,006
US Impact + Savings	$38,944	137	$7,828	$7,528	$1,280	$25,642

Transportation efficiencies in Oklahoma's portion of the MKARNS (i.e., by deepening the navigation channel an additional three feet) are estimated to increase the nation's business sales annually by $38.9 million (in 2015 prices): see Table 86. The contribution to the nation's gross domestic product (GDP) is $25.6 million and gross business operating surpluses of $7.5 million. Oklahoma's portion of the MKARNS is responsible for 140 of the nation's full and part-time jobs and for $7.8 million in employee compensation. Business taxes and license fees total $1.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $2.5 million in business sales, $1.2 million in GDP, 10 full and part-time jobs, $520 thousand in employee compensation, $600 thousand in gross operating surplus, and $120

[149] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

thousand in business taxes. The State of Oklahoma also shares in the economic value: $860 thousand in business sales, $410 thousand in GDP, 4 full and part-time jobs, $150 thousand in employee compensation, $210 thousand in gross business operating surpluses, and $50 thousand in business taxes.

VII.2.3 Investment Economic Effects of Deepening the MKARNS Navigation Channel

The approximate cost of deepening the entire MKARNS navigation channel is about $185 million of which about 44% is Oklahoma's share ($81.4 million). There will be short-run impacts associated with spending these funds while constructing the deeper navigation channel. However, it is expected that the construction period of the channel deepening will take about four years. Consequently, we do not consider these short-term impacts in this analysis. Rather, the channel deepening represents an investment in the value of MKARNS capital stock. As a result, deepening the MKARNS' navigation channel also provides productivity benefits. These productivity effects are long-term and are expected to generate annual increases in business sales, gross domestic product, employment, employee compensation, gross operating surpluses, and business tax revenues—as long as the deeper navigation channel is maintained.

Table 87 Productivity Impacts due to Deepening the MKARNS[150]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$154,652	1,005	$43,843	$30,863	$5,441	$80,147
Arkansas	$4,195	22	$867	$665	$109	$1,641
Oklahoma	$106,374	760	$33,337	$20,209	$3,649	$57,195
Kansas	$5,036	26	$989	$946	$129	$2,064
Missouri	$5,879	33	$1,347	$1,121	$179	$2,648
Texas	$33,168	163	$7,302	$7,922	$1,375	$16,599
Rest of US	$66,621	340	$16,280	$14,175	$2,338	$32,793
US Total Impact	$221,273	1,345	$60,122	$45,038	$7,779	$112,940

The productivity effects are computed by first estimating the reduction labor, materials, and energy costs by industry using the Model B version of the infrastructure productivity model given in Appendix C. The approximate cost of deepening the entire MKARNS navigation channel is about $185 million of which about $81.4 million Oklahoma's. Multiplying the estimated labor, material, and energy cost reductions derived the infrastructure production model (in percentage terms) by their existing cost shares by industry will provide estimates of demand changes for goods and services in each region. That is, even though the infrastructure investment (i.e., channel deepening) is being made on the MKARNS in Oklahoma the productivity effects will be felt throughout the nation. These industry demand change estimates by regional are used in the MKARNS MRVIO spreadsheet program to evaluate the economic impacts in each region.

[150] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

Investments in Oklahoma's portion of the MKARNS (i.e., deepening the navigation channel an additional three feet) are estimated to increase the nation's business sales annually by $221.3 million (in 2015 prices): see Table 87. The contribution to the nation's gross domestic product (GDP) is $112.9 million and gross business operating surpluses of $45.0 million. Oklahoma's portion of the MKARNS is responsible for 1,350 of the nation's full and part-time jobs and for $60.1 million in employee compensation. Business taxes and license fees total $7.8 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $154.7 million in business sales, $80.1 million in GDP, 1,010 full and part-time jobs, $43.8 million in employee compensation, $30.9 million in gross operating surplus, and $5.4 million in business taxes. The State of Oklahoma also shares in the economic value: $106.4 million in business sales, $57.2 million in GDP, 760 full and part-time jobs, $33.3 million in employee compensation, $20.2 million in gross business operating surpluses, and $3.6 million in business taxes.

VII.2.4 Total Economic Effects of Deepening the MKARNS Navigation Channel

Finally, we can see the total economic effects of deepening the MKARNS in Oklahoma by summing the additional operations and maintenance impacts, the transportation impact, and the productivity impacts. The economic value of deepening the McClellan-Kerr Arkansas River Navigation System navigation channel an additional 3 feet is estimated to increase the nation's business sales annually by $265.1 million (in 2015 prices): see Table 88. The contribution to the nation's gross domestic product (GDP) is $141.2 million and gross business operating surpluses of $53.6 million. Oklahoma's portion of the MKARNS is responsible for 1,520 of the nation's full and part-time jobs and for $69.3 million in employee compensation. Business taxes and license fees total $9.3 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $160.7 million in business sales, $83.3 million in GDP, 1,040 full and part-time jobs, $45.4 million in employee compensation, $32.2 million in gross operating surplus, and $5.7 million in business taxes. The State of Oklahoma also shares in the economic value: $109.6 million in business sales, $59.0 million in GDP, 780 full and part-time jobs, $34.2 million in employee compensation, $20.9 million in gross business operating surpluses, and $3.8 million in business taxes.

Table 88 Total Economic Effects of Deepening the MKARNS Navigation Channel Three Extra Feet: Transportation Saving Plus Productivity Effects[151]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$160,677	1,041	$45,403	$32,232	$5,702	$83,337
Arkansas	$4,414	23	$919	$702	$116	$1,737
Oklahoma	$109,628	783	$34,247	$20,920	$3,796	$58,964
Kansas	$5,186	27	$1,021	$975	$134	$2,130
Missouri	$6,134	34	$1,406	$1,176	$188	$2,770
Texas	$35,314	173	$7,810	$8,459	$1,468	$17,737
Rest of US	$95,409	474	$23,946	$21,390	$3,552	$48,888
US Total Impact	$256,086	1,516	$69,349	$53,622	$9,255	$132,225
Transport Savings	$9,006	0	$0	$0	$0	$9,006
US Impact + Savings	$265,092	1,516	$69,349	$53,622	$9,255	$141,231

[151] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

VIII ECONOMIC COSTS AND IMPACTS OF TRAFFIC DISRUPTIONS ON THE MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM

Inland waterway ports are vital to the U.S. economy since these ports serve as multimodal transport hub by connecting barge, train, and truck transportation modes (MacKenzie et al., 2012). In fact the Oklahoma Department of Transportation (ODOT) reported 12.1 million tons traveled the entire McClellan-Kerr Arkansas River Navigation System (about half of the tonnage traveled on the Oklahoma portion on the MKARNS). Disruptive events such as the closure of an inland port can significantly effects the flow of commodities, thus impacting the businesses that rely on the MKARNS for delivery of their cargo in a timely manner (Grier, 2009). In this section we address the economic costs associated disruptive closures on the MKARNS and their economic effects.

VIII.1 Business Costs of MKARNS Traffic Disruptions in Oklahoma [152]

When a traffic disruption occurs tow boats have several choices. A tow boat can either wait for the system to become operable or choose to use an alternative mode of transportation. If the tow boat decides to wait, there are two costs associated with that decision: a penalty cost and a holding cost. If another mode of transportation is chosen there is an extra transportation cost in addition to the penalty and holding costs.

It is assumed in this model that, if a tow is carrying different commodities, some of the barges can choose to wait while others can opt for an alternative mode of transportation. Once the decision to wait or use an alternative mode of transportation is made, it cannot be changed. The decision to wait is done by calculating the maximum days to wait without exceeding the cost of using the alternative mode of transportation. The decision is made based on the expected disruption duration. Our aim is to reduce total transportation costs, given the expected disruption time.

Furthermore, commodities are assumed to incur a 3% penalty cost for the first week in the water, and a 7% penalty cost for each subsequent week. The holding cost is estimated to be 24.33% yearly. In case of using an alternative mode of transportation, it is assumed that truck or rail will be used and that these modes have enough capacity to handle the extra cargo. The ratio of truck-to-rail usage is based on the U.S. Commodity Flow Survey. If an alternative mode of transportation is used, it is estimated that there is a one-week waiting time to get the alternative mode.

The daily arrival rate for each commodity was determined based on annual tonnages, barge capacities, and number of barges per tow. A triangular distribution was used for the number of barges per tow (6, 8, 15), a uniform distribution was used for the barge capacity

[152] We thank Professor Heather Nachtman and Mr. Furkan Oztanriseven for providing the disruption costs.

(1400, 1500), and a Poisson distribution was used for the barges arrival rate. The total cost incurred during the disruption time is the sum of the holding cost, penalty cost, and transportation cost (if any).

Monte Carlo simulations were run using the @Risk software. @Risk software allows the user to perform risk analysis by showing all the possible outcomes to the user. The software mathematically calculates possible future scenarios and reports the probabilities and risk associated with each possibility (http://www.palisade.com/risk/). The output is the total cost while the input is the barges per tow, barges capacity, and the arrival rate. That allowed us to determine an upper and lower limit for the total cost. The total added cost was divided by the tonnage shipped during the disruption period to determine the increase in price per ton during that period. Table 89 shows the estimated average business disruption costs per ton for the types of commodities shipped on the MKARNS for delays of varying duration.

Table 89 Delay Costs per Ton of Commodity Shipped for Varying Disruption Durations[153]

Commodity	1 day	2 days	3 days	2 weeks	2 months	6 months
Chemical Fertilizers	$0.01	$0.02	$0.04	$1.10	$11.25	$38.39
Coal and Coke	$0.00	$0.00	$0.01	$0.21	$5.23	$28.10
Food/Farm Products	$0.00	$0.01	$0.01	$0.29	$6.84	$30.13
Iron and Steel	$0.01	$0.03	$0.06	$1.70	$13.06	$43.29
Manufacturing Equipment and Machinery	$0.07	$0.21	$0.40	$3.74	$34.40	$109.63
Minerals and Building Materials	$0.00	$0.01	$0.03	$0.77	$10.07	$35.71
Miscellaneous Products	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other Chemicals	$0.00	$0.01	$0.03	$0.74	$10.01	$35.47
Petroleum Products	$0.01	$0.02	$0.03	$0.82	$10.31	$36.11
Sand, Gravel and Rock	$0.00	$0.00	$0.00	$0.02	$0.55	$5.50
Grain	$0.00	$0.01	$0.02	$0.35	$7.41	$30.92

VIII.2 Economic Impacts of MKARNS Traffic Disruptions in Oklahoma

Transportation cost estimates are computed by multiplying the per ton delay costs by the outgoing and incoming 2012 Waterborne Commerce traffic data for each commodity type: see Table 90. Note, delays that are 3 days or less have total delay costs that are less than $1 million. We do not expect that delay costs that are less than $1 million in total are likely to generate substantial regional economic impacts and, as a result, they are not summarized herein. However, we do show the impacts of traffic delays of one day, two days, and three days in Tables 91 through 93. Below, we review the economic consequences of traffic disruptions lasting 2 weeks, 2 months, and 6 months in Table 94 through 97.

[153] Source: Calculations by Professor Heather Nachtmann, and Mssers. Furkan Oztanriseven and Othman Boudhaoum, University of Arkansas at Fayetteville.

Table 90 Traffic Delay Costs for Varying Disruptions[154]

Delay	AR	OK	MO	TX	RUS	Total
From Oklahoma	$7	$0	$2	$4	$68	$82
To Oklahoma	$1	$0	$5	$1	$44	$52
1 Day Delay Total	$9	$0	$7	$5	$113	$133
From Oklahoma	$22	$1	$5	$11	$212	$252
To Oklahoma	$5	$1	$15	$2	$120	$143
2 Day Delay Total	$27	$1	$20	$13	$332	$394
From Oklahoma	$43	$3	$10	$19	$399	$474
To Oklahoma	$9	$3	$29	$4	$230	$274
3 Day Delay Total	$51	$3	$38	$23	$629	$745
From Oklahoma	$399	$25	$92	$243	$4,363	$5,121
To Oklahoma	$146	$25	$267	$33	$3,660	$4,131
2 Week Delay Total	$544	$25	$359	$276	$8,023	$9,227
From Oklahoma	$3,666	$232	$844	$2,550	$48,744	$56,036
To Oklahoma	$1,405	$232	$2,459	$302	$36,045	$40,442
2 Month Delay Total	$5,071	$232	$3,303	$2,852	$84,788	$96,246
From Oklahoma	$11,684	$738	$2,691	$8,497	$172,808	$196,418
To Oklahoma	$5,183	$738	$7,837	$962	$121,736	$136,456
6 Month Delay Total	$16,867	$738	$10,528	$9,459	$294,543	$332,136

Table 91 Economic Effects of a 1-Day Delay in MKARNS Traffic[155]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$11	0	$3	$2	$0	$5
Arkansas	$1	0	$0	$0	$0	$0
Oklahoma	$3	0	$1	$1	$0	$1
Kansas	$0	0	$0	$0	$0	$0
Missouri	$0	0	$0	$0	$0	$0
Texas	$7	0	$2	$2	$0	$3
Rest of US	$154	1	$41	$38	$6	$86
US Total Impact	$165	1	$44	$41	$7	$91
Transport Savings	$133	0	$0	$0	$0	$133
US Impact + Savings	$298	1	$44	$41	$7	$224

154 Note: Monetary values in thousands of 2015 annualized net present value dollars. Savings for Oklahoma is both incoming and outgoing, the total only counts it once.

155 Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

Table 92 Economic Effects of a 2-Day Delay in MKARNS Traffic[156]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$32	0	$8	$7	$1	$16
Arkansas	$3	0	$1	$1	$0	$2
Oklahoma	$8	0	$2	$2	$0	$4
Kansas	$1	0	$0	$0	$0	$0
Missouri	$2	0	$0	$0	$0	$1
Texas	$19	0	$4	$4	$1	$9
Rest of US	$468	2	$123	$119	$19	$261
US Total Impact	$500	2	$131	$126	$20	$277
Transport Savings	$394	0	$0	$0	$0	$394
US Impact + Savings	$894	2	$131	$126	$20	$671

Table 93 Economic Effects of a 3-Day Delay in MKARNS Traffic[157]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$63	0	$15	$14	$2	$31
Arkansas	$6	0	$1	$1	$0	$3
Oklahoma	$16	0	$4	$4	$1	$8
Kansas	$1	0	$0	$0	$0	$0
Missouri	$3	0	$1	$1	$0	$2
Texas	$36	0	$8	$9	$1	$18
Rest of US	$876	4	$233	$221	$36	$490
US Total Impact	$939	4	$247	$235	$38	$521
Transport Savings	$745	0	$0	$0	$0	$745
US Impact + Savings	$1,684	4	$247	$235	$38	$1,266

The economic value of traffic disruptions on the MKARNS lasting 2 weeks is estimated to decrease the nation's business sales annually by $26.5 million (in 2015 prices): see Table 94. The contribution to the nation's gross domestic product (GDP) is $18.7 million and gross business operating surpluses of $4.3 million. Oklahoma's portion of the MKARNS is responsible for 80 of the nation's full and part-time jobs and for $4.6 million in employee compensation. Business taxes and license fees total $0.7 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $1.1 million in business sales, $550 thousand in GDP, 5 full and part-time jobs, $250 thousand in employee compensation, $250 thousand in gross operating surplus, and $40 thousand in business taxes. The State of Oklahoma also shares in the economic value: $220 thousand in business sales, $110 thousand in GDP, 1 full

[156] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

[157] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

and part-time jobs, $50 thousand in employee compensation, $50 thousand in gross business operating surpluses, and $10 thousand in business taxes.

Table 94 Economic Effects of a 2-Week Delay in MKARNS Traffic[158]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$1,110	5	$254	$252	$39	$546
Arkansas	$109	1	$25	$20	$3	$48
Oklahoma	$222	1	$53	$52	$9	$113
Kansas	$22	0	$4	$4	$1	$9
Missouri	$64	0	$14	$15	$2	$32
Texas	$693	3	$158	$161	$25	$344
Rest of US	$16,181	74	$4,251	$4,027	$661	$8,939
US Total Impact	$17,291	79	$4,506	$4,279	$700	$9,485
Transport Savings	$9,227	0	$0	$0	$0	$9,227
US Impact + Savings	$26,518	79	$4,506	$4,279	$700	$18,712

Table 95 Economic Effects of a 2-Month Delay in MKARNS Traffic[159]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	$13,276	63	$2,949	$3,072	$493	$6,514
Arkansas	$1,332	8	$287	$244	$35	$566
Oklahoma	$2,854	18	$622	$684	$123	$1,429
Kansas	$280	1	$52	$55	$8	$114
Missouri	$896	4	$190	$220	$35	$445
Texas	$7,915	33	$1,799	$1,869	$292	$3,960
Rest of US	$185,637	841	$48,163	$46,772	$7,701	$102,637
US Total Impact	$198,913	904	$51,113	$49,844	$8,195	$109,151
Transport Savings	$96,246	0	$0	$0	$0	$96,246
US Impact + Savings	$295,159	904	$51,113	$49,844	$8,195	$205,397

The economic value of traffic disruptions on the MKARNS lasting 2 months is estimated to decrease the nation's business sales annually by $295.2 million (in 2015 prices): see Table 95. The contribution to the nation's gross domestic product (GDP) is $205.4 million and gross business operating surpluses of $49.8 million. Oklahoma's portion of the MKARNS is responsible for 900 of the nation's full and part-time jobs and for $51.1 million in employee compensation. Business taxes and license fees total $8.2 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $13.3 million in business sales, $6.5 million in GDP, 60 full and part-time jobs, $2.9 million in employee compensation,

158 Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

159 Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

$3.1 million in gross operating surplus, and $490 thousand in business taxes. The State of Oklahoma also shares in the economic value: $2.9 million in business sales, $1.4 million in GDP, 20 full and part-time jobs, $620 thousand in employee compensation, $680 thousand in gross business operating surpluses, and $120 thousand in business taxes.

The economic value of traffic disruptions on the MKARNS lasting 6 months is estimated to decrease the nation's business sales annually by $1.1 billion (in 2015 prices): see Table 96. The contribution to the nation's gross domestic product (GDP) is $722.0 million and gross business operating surpluses of $178.2 million. Oklahoma's portion of the MKARNS is responsible for 3,230 of the nation's full and part-time jobs and for $182.3 million in employee compensation. Business taxes and license fees total $29.4 million. For Oklahoma and the surrounding region, the Oklahoma portion the MKARNS provides $48.8 million in business sales, $23.9 million in GDP, 230 full and part-time jobs, $10.7 million in employee compensation, $11.4 million in gross operating surplus, and $1.9 million in business taxes. The State of Oklahoma also shares in the economic value: $11.0 million in business sales, $5.5 million in GDP, 60 full and part-time jobs, $2.3 million in employee compensation, $2.7 million in gross business operating surpluses, and $500 thousand in business taxes.

Table 96 Economic Effects of a 6-Month Delay in MKARNS Traffic[160]

Region	Sales	Employ ment	Employee Comp	Gross Surplus	Business Taxes	Value Added
MKARNS Region	**$48,770**	**229**	**$10,722**	**$11,352**	**$1,871**	**$23,944**
Arkansas	**$4,935**	**28**	**$1,039**	**$898**	**$129**	**$2,067**
Oklahoma	**$11,002**	**63**	**$2,309**	**$2,656**	**$505**	**$5,470**
Kansas	**$1,043**	**4**	**$191**	**$204**	**$30**	**$425**
Missouri	**$3,397**	**16**	**$719**	**$833**	**$136**	**$1,688**
Texas	**$28,393**	**117**	**$6,464**	**$6,760**	**$1,071**	**$14,295**
Rest of US	**$660,830**	**2,997**	**$171,549**	**$166,829**	**$27,544**	**$365,922**
US Total Impact	**$709,600**	**3,226**	**$182,271**	**$178,181**	**$29,415**	**$389,866**
Transport Savings	**$332,136**	**0**	**$0**	**$0**	**$0**	**$332,136**
US Impact + Savings	**$1,041,736**	**3,226**	**$182,271**	**$178,181**	**$29,415**	**$722,002**

[160] Note: All monetary values in thousands of 2015 dollars. Employment is full and part-time jobs.

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APPENDIX A: COMPILING THE MKARNS MULTIREGIONAL SOCIAL ACCOUNTING MATRIX USING IMPLAN'S DATABASES

A.1 Introduction

One of the key components that is necessary to generate the information that will be used to market and educate public officials about the benefits of a 100% fully functional MKARNS is a working model of the economy that is potentially impacted by the navigation system and its water resource-related activities (that is, water borne commerce, hydropower, water supply, recreation, and environmental protection). This report describes an economic model (called the MKARNS Multiregional Social Accounting Matrix Model) has been compiled for the Regional Economic Impact Study of the McClellan-Kerr Arkansas River Navigation System. Included herein are the data sources and procedures that were used in the construction of the MKARNS MRSAM model. The MKARNS MRSAM model has a six-region spatial and an 89-sector industrial configuration. The six regions of the model are the States of Arkansas, Oklahoma, Kansas, Missouri, Texas, and the sum of remaining states and the District of Columbia. The 89 sectors included in the model are defined in a later part of this report. Note that many of the components of the MKARNS MRSAM model are too voluminous to be included in this text. The entire MKARNS MRSAM model and the necessary ancillary data are included in a companion spreadsheet.

This model construction documentation report includes the following agenda. First, social accounting matrices and SAM multipliers are briefly described. Second, an explanation of the process of compiling the SAM models for each of the MKARNS regions using the IMPLAN data for 2011. Third, the procedures and data sources used to spatially interconnect the industrial structures of the individual regional SAMs to construct the MKARNS MRSAM impact multiplier model are provided. And fourth, the calculation and use of the MKARNS MRSAM impact multipliers are explained.

A.2 Compiling the MKARNS Single-Region SAMs

A.2.1The IMPLAN Social Accounting Matrix Format

IMPLAN (MIG 1998) has developed a social accounting matrix format (Table A1) that follows the basic SAM principles discussed earlier. The IMPLAN SAM for a regional economy is compiled from the "26 File CGE Format Files" (there are actually 27 files) in a convenient folder that is created when an IMPLAN user constructs a model for the region that is chosen. When downloaded from the IMPLAN software a new folder will be created for these files. Table A2 shows the names, information contents, and maximum dimensions that will be generated by IMPLAN for each region. IMPLAN SAM accounting formats and their elements are discussed in detail by MIG (1998).

"Industry" represents each of the IMPLAN industrial sectors and "commodity" represents each of the IMPLAN commodities. There are currently 440 industries and commodities in the IMPLAN data bases. "Factors" include employee compensation, proprietors' income, other property-type income, and business taxes. "Institutions" include households (by income levels), federal government (defense, non-defense, and investment), state and local government (education, non-education, and investment), enterprises (mainly corporate profits), capital, and inventory. "Foreign trade" consists of foreign exports and imports. And, "domestic trade" includes domestic exports and imports.

Table A1 Detailed Single Region IMPLAN SAM Model Accounting Structure (Sales and Distributions)[161]

Payments and Receipts*	Industry	Commodity	Factor	Institution	Foreign Trade	Domestic Trade
Industry	0	Local industry make (1×2)	0	0	Industry foreign exports by commodity (1×7)	Industry domestic exports by commodity (1×8)
Commodity	Industry use of local commodities (2×1)	0	0	Institutional use of local commodities (2×4)	0	0
Factor	Factor incomes (3×1)	0	0	0	0	0
Institution	0	Local institutional sales (4×2)	Institution factor distributions (4×3)	Institutional transfers (4×4)	Institutional foreign exports (4×7)	Institutional domestic exports (4×8)
Foreign Trade	Industry foreign imports by commodity (7×1)	0	Foreign factor imports (5×3)	Institutional foreign imports (7×4)	Foreign transshipments (5×5)	0
Domestic Trade	Industry domestic imports by commodity (8×1)	0	Domestic factor imports (6×3)	Institutional domestic imports by commodity (8×4)	0	0

Table A2 IMPLAN CGE File Names and Dimensions

#	CGE File Name	Information	Rows	Columns
1	CGE Files (Text304) 1x2.dat	Local industry make	440	440
2	CGE Files (Text304) 1x5.dat	Industry foreign exports (aggregated)	440	1
3	CGE Files (Text304) 1x6.dat	Industry domestic exports (aggregated)	440	1
4	CGE Files (Text304) 1x7.dat	Industry foreign exports by commodity	440	440
5	CGE Files (Text304) 1x8.dat	Industry domestic exports by commodity	440	440
6	CGE Files (Text304) 2x1.dat	Industry use of locally produced commodities	440	440
7	CGE Files (Text304) 2x4.dat	Institutional use of locally produced commodities	440	18
8	CGE Files (Text304) 3x1.dat	Factor incomes by industry	4	440
9	CGE Files (Text304) 4x2.dat	Local institutional sales by commodity	18	440
10	CGE Files (Text304) 4x3.dat	Institutional factor distributions	18	4
11	CGE Files (Text304) 4x4.dat	Institutional transfers	18	18
12	CGE Files (Text304) 4x5.dat	Institutional foreign exports (aggregated)	18	1
13	CGE Files (Text304) 4x6.dat	Institutional domestic exports (aggregated)	18	1

[161] * Values in millions of dollars. The zero cells are filled with zero elements.

#	CGE File Name	Information	Rows	Columns
14	CGE Files (Text304) 4x7.dat	Institutional foreign exports by commodity	18	440
15	CGE Files (Text304) 4x8.dat	Institutional domestic exports by commodity	18	440
16	CGE Files (Text304) 5x1.dat	Industry foreign imports (aggregated)	1	440
17	CGE Files (Text304) 5x3.dat	Foreign factor imports	1	4
18	CGE Files (Text304) 5x4.dat	Institutional foreign imports	1	18
19	CGE Files (Text304) 5x5.dat	Foreign transhipments	1	1
20	CGE Files (Text304) 6x1.dat	Industry domestic imports (aggregated)	1	440
21	CGE Files (Text304) 6x3.dat	Domestic factor imports	1	4
22	CGE Files (Text304) 6x4.dat	Institutional domestic imports (aggregated)	1	440
23	CGE Files (Text304) 7x1.dat	Industry foreign imports by commodity	440	440
24	CGE Files (Text304) 7x4.dat	Institutional foreign imports by commodity	440	18
25	CGE Files (Text304) 8x1.dat	Industry domestic imports by commodity	440	440
26	CGE Files (Text304) 8x4.dat	Institutional domestic imports by commodity	440	18
27	CGE Files (Text304) EMP.dat	Industry employment	440	1

The contents of each occupied cell in Table A 1 are reviewed here (the unoccupied cells are shown in dark grey—their contents are all equal to zero). Starting with column one ("Industry), cell (2x1) contains the use (purchase) of locally produced commodities by industries. Cell (3x1) provide factor income or payments to workers, interest, profits, rents, and governments. Cell (7x1) include foreign imports of commodities by industries. Cell (8x1) include domestic imports of commodities by industries. In column two ("Commodity"), cell (1x2) contains the commodities produced by industries. Cell (4x2) shows the commodities produced by institutions.

Column three ("Factor") represents the payments by or distributions of factor incomes. Cell (4x3) show the factor income distributions to institutions. Cell (5x3) are the foreign factor imports and cell (6x3) are the domestic factor imports.

Column four ("Institution") represents the payments by institutions for commodities or to other institutions. Cell (2x4) contains the institutional use of locally produced commodities. Cell (4x4) includes the inter-institutional income transfers. Cell (7x4) contains the institutional use of foreign produced commodities. Cell (8x4) contains the institutional use of commodities produced elsewhere in the nation.

Column five ("Foreign Trade") provides foreign exports. Cell (1x7) contains foreign commodities by local industries. Cell (4x7) contains the for commodity exports for each institution. Cell (5x5) provides the foreign trans-shipments. Trans-shipments are goods that are shipped into the U.S. and then shipped out without further processing.

Column six ("Domestic Trade") would normally contain domestic commodity exports produced by local industries and institutions. However, these are left empty (or contain zero values). The values in these sub-matrices will be determined when domestic commodity imports are calculated via a trade-flow procedure explained below. Note that the commodity imports purchased by users in region A from region B are also the commodity exports from region B to region A.

IMPLAN's social accounting matrices have a flexible six-row and six-column format. Many arrangements of the 27 IMPLAN CGE files are possible depending on a user's needs. For the MKARNS multiregional social accounting matrix model we first arranged 18 of the 27 IMPLAN CGE files in a SAM accounting format for each of the regions used—as shown in Figure A1. Then we added the import sub-matrices to their corresponding local industry and institutional use sub-matrices as shown in Table A3.

Table A3 Detailed Single Region IMPLAN SAM Model Accounting Framework with Imports Aggregated (Sales and Distributions)

Payments and Receipts*	Industry	Commodity	Factor	Institution	Foreign Trade	Domestic Trade
Industry	0	Local industry make (1×2)	0	0	Industry foreign exports by commodity (1×7)	Industry domestic exports by commodity (1×8)
Commodity	Total Industry use of commodities (2×1)+(7x1)+(8x1)	0	0	Total Institutional use of commodities (2×4)+(7x4)+(8x4)	0	0
Factor	Factor incomes (3×1)	0	0	0	0	0
Institution	0	Local institutional sales (4×2)	Institution factor distributions (4×3)	Institutional transfers (4×4)	Institutional foreign exports (4×7)	Institutional domestic exports (4×8)
Foreign Trade	0	0	Foreign factor imports (5×3)	0	Foreign transshipments (5×5)	0
Domestic Trade	0	0	Domestic factor imports (6×3)	0	0	0

A.2.2 Structure with Total Industry and Institutional Use of Commodities

Aggregations: Industries, Commodities, and Regions

IMPLAN's industry and commodity specifications are more detailed that can be accommodated for the MKARNS MRSAM model. This is partly due to the commodity state-to-state trade flow data available from the U.S. Department of Transportation which has trade flows for about 41 identifiable commodities.[162] The majority of the remaining industries and

[162]Due to sectoring consistencies with the detailed IMPLAN commodity categories, several DOT commodity categories were aggregated to match the IMPLAN commodities. Sand mining (DOT code 11) was aggregated with gravel quarrying and crushed stone (DOT code 12). Also, gasoline and aviation fuel (DOT code 17) was aggregated with fuel oil (DOT code 18).

commodities were aggregated at the 3-digit NAICS code levels. The 89 resulting industries and commodities used in the MKARNS MRSAM model are shown in Table A4.

Table A4 MKARNS Industry/Commodity Definitions and Cross Walk to IMPLAN

Code	Industry or Commodity	IMPLAN Codes
1	Live animals and fish	011 - 014, 017, 018
2	Cereal grains	002
3	Other agricultural products	001, 003 - 010
4	Animal feed	041 - 042
5	Meat, fish, seafood and preparations	059 - 061
6	Milled grains and bakery products	043, 044, 047, 062 - 065
7	Other foodstuffs and fats and oils	045, 046, 048 - 058, 066 - 070
8	Alcoholic beverages	071 - 073
9	Tobacco products	074
10	Monument and building stone	025, 166
11	Natural sands, gravel and crushed stone	026
12	Nonmetallic minerals, NEC	027
13	Metallic ores and concentrates	022 - 024
14	Coal	021
15	Crude petroleum	020
16	Gasoline, aviation turbine fuel and fuel oils	115
17	Coal and petroleum products, NEC	116 - 119
18	Basic chemicals	120 - 126
19	Pharmaceuticals	132 - 135
20	Fertilizers	130
21	Chemical products and preparations, NEC	127 - 129, 131, 136 - 141
22	Plastics and rubber products	142 - 152
23	Logs and wood in the rough	015, 016, 095
24	Wood products	096 - 103
25	Pulp, newsprint, paper and paperboard	104 - 106, 108
26	Paper and paperboard articles	107, 109 - 112
27	Printed products	113
28	Textiles and leather products	075 - 094
29	Nonmetalic mineral products	153 - 165, 167 -169
30	Primary and semifinished base metal forms and shapes	170 - 182
31	Base metal products	183 - 190, 193 - 202
32	Machinery	203 - 233
33	Electronic and electrical equipment and components	234 - 258, 266 - 275
34	Motorized vehicles (including parts)	276 - 283, 292 - 294
35	Transport equipment	284 - 286, 289 - 291
36	Precision instruments and apparatus	305 - 309
37	Furniture, fixtures, lamps and lighting equipment	259 - 265, 295 - 304

Code	Industry or Commodity	IMPLAN Codes
38	Miscellaneous manufactured products	191, 192, 287, 288, 310 - 318
39	Waste and scrap	434, 435
40	Support activities for agriculture and forestry	019
41	Support activities for mining	028-030
42	Utilities	031 - 033, 428, 431
43	Contract construction	034 - 040
44	Support activities for printing	114
45	Wholesale trade	319
46	Retail stores	320 - 331
47	Air transportation	332
48	Rail transportation	333
49	Water transportation	334
50	Truck transportation	335
51	Transit and ground passenger transportation	336, 430
52	Pipeline transportation	337
53	Scenic, sightseeing and transportation support	338
54	Postal service	427
55	Couriers and messengers	339
56	Warehousing and storage	340
57	Publishing industries (except internet)	341 - 345
58	Motion picture and sound recording industries	346, 347
59	Broadcasting (except internet)	348, 349
60	Telecommunications	351
61	Data Processing, hosting and related services	352
62	Other information services	350, 353
63	Monetary authorities and credit intermediation	354, 355
64	Securities, commodity contracts and other financial investments and related activities	356
65	Insurance carriers and related activities	357, 358
66	Funds, trusts and other financial vehicles	359
67	Real estate	360, 361
68	Rental and leasing services	362 - 365
69	Lessors of nonfinancial intangible assets (except copyrighted works)	366
70	Professional, scientific and technical services	367 - 380
71	Management of companies and enterprises	381
72	Administrative and support services	382 - 389
73	Waste management and remediation services	390
74	Educational services	391 - 393
75	Ambulatory health care services	394 - 396
76	Hospitals	397
77	Nursing and residential care facilities	398

Code	Industry or Commodity	IMPLAN Codes
78	**Social assistance**	**399 - 401**
79	**Performing arts, spectator sports and related industries**	**402 - 405**
80	**Museums, historical sites and similar institutions**	**406**
81	**Amusement, gambling and recreation industries**	**407 - 410**
82	**Accommodation**	**411, 412**
83	**Food services and drinking places**	**413**
84	**Repair and maintenance**	**414 - 418**
85	**Personal and laundry services**	**419 - 422**
86	**Religious, grantmaking, civic, professional and similar organizations**	**423 - 425**
87	**Private households**	**426**
88	**Public institutions**	**429, 432, 437 - 440**
89	**Noncomparable imports and non-sector accounts**	**435, 436**

IMPLAN offers its SAM model capabilities for any region that a user defines (counties, states, and even the nation). The MKARNS MRSAM model has a 6-region configuration.

#	Abbreviation	Region
1	AR	State of Arkansas
2	OK	State of Oklahoma
3	KS	State of Kansas
4	MO	State of Missouri
5	TX	State of Texas
6	RUS	Rest of the United States (includes Alaska, Hawaii, and the District of Columbia)

So, an IMPLAN SAM model using the 2011 IMPLAN data bases was compiled for each of the regions shown above.

Moving from Single Region SAMs to a Multi-Region SAM Model

Endogenous/Exogenous Decisions and Construction of the MKARNS MRSAM. Decisions have to be made concerning what portions of the SAM framework will be considered "endogenous" (or determined within the regional context) and what portions will be considered external or exogenously determined by forces outside the regional context. Obviously, decisions concerning locally produced commodities are made by establishments located within the region and are assumed to be endogenous. Similarly, decisions concerning the use of labor are also made by local firms and usually considered endogenous. In the MKARNS MRSAM model the two labor factor incomes (employee compensation and proprietors' income) and the household institutions are considered endogenous for purposes of computing multipliers.[163] The non-labor factors and non-household institutions are assumed to be exogenous.[164]

This task just requires that the factor and institution cells in Table A3 be split according to the endogenous/exogenous categorization that is desirable and then some rearrangement of the split cells. Table A5 shows the endogenous component sub-matrices of each regional SAM arranged in a multiregional format before any further processing is completed.[165]

Table A5 MKARNS Endogenous Multiregional Social Accounting Matrix Prior to Regional Distributions of Commodity Consumption and Labor

		Industry Consumption			Employee Compensation			Proprietor's Income			Households		
		Reg 1	●●●	Reg 6	Reg 1	●●●	Reg 6	Reg 1	●●●	Reg 6	Reg 1	●●●	Reg 6
Commodities Consumed	Reg 1	Total industry use of commodities: Reg 1	0	0	0	0	0	0	0	0	HH Exp Reg 1	0	0
	●●●	0	●●●	0	0	0	0	0	0	0	0	●●●	0
	Reg 6	0	0	Total industry use of commodities: Reg 6	0	0	0	0	0	0	0	0	HH Exp Reg 6
Employee Compensation	Reg 1	EC Reg 1	0	0	0	0	0	0	0	0	0	0	0
	●●●	0	●●●	0	0	0	0	0	0	0	0	0	0
	Reg 6	0	0	EC Reg 6	0	0	0	0	0	0	0	0	0
Proprietors' Income	Reg 1	PI Reg 1	0	0	0	0	0	0	0	0	0	0	0
	●●●	0	●●●	0	0	0	0	0	0	0	0	0	0
	Reg 6	0	0	PI Reg 6	0	0	0	0	0	0	0	0	0
Households	Reg 1	0	0	0	ECD 1	0	0	PID 1	0	0	XFR 1	0	0
	●●●	0	0	0	0	●●●	0	0	●●●	0	0	●●●	0
	Reg 6	0	0	0	0	0	ECD 6	0	0	PID 6	0	0	XFR 6

[163] This is consistent with the endogenous/exogenous bifurcation suggested by Round (2007).

[164] Some SAM modelers include state and local governments and capital as endogenous. This is a choice requires consideration of the availability of data and the purposes for which the model will be applied.

[165] The cells with the three dots (●●●) represent a continuation of the pattern of diagonal submatrices by region.

An explanation of the notation used in Table A 5 should help in its interpretation. The cell labelled "Total industry use of commodities: Reg 1" comes directly from Arkansas' SAM (e.g., as shown in Table A 5). The cell labelled "EC Reg 1" is the employee compensation component of Arkansas' factor income cell from Table A 5. The cell labelled "PI Reg 1" is the proprietors' income component of Arkansas' factor income cell from Table A 5. The cell "HH EXP Reg 1" is the total household's part of Table A 5's cell labelled "Total institutional use of commodities".[166] "ECD 1" is Arkansas' employee compensation distribution to all households in Arkansas. "PID 1" is Arkansas' proprietors' income distribution to all households in Arkansas. "XFR 1" is the income transfers between Arkansas' households. The other, similarly labelled cells refer to the respective regions.

Spatially Distributing Commodity Consumption and Labor Factor Payments. A single region IMPLAN SAM model is compiled from an "internal" point-of-view: goods and services are either produced or consumed locally or they are produced or consumed elsewhere. The only outside distinction within the IMPLAN accounting framework is either foreign (outside the U.S.) or somewhere else within the U.S. As long as the focus of an economic impact analysis is local, then the production or consumption occurring outside the region of interest is not important.

Building multiregional SAM models based on the internal economic accounting within the IMPLAN system assumes that IMPLAN's computation of local consumption out of local supply (the regional purchase coefficients, RPCs) is correct. As a result, only the consumption outside the region within the U.S. is distributed via the inter-county commodity trade information supplied by IMPLAN. Unfortunately, this creates a distortion in the interregional impacts estimated. The distinction of where production and consumption occurs is important when compiling multiregional SAM models when using IMPLAN data. Both of these concerns can be overcome by using interregional commodity trade flows to distribute consumption and production and by using interregional commuting patterns to distribute labor factor payments.

MKARNS MRSAM Commuting Distributions. The labor factor components of in IMPLAN (employee compensation and proprietors' income) are measured on a "place-of-work" basis. The MKARNS MRSAM model distributes the earnings of workers and proprietors to their places of residence and, as a consequence, it will compute both "place-of-work" and "place-of-residence" earnings impacts. The geographic distribution of the labor factor components of the MKARNS MRSAM model using the latest county-to-county "journey-to-work" commuting flows available from the American Community Survey (U.S. Census Bureau). These data are published for the period 2006 to 2010.

We aggregated the county-level commuter flows to the regions of the MKARNS MRSAM model (i.e., Arkansas, Oklahoma, Kansas, Missouri, Texas, and the rest of the nation). The commuter flows should be arranged in a matrix, C, such that the columns represent places of work and the rows are places of residence,

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[166] Total households means the sum of the households by income category.

[A1] $$C = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} & C_{16} \\ C_{21} & C_{22} & C_{23} & C_{24} & C_{25} & C_{26} \\ C_{31} & C_{32} & C_{33} & C_{34} & C_{35} & C_{36} \\ C_{41} & C_{42} & C_{43} & C_{44} & C_{45} & C_{46} \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & C_{56} \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} \end{bmatrix}.$$

The common element of the commuter flow matrix, C_{RS}, represents the number of workers that reside in region R and work in region S. The commuter flow matrix is converted into a commuter flow proportion (***CFP***) matrix, c, by dividing each of the elements of the commuter flow matrix by their respective column sums ($c_{RS} = C_{RS}/\sum_{r=1}^{6} C_{rS}$),

[A2] $$CFP = c = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} & c_{15} & c_{16} \\ c_{21} & c_{22} & c_{23} & c_{24} & c_{25} & c_{26} \\ c_{31} & c_{32} & c_{33} & c_{34} & c_{35} & c_{36} \\ c_{41} & c_{42} & c_{43} & c_{44} & c_{45} & c_{46} \\ c_{51} & c_{52} & c_{53} & c_{54} & c_{55} & c_{56} \\ c_{61} & c_{62} & c_{63} & c_{64} & c_{65} & c_{66} \end{bmatrix}.$$

The labor factor incomes are distributed by column using the respective column elements. The first column of the ***CFP*** matrix shows the proportions of people who work in Arkansas and commute to where they reside. The second column contains the proportions of people who work in Oklahoma and commute to where they live. Similarly, columns 3, 4, 5, and 6 represent the commuting patterns for Kansas, Missouri, Texas, and the rest of the nation. Table A 6 provides the commuter flow matrix for the MKARNS MRSAM model and Table A7 shows the resulting the commuter flow proportions.

Table A6 Commuter Flows by MKARNS Regions: 2006-2010 Average[167]

Residence	AR (1)	OK (2)	KS (3)	MO (4)	TX (5)	RUS (6)
AR (1)	1,185,537	4,393	273	6,310	13,725	19,217
OK (2)	16,553	1,608,395	5,737	3,521	12,616	7,798
KS (3)	306	4,614	1,272,591	87,348	1,562	7,366
MO (4)	10,488	2,414	99,122	2,595,950	1,934	41,495
TX (5)	8,300	10,968	1,336	2,284	10,835,291	82,320
RUS (6)	13,199	5,837	8,244	103,107	78,812	120,978,651
Total	1,234,383	1,636,621	1,387,303	2,798,520	10,943,940	121,136,847

[167] Note: Numbers of workers. Source: Journey-to-Work. American Community Survey 2006-2010, US Census Bureau.

Table A7 Commuter Flow Coefficients by MKARNS Regions

Residence	AR (1)	OK (2)	KS (3)	MO (4)	TX (5)	RUS (6)
AR (1)	96.04%	0.27%	0.02%	0.23%	0.13%	0.02%
OK (2)	1.34%	98.28%	0.41%	0.13%	0.12%	0.01%
KS (3)	0.02%	0.28%	91.73%	3.12%	0.01%	0.01%
MO (4)	0.85%	0.15%	7.14%	92.76%	0.02%	0.03%
TX (5)	0.67%	0.67%	0.10%	0.08%	99.01%	0.07%
RUS (6)	1.07%	0.36%	0.59%	3.68%	0.72%	99.87%

Adjusting Commodity Consumption for Foreign Imports. Commodity consumption in Table A 5 either by industries or by households is gross commodity consumption—that is, without distinction about where it might be produced. IMPLAN identifies two sources of imports: one source is from places outside the U.S. (called foreign imports) and the other source is from other parts of the U.S. outside the region for which the SAM is built. In addition, there are two types of foreign imports—one type is called non-competitive foreign imports because there are no U.S. firms producing the commodities and the other type is called competitive foreign imports because U.S. firms also produce the commodities. The non-competitive foreign imports are treated as a separate commodity (they are included as part of MKARNS sector 89).

However, the competitive imports need to be separated from the gross commodity consumption. This is done by the use of a foreign import proportions (***FIP***) matrix. The only source for this information is the U.S. National Benchmark Input-Output Accounts that is compiled and published every five years by the US Bureau of Economic Analysis (BEA). In addition to a "Use" account, BEA also generates a "Foreign Import" account as part of the National Benchmark IO Accounts. Both the Use and Foreign Import accounts have exactly the same dimensions (i.e., the same number of rows and columns). Also, the industry/commodity sectoring matches that of IMPLAN with only a few differences. Dividing the foreign imports by the commodity consumption on a cell-by-cell basis provides a detailed national import proportions matrix. Multiplying each of the national import proportions by the corresponding commodity consumption cells for each of the regional gross commodity consumption by industries and households provides a cell-by-cell estimate of foreign competitive imports for each region. A region-specific foreign import matrix can be derived by aggregating the detailed foreign imports to the MKARNS industry/commodity sectors. Finally, net-out the estimated foreign imports from the gross industry commodity consumption for each region. The market shares matrices for each of the MKARNS regions are shown in the companion spreadsheet.

MKARNS MRSAM Model Trade Flows Patterns. U.S. interregional freight and commodity trade is not well documented in public sources due to the openness of the nation's economy. As a result, a number of indirect methods have been used to construct U.S. interregional trade patterns. Robinson and Liu (2006) showed that estimated MRSAM impact multipliers are very sensitive to the methods used to construct interregional freight and commodity trade flow patterns. We used two separate data sources for the interregional trade patterns in the MKARNS MRSAM model. State-to-state trade flows are available for 2011 from Federal

Highway Administration's (FHWA) Freight Analysis Framework 3 (Battelle, 2012) data base for freight flows (MKARNS sectors 1 to 39). For the non-freight sectors (MKARNS sectors 40 to 89) we used IMPLAN's county-to-county trade flow data by commodity. The IMPLAN county-to-county commodity trade data are available for each of the 440 IMPLAN commodities. These data were aggregated regionally to the MKARNS regions and industrially to the MKARNS sectors. Each of the resulting MKARNS region-to-region commodity trade flow matrices were then updated to 2011 values using a double allocation procedure called "RAS".[168]

The trade flows for commodity j, are arranged in a matrix format, T^j, such that the columns represent "purchasing" regions and the rows are "producing or selling" regions,

[A3]
$$T^j = \begin{bmatrix} T_{11}^j & T_{12}^j & T_{13}^j & T_{14}^j & T_{15}^j & T_{16}^j \\ T_{21}^j & T_{22}^j & T_{23}^j & T_{24}^j & T_{25}^j & T_{26}^j \\ T_{31}^j & T_{32}^j & T_{33}^j & T_{34}^j & T_{35}^j & T_{36}^j \\ T_{41}^j & T_{42}^j & T_{43}^j & T_{44}^j & T_{45}^j & T_{46}^j \\ T_{51}^j & T_{52}^j & T_{53}^j & T_{54}^j & T_{55}^j & T_{56}^j \\ T_{61}^j & T_{62}^j & T_{63}^j & T_{64}^j & T_{65}^j & T_{66}^j \end{bmatrix}$$

The common element of the trade flow matrix, T_{RS}^j, represents the value of shipments of commodity j from region R to region S. The trade consumption proportions (***TCP***) are computed by dividing each element of [A3] by its respective column sum,

[A4]
$$t_{RS}^j = \frac{T_{RS}^j}{\sum_{R=1}^{6} T_{RS}^j}.$$

The trade consumption proportions (***TCP***) matrix is

[A5]
$$TCP = t^j = \begin{bmatrix} t_{11}^j & t_{12}^j & t_{13}^j & t_{14}^j & t_{15}^j & t_{16}^j \\ t_{21}^j & t_{22}^j & t_{23}^j & t_{24}^j & t_{25}^j & t_{26}^j \\ t_{31}^j & t_{32}^j & t_{33}^j & t_{34}^j & t_{35}^j & t_{36}^j \\ t_{41}^j & t_{42}^j & t_{43}^j & t_{44}^j & t_{45}^j & t_{46}^j \\ t_{51}^j & t_{52}^j & t_{53}^j & t_{54}^j & t_{55}^j & t_{56}^j \\ t_{61}^j & t_{62}^j & t_{63}^j & t_{64}^j & t_{65}^j & t_{66}^j \end{bmatrix}.$$

Note that all of the column sums of the trade consumption proportions (***TCP***) matrix are all equal to one. The TCPs are used to regionally distribute the commodity purchases by consumers

[168] The "RAS" procedure is usually attributed to Ronald A. Stone from his 1961 published report. Please refer to Miller and Blair (2009, pp. 313-336) for an extensive explanation of various "RAS" procedures.

(firms and households) located in region S to the places where the commodities are produced or sold (e.g., region R).[169]

The example of trade flow matrix for MKARNS commodity 21 (Chemical Products & Preparations, NEC) is given in Table A8 and the trade flow consumption proportions (coefficients) are shown in Table A9. The trade flow and trade consumption proportions matrices are provided in the companion spreadsheet to this report.

Table A8 Chemical Products and Preparations Trade Flows by Purchasing Region[170]

Selling Region	AR (1)	OK (2)	KS (3)	MO (4)	TX (5)	RUS (6)
AR (1)	$1,181	$41	$31	$48	$692	$2,973
OK (2)	$714	$1,794	$73	$655	$1,627	$2,850
KS (3)	$31	$65	$1,126	$1,410	$408	$2,747
MO (4)	$367	$158	$336	$5,191	$456	$9,403
TX (5)	$535	$593	$558	$385	$20,914	$16,354
RUS (6)	$1,904	$911	$1,685	$4,177	$13,971	$320,749
Total	$4,732	$3,562	$3,809	$11,866	$38,068	$355,075

Table A9 Chemical Products and Preparations Trade Flow Coefficients by Purchasing Region

Selling Region	AR (1)	OK (2)	KS (3)	MO (4)	TX (5)	RUS (6)
AR (1)	24.97%	1.15%	0.82%	0.41%	1.82%	0.84%
OK (2)	15.08%	50.38%	1.92%	5.52%	4.27%	0.80%
KS (3)	0.66%	1.82%	29.55%	11.88%	1.07%	0.77%
MO (4)	7.75%	4.44%	8.82%	43.75%	1.20%	2.65%
TX (5)	11.31%	16.64%	14.64%	3.25%	54.94%	4.61%
RUS (6)	40.24%	25.56%	44.25%	35.20%	36.70%	90.33%

Assigning Commodities to their Producing Industries. Table A5 contains all of the information found in the endogenous portion of each region's SAM except the "Local Industry Make" matrices. The Make matrices show the kinds of goods and services (commodities in input-output jargon) produced by each industry. Or, to put it differently, the Make matrices show the industries that produce each kind of good or service. This issue is often called the "secondary product" problem. The secondary product problem is a "problem" in that one of the basic input-output assumptions (and by extension, SAM assumptions) is that each industry is

[169] The TCP coefficients are employed in the same manner as are the CFP are, except the TCP are used to spatially distribute commodity purchases.

[170] Note: Monetary value are in millions of 2011 dollars. Source: *Freight Analysis Framework 3*. Federal Highway Administration. US Department of Transportation (2012).

assumed to produce one good or service and each good or service is assumed to be produced by one industry.

After the industry and household commodity consumption expenditures have been spatially distributed to their production sources, the next step is to assign the commodities that are consumed either by industries or by households to the industries that produced them. There is a variety of ways to make this assignment. Our approach to assigning consumed commodities to their production source is to use the "Industry-Based Technology" assumption. [171] In IMPLAN, a "market shares" matrix is computed from the Make matrix. One computes the proportions of total commodity sales that each industry makes—that is, each industry's market share of a commodity's sales. This is easily done by computing the proportion that each column element is of its column's sum. If M^R is a Make matrix for region R, then M_{ij}^R is its common element meaning it is the value of the commodity i produced by industry j in region R. A market shares matrix (m^R) computed from M^R will have the common element $m_{ij}^R = M_{ij}^R / \sum_{i=1}^{89} M_{ij}^R$. The meaning of m_{ij}^R is the proportion of commodity i produced by industry j located in region R. The market shares matrices for each of the MKARNS regions are provided in the companion spreadsheet.

One should apply these market shares to the spatially distributed commodity consumption expenditures by the region of commodity production. Table A10 shows the MKARNS endogenous MRSAM after commodity purchases have been spatially distributed to producing regions and the commodities consumed have been assigned to their producing industries.

[171] There are a variety of ways to assign commodities to their industrial producers. Chapter 5 of Miller and Blair (2009) provides a rather complete discussion of the issues and solutions to the "secondary product" problem.

Table A10 Spatially Distributed Endogenous MKARNS Multiregional Social Accounting Matrix Framework

		Consuming Industries					Employee Compensation					Proprietor's Income					Households				
		Reg 1	Reg 2	•••	Reg 5	Reg 6	Reg 1	Reg 2	•••	Reg 5	Reg 6	Reg 1	Reg 2	•••	Reg 5	Reg 6	Reg 1	Reg 2	•••	Reg 5	Reg 6
Producing Industries	Reg 1	IC_{11}	IC_{12}	•••	IC_{15}	IC_{16}	0	0	•••	0	0	0	0	•••	0	0	HH_{11}	HH_{12}	•••	HH_{15}	HH_{16}
	Reg 2	IC_{21}	IC_{22}	•••	IC_{25}	IC_{26}	0	0	•••	0	0	0	0	•••	0	0	HH_{21}	HH_{22}	•••	HH_{25}	HH_{26}
	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••
	Reg 5	IC_{51}	IC_{52}	•••	IC_{55}	IC_{56}	0	0	•••	0	0	0	0	•••	0	0	HH_{51}	HH_{52}	•••	HH_{55}	HH_{56}
	Reg 6	IC_{61}	IC_{62}	•••	IC_{65}	IC_{66}	0	0	•••	0	0	0	0	•••	0	0	HH_{61}	HH_{62}	•••	HH_{65}	HH_{66}
Employee Compensation	Reg 1	EC_{11}	EC_{12}	•••	EC_{15}	EC_{16}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
	Reg 2	EC_{21}	EC_{22}	•••	EC_{25}	EC_{26}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••
	Reg 5	EC_{51}	EC_{52}	•••	EC_{55}	EC_{56}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
	Reg 6	EC_{61}	EC_{62}	•••	EC_{65}	EC_{66}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
Proprietors' Income	Reg 1	PI_{11}	PI_{12}	•••	PI_{15}	PI_{16}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
	Reg 2	PI_{21}	PI_{22}	•••	PI_{25}	PI_{26}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••
	Reg 5	PI_{51}	PI_{52}	•••	PI_{55}	PI_{56}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
	Reg 6	PI_{61}	PI_{62}	•••	PI_{65}	PI_{66}	0	0	•••	0	0	0	0	•••	0	0	0	0	•••	0	0
Households	Reg 1	0	0	•••	0	0	ECD 1	0	•••	0	0	PID 1	0	•••	0	0	XFR 1	0	•••	0	0
	Reg 2	0	0	•••	0	0	0	ECD 2	•••	0	0	0	PID 2	•••	0	0	0	XFR 2	•••	0	0
	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••
	Reg 5	0	0	•••	0	0	0	0	•••	ECD 5	0	0	0	•••	PID 5	0	0	0	•••	XFR 5	0
	Reg 6	0	0	•••	0	0	0	0	•••	0	ECD 6	0	0	•••	0	PID 6	0	0	•••	0	XFR 6

A.3 Basic Impact Conversion Factors

Impact conversion factors will be used within the MKARNS MRSAM model to translate sales or output impacts into employment, income, and taxes effects. There are five basic types of conversion factors,

- Sales to employment
- Sales to employee compensation
- Sales to proprietors' income
- Sales to other property-type income
- Sales to business taxes

The five sales conversion factors need are computed for each industry of each region in the MKARNS MRSAM model. The sales conversion factors are computed using the data found in IMPLAN's **rptSAIndustry Data** file that have been aggregated to the industrial level used in the MKARNS MRSAM model. For any industry i in any region R, the sales to employment conversion factor is

[A6] $$\Psi_{i,R}^{E} = \$1{,}000{,}000 \times \frac{Employment}{Gross\ Industry\ Output}.$$

The sales to employee compensation conversion factor is

[A7] $$\Psi_{i,R}^{EC} = \frac{Employee\ Compensation}{Gross\ Industry\ Output}.$$

The sales to proprietors' income conversion factor is

[A8] $$\Psi_{i,R}^{PI} = \frac{Proprietors'Income}{Gross\ Industry\ Output}.$$

The sales to other property-type income conversion factor is

[A9] $$\Psi_{i,R}^{OPI} = \frac{Other\ Property{-}Type\ Income}{Gross\ Industry\ Output}.$$

The sales to indirect business tax conversion factor is

[A10] $$\Psi_{i,R}^{IBT} = \frac{Indirect\ Business\ Taxes}{Gross\ Industry\ Output}.$$

Tables A 11 through A 16 provide the computed values for the basic impact conversion factors: employment, employee compensation, proprietors' income, other property-type income, and business taxes.[172] Again, they are calculated on a per-dollar of sales or output basis,

[172] Employment is measured in terms of full- and part-time jobs. Employee compensation is wages and salaries plus employer contributions to employee benefits (for health insurance and retirement). Proprietors' income is the income payments to sole proprietors and partnerships. Other property-type income includes rents, dividends, interest, profits, etc. (in general, the returns paid to owners of capital).

except for employment which is calculated in terms of per million dollars of sales or output. We will use the impact conversion factors for Oklahoma to help with their interpretation. The impact conversion factors for Machinery (MKARNS MRSAM sector 32) are 2.42 jobs per million dollars of output (or sales), \$0.168 of employee compensation per dollar of output, \$0.050 proprietors' income per dollar of output (or sales), \$0.074 of other property-type income per dollar of output (or sales), and \$0.009 of business taxes per dollar of output (or sales).

Other Possible Types of Impact Conversion Factors. There are many other possible types of impact conversion factors that can be computed using IMPLAN's data bases. For example, we might wish to know more about the effects that projects may have on more specific types of tax revenues. These may include sales taxes and property taxes (among others). Because these are components of business taxes, the basis for these conversion factors is business taxes. The sales and property tax conversion factors are computed using IMPLAN's **SATransfers** data files. IMPLAN shows sales taxes being paid by businesses as part of their business taxes. The sales taxes paid by businesses as part of their business taxes are indicated as IMPLAN transfer type 15020. The sales to indirect business tax to sales tax conversion factor is

[A11] $$\Psi_R^{IBT,ST} = \frac{Transfer\ Type\ 15020}{Indirect\ Business\ Taxes}.$$

Property taxes are paid both by businesses and individuals. Property taxes are indicated as IMPLAN transfer type 15021 for those transfers paid by business taxes (IMPLAN code 8001). The indirect business tax to property tax conversion factor is

[A12] $$\Psi_R^{IBT,PT} = \frac{Transfer\ Type\ 15021}{Total\ Indirect\ Business\ Tax\ Transfers}.$$

Property taxes paid by individuals have to be computed using a two-step procedure. First, compute the proportion of labor income (i.e., employee compensation and proprietors' income) transferred to households. Calculate total transfers for the employee compensation and proprietors' income transfer making institutions (i.e., IMPLAN codes 5001 and 6001) as the sum of both categories. Then sum the transfer values for types of transfers 15002, 15003, and 15004 (again for only the 5001 and 6001 transfer making institutions). The proportion of labor income transferred to households is the ratio of the second sum to the first sum. Second, compute the proportion of property taxes paid out of total household income. Calculate total transfers made by households as the sum of those transfer values for IMPLAN codes 100001 to 10009. Property taxes paid by individuals are indicated by transfer type 15031. The labor income to property tax conversion factor is

[A13] $$\Psi_R^{IBT,PT} = \frac{\sum Transfer\ Types\ 15002{,}15003\ and\ 15004}{\sum Total\ Labor\ Income\ Transfers} \times \frac{Transfer\ Type\ 15031}{\sum Total\ Household\ Transfers}$$

Tables A11 through A16 contain the impact conversion factors used in the MKARNS MRSAM model.

Business taxes include sales taxes, income taxes, property taxes, and business license and fees paid to the various levels of government.

Table A11 Impact Conversion Factors for Arkansas[173]

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	Live animals and fish	3.2342	0.0538	0.0556	0.1044	0.0001
2	Cereal grains	15.9385	0.0208	0.1426	0.1494	0.0000
3	Other agricultural products	7.8986	0.0378	0.1972	0.1777	0.0000
4	Animal feed	0.9130	0.0439	0.0005	0.0697	0.0021
5	Meat, fish, seafood and preparations	2.7417	0.0915	0.0015	0.0498	0.0022
6	Milled grains and bakery products	1.7111	0.0854	0.0010	0.0788	0.0036
7	Other foodstuffs and fats and oils	1.6948	0.0793	0.0009	0.0469	0.0023
8	Alcoholic beverages	0.8612	0.0598	0.0003	0.0304	0.4567
9	Tobacco products	0.0000	0.0000	0.0000	0.0000	0.0000
10	Monument and building stone	4.2913	0.2094	0.0027	0.3850	0.0151
11	Natural sands, gravel and crushed stone	6.1351	0.3194	0.0045	0.1708	0.0155
12	Nonmetallic minerals, NEC	3.8997	0.2002	0.0070	0.2461	0.0195
13	Metallic ores and concentrates	2.2795	0.1459	0.0096	0.4682	0.0383
14	Coal	3.4204	0.1931	0.0066	0.1575	0.0600
15	Crude petroleum	2.9648	0.0742	0.0082	0.1870	0.0553
16	Gasoline, aviation turbine fuel and fuel oils	0.0986	0.0103	0.0004	0.0783	0.0020
17	Coal and petroleum products, NEC	0.9231	0.0695	0.0018	0.3030	0.0026
18	Basic chemicals	0.7855	0.0654	0.0015	0.0388	0.0083
19	Pharmaceuticals	1.3440	0.0863	0.0024	0.1096	0.0024
20	Fertilizers	0.7910	0.0626	0.0015	0.0370	0.0074
21	Chemical products and preparations, NEC	1.3177	0.0837	0.0020	0.0991	0.0039
22	Plastics and rubber products	3.1553	0.1799	0.0005	0.1173	0.0128
23	Logs and wood in the rough	4.9710	0.1808	0.1492	0.0384	0.0133
24	Wood products	3.8711	0.1800	0.2124	0.0796	0.0321
25	Pulp, newsprint, paper and paperboard	1.3438	0.1253	0.0019	0.1198	0.0112
26	Paper and paperboard articles	2.2311	0.1328	0.0017	0.0926	0.0053
27	Printed products	6.5367	0.2895	0.0024	0.0325	0.0103
28	Textiles and leather products	6.6162	0.2350	0.0012	0.0533	0.0088
29	Nonmetalic mineral products	3.6068	0.1837	0.0000	0.0875	0.0116
30	Primary and semifinished base metal forms and shapes	1.4240	0.1074	0.0000	0.0564	0.0096
31	Base metal products	4.0800	0.2086	0.0080	0.0827	0.0061
32	Machinery	3.1321	0.1535	0.0290	0.0719	0.0059
33	Electronic and electrical equipment and components	2.7899	0.1754	0.0001	0.0794	0.0022
34	Motorized vehicles (including parts)	2.4333	0.1170	0.0000	0.0179	0.0050
35	Transport equipment	2.4863	0.1426	0.0000	0.0621	0.0068
36	Precision instruments and apparatus	5.4740	0.2588	0.0411	0.2311	0.0022
37	Furniture, fixtures, lamps and lighting equipment	3.9032	0.1836	0.0174	0.0964	0.0024
38	Miscellaneous manufactured products	3.3158	0.1837	0.0117	0.1330	0.0273
39	Waste and scrap	0.0000	0.0000	0.0000	0.0000	0.0000

[173] Note: All conversion factors are per dollar of business sales (output) except for employment which is jobs per million dollars of business sales (2011 price levels).

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
40	Support activities for agriculture and forestry	34.5789	0.7625	0.1842	0.0000	0.0228
41	Support activities for mining	3.3372	0.2358	0.0002	0.1441	0.0175
42	Utilities	1.3640	0.1324	0.0027	0.2531	0.1096
43	Contract construction	10.5144	0.2980	0.1277	0.0420	0.0095
44	Support activities for printing	9.6934	0.3810	0.0030	0.0311	0.0166
45	Wholesale trade	6.1531	0.3743	0.0295	0.1513	0.1492
46	Retail stores	15.9063	0.3711	0.0807	0.1038	0.1344
47	Air transportation	3.4881	0.2160	0.0028	0.0746	0.0729
48	Rail transportation	2.5936	0.2273	0.0000	0.1728	0.0000
49	Water transportation	2.1741	0.1465	0.0012	0.1541	0.0229
50	Truck transportation	7.5041	0.3144	0.0543	0.0705	0.0115
51	Transit and ground passenger transportation	20.9100	0.3941	0.1113	0.0864	0.0236
52	Pipeline transportation	1.3415	0.1306	0.3494	0.0000	0.0798
53	Scenic, sightseeing and transportation support	14.8542	0.3322	0.0405	0.0000	0.0188
54	Postal service	12.1302	0.8610	0.0000	0.0000	0.0000
55	Couriers and messengers	10.1656	0.3414	0.0012	0.2410	0.0202
56	Warehousing and storage	12.4824	0.4959	0.0104	0.1421	0.0102
57	Publishing industries (except internet)	6.3723	0.2357	0.0005	0.1310	0.0058
58	Motion picture and sound recording industries	7.4130	0.1627	0.0097	0.1342	0.0168
59	Broadcasting (except internet)	6.8812	0.2827	0.1986	0.0000	0.0070
60	Telecommunications	1.8074	0.1385	0.0112	0.3248	0.0548
61	Data Processing, hosting and related services	4.3634	0.1990	0.0029	0.3215	0.0105
62	Other information services	7.1598	0.2750	0.0230	0.0983	0.0040
63	Monetary authorities and credit intermediation	3.6848	0.1778	0.0063	0.4104	0.0137
64	Securities, commodity contracts and other financial investments and related activities	7.2578	0.1918	0.0161	0.0078	0.0051
65	Insurance carriers and related activities	5.9890	0.2650	0.0341	0.2270	0.0288
66	Funds, trusts and other financial vehicles	3.8358	0.0761	0.0037	0.1170	0.0175
67	Real estate	3.0158	0.0225	0.0058	0.5478	0.0904
68	Rental and leasing services	4.3671	0.1296	0.4116	0.1259	0.1162
69	Lessors of nonfinancial intangible assets (except copyrighted works)	0.5800	0.0166	0.0031	0.7126	0.0160
70	Professional, scientific and technical services	9.7130	0.4065	0.1313	0.1297	0.0147
71	Management of companies and enterprises	5.0040	0.5266	0.0017	0.0555	0.0253
72	Administrative and support services	22.8038	0.4558	0.0676	0.0720	0.0108
73	Waste management and remediation services	5.3275	0.2341	0.0370	0.1599	0.0318
74	Educational services	20.7093	0.4605	0.0286	0.0614	0.0244
75	Ambulatory health care services	9.3110	0.5069	0.0922	0.0418	0.0114
76	Hospitals	8.7326	0.4349	0.0059	0.0373	0.0118
77	Nursing and residential care facilities	18.7213	0.5152	0.0315	0.0407	0.0428
78	Social assistance	26.8417	0.5322	0.0523	0.0383	0.0077
79	Performing arts, spectator sports and related industries	25.7606	0.1881	0.1442	0.0641	0.0332
80	Museums, historical sites and similar institutions	7.8222	0.2621	0.0044	0.2915	0.0278
81	Amusement, gambling and recreation industries	21.6375	0.3675	0.0118	0.0742	0.0539
82	Accommodation	11.8124	0.2265	0.0203	0.1080	0.0694

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
83	Food services and drinking places	19.6615	0.3082	0.0327	0.0918	0.0652
84	Repair and maintenance	12.8433	0.2856	0.2399	0.0388	0.0631
85	Personal and laundry services	17.2362	0.2617	0.3718	0.0111	0.0320
86	Religious, grantmaking, civic, professional and similar organizations	17.1539	0.4975	0.0205	0.0322	0.0122
87	Private households	80.1235	1.0000	0.0000	0.0000	0.0000
88	Public institutions	14.3774	0.8271	0.0000	0.1368	0.0000
	Total for all sectors	7.1610	0.2705	0.0380	0.1388	0.0330

Table A12 Impact Conversion Factors for Oklahoma[174]

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	Live animals and fish	11.1869	0.0520	0.0319	0.1725	0.0038
2	Cereal grains	22.5626	0.0210	0.2183	0.0735	0.0000
3	Other agricultural products	7.9692	0.0821	0.4182	0.0321	0.0000
4	Animal feed	0.8892	0.0468	0.0028	0.0872	0.0023
5	Meat, fish, seafood and preparations	3.0160	0.1089	0.0081	0.0261	0.0020
6	Milled grains and bakery products	3.1157	0.1317	0.0091	0.0635	0.0055
7	Other foodstuffs and fats and oils	1.4815	0.0715	0.0025	0.0308	0.0026
8	Alcoholic beverages	1.0966	0.0951	0.0012	0.1071	0.2585
9	Tobacco products	0.4602	0.0397	0.0004	0.3555	0.2312
10	Monument and building stone	4.9801	0.1853	0.0148	0.3365	0.0137
11	Natural sands, gravel and crushed stone	6.7742	0.2674	0.0252	0.1526	0.0138
12	Nonmetallic minerals, NEC	3.7390	0.1783	0.0411	0.2548	0.0202
13	Metallic ores and concentrates	1.7797	0.0971	0.0348	0.4557	0.0478
14	Coal	2.7638	0.2088	0.0474	0.1976	0.0753
15	Crude petroleum	2.3662	0.0981	0.0179	0.2663	0.0788
16	Gasoline, aviation turbine fuel and fuel oils	0.0814	0.0125	0.0191	0.2124	0.0054
17	Coal and petroleum products, NEC	0.5501	0.0534	0.0681	0.4605	0.0048
18	Basic chemicals	1.0234	0.0879	0.0374	0.1134	0.0131
19	Pharmaceuticals	1.0582	0.0953	0.0441	0.1754	0.0038
20	Fertilizers	0.7426	0.0708	0.0270	0.0545	0.0108
21	Chemical products and preparations, NEC	1.1371	0.0704	0.0267	0.0969	0.0045
22	Plastics and rubber products	2.8145	0.1795	0.0003	0.1144	0.0190
23	Logs and wood in the rough	1.5657	0.0729	0.5321	0.1490	0.0685
24	Wood products	7.1231	0.2213	0.0143	0.0297	0.0055
25	Pulp, newsprint, paper and paperboard	1.3869	0.1082	0.0014	0.1038	0.0098
26	Paper and paperboard articles	2.7222	0.1531	0.0012	0.0402	0.0067
27	Printed products	6.9248	0.2473	0.0104	0.0286	0.0091
28	Textiles and leather products	7.6577	0.2314	0.0009	0.0483	0.0136
29	Nonmetalic mineral products	3.6020	0.1996	0.0000	0.0939	0.0113

[174] Note: All conversion factors are per dollar of business sales (output) except for employment which is jobs per million dollars of business sales (2011 price levels).

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
30	Primary and semifinished base metal forms and shapes	1.5604	0.0914	0.0001	0.0547	0.0084
31	Base metal products	3.9892	0.2243	0.0213	0.0839	0.0063
32	Machinery	2.4208	0.1682	0.0496	0.0744	0.0093
33	Electronic and electrical equipment and components	2.5855	0.1754	0.0020	0.0705	0.0039
34	Motorized vehicles (including parts)	1.9520	0.1036	0.0000	0.0203	0.0050
35	Transport equipment	1.9783	0.1536	0.0000	0.0699	0.0050
36	Precision instruments and apparatus	4.9576	0.2321	0.0932	0.1524	0.0046
37	Furniture, fixtures, lamps and lighting equipment	4.0496	0.1560	0.0188	0.0764	0.0024
38	Miscellaneous manufactured products	5.8002	0.2188	0.0764	0.0895	0.0072
39	Waste and scrap	0.0000	0.0000	0.0000	0.0000	0.0000
40	Support activities for agriculture and forestry	42.7093	0.5667	0.3062	0.0000	0.0205
41	Support activities for mining	3.3202	0.2538	0.0044	0.1405	0.0182
42	Utilities	1.2636	0.1316	0.0161	0.2221	0.0954
43	Contract construction	10.3528	0.3192	0.1158	0.0375	0.0090
44	Support activities for printing	10.9525	0.3063	0.0122	0.0256	0.0137
45	Wholesale trade	6.4597	0.3566	0.0407	0.1472	0.1451
46	Retail stores	14.7102	0.3597	0.0941	0.1218	0.1371
47	Air transportation	3.0075	0.2707	0.0001	0.0925	0.0903
48	Rail transportation	2.5909	0.2278	0.0000	0.1731	0.0000
49	Water transportation	3.1508	0.0000	0.0106	0.0094	0.0014
50	Truck transportation	7.1717	0.2648	0.1256	0.0727	0.0119
51	Transit and ground passenger transportation	9.4293	0.3564	0.0679	0.0313	0.0085
52	Pipeline transportation	1.1879	0.1226	0.4082	0.0000	0.0876
53	Scenic, sightseeing and transportation support	5.1056	0.0416	0.7336	0.0000	0.0479
54	Postal service	11.7218	0.8698	0.0000	0.0000	0.0000
55	Couriers and messengers	10.1353	0.3418	0.0014	0.2414	0.0203
56	Warehousing and storage	13.7547	0.4742	0.0081	0.1318	0.0094
57	Publishing industries (except internet)	5.2862	0.2553	0.0006	0.1273	0.0059
58	Motion picture and sound recording industries	7.4705	0.1256	0.0104	0.1098	0.0133
59	Broadcasting (except internet)	4.5429	0.2161	0.4773	0.0000	0.0108
60	Telecommunications	2.0487	0.1299	0.0010	0.2870	0.0484
61	Data Processing, hosting and related services	4.4902	0.1855	0.0121	0.3126	0.0102
62	Other information services	6.2033	0.3170	0.0442	0.0689	0.0043
63	Monetary authorities and credit intermediation	3.6285	0.1762	0.0294	0.4201	0.0146
64	Securities, commodity contracts and other financial investments and related activities	7.8306	0.1206	0.0295	0.0056	0.0036
65	Insurance carriers and related activities	5.8440	0.2598	0.0383	0.2303	0.0297
66	Funds, trusts and other financial vehicles	2.7515	0.0554	0.1171	0.2295	0.0344
67	Real estate	2.7558	0.0216	0.0133	0.5601	0.0926
68	Rental and leasing services	5.6941	0.2346	0.1059	0.1349	0.1079
69	Lessors of nonfinancial intangible assets (except copyrighted works)	0.3465	0.0156	0.0002	0.8157	0.0183
70	Professional, scientific and technical services	9.6326	0.3914	0.1176	0.1546	0.0155
71	Management of companies and enterprises	5.2039	0.5115	0.0034	0.0541	0.0247
72	Administrative and support services	18.2442	0.4815	0.0549	0.1095	0.0096

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
73	Waste management and remediation services	5.4242	0.2336	0.0314	0.1568	0.0311
74	Educational services	17.6474	0.4622	0.0287	0.0738	0.0239
75	Ambulatory health care services	9.9417	0.4843	0.1275	0.0550	0.0113
76	Hospitals	8.0611	0.4561	0.0202	0.0401	0.0127
77	Nursing and residential care facilities	18.3703	0.5297	0.0233	0.0411	0.0432
78	Social assistance	26.3482	0.4748	0.1074	0.0410	0.0077
79	Performing arts, spectator sports and related industries	25.3406	0.2945	0.1006	0.0326	0.0404
80	Museums, historical sites and similar institutions	8.3683	0.2507	0.0025	0.2772	0.0265
81	Amusement, gambling and recreation industries	16.9950	0.3354	0.0068	0.1447	0.1064
82	Accommodation	11.6238	0.2357	0.0170	0.1066	0.0694
83	Food services and drinking places	18.3338	0.3050	0.0597	0.0977	0.0694
84	Repair and maintenance	13.2884	0.3203	0.1916	0.0431	0.0641
85	Personal and laundry services	15.5934	0.2420	0.3767	0.0128	0.0323
86	Religious, grantmaking, civic, professional and similar organizations	17.3852	0.5202	0.0184	0.0363	0.0143
87	Private households	76.3796	1.0000	0.0000	0.0000	0.0000
88	Public institutions	11.9258	0.8167	0.0000	0.1406	0.0000
	Total for all sectors	6.7323	0.2741	0.0441	0.1747	0.0390

Table A13 Impact Conversion Factors for Kansas[175]

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	Live animals and fish	3.1894	0.0408	0.0106	0.1688	0.0017
2	Cereal grains	6.9559	0.0187	0.1890	0.1051	0.0000
3	Other agricultural products	3.4917	0.0255	0.3026	0.0934	0.0000
4	Animal feed	0.8682	0.0542	0.0007	0.1009	0.0026
5	Meat, fish, seafood and preparations	3.2892	0.1476	0.0020	0.0001	0.0019
6	Milled grains and bakery products	1.8754	0.0912	0.0014	0.0813	0.0038
7	Other foodstuffs and fats and oils	1.5071	0.0782	0.0012	0.0983	0.0024
8	Alcoholic beverages	2.2653	0.0862	0.0009	0.0322	0.1563
9	Tobacco products	0.0000	0.0000	0.0000	0.0000	0.0000
10	Monument and building stone	4.8125	0.2007	0.0087	0.3443	0.0142
11	Natural sands, gravel and crushed stone	6.2112	0.3048	0.0159	0.1682	0.0152
12	Nonmetallic minerals, NEC	3.4700	0.2077	0.0265	0.2749	0.0218
13	Metallic ores and concentrates	0.0000	0.0000	0.0000	0.0000	0.0000
14	Coal	2.5286	0.2435	0.0306	0.2137	0.0815
15	Crude petroleum	3.6660	0.0289	0.0142	0.0941	0.0279
16	Gasoline, aviation turbine fuel and fuel oils	0.0852	0.0151	0.0115	0.1833	0.0046
17	Coal and petroleum products, NEC	0.5986	0.0668	0.0420	0.4358	0.0045
18	Basic chemicals	0.7764	0.0669	0.0277	0.0589	0.0110
19	Pharmaceuticals	1.1601	0.0837	0.0400	0.1532	0.0033
20	Fertilizers	0.7493	0.0667	0.0266	0.0519	0.0103
21	Chemical products and preparations, NEC	1.0603	0.0737	0.0303	0.1276	0.0046
22	Plastics and rubber products	3.1755	0.1774	0.0013	0.1128	0.0118
23	Logs and wood in the rough	2.4885	0.0135	0.9661	0.0013	0.0339
24	Wood products	6.6151	0.2349	0.0196	0.0420	0.0071
25	Pulp, newsprint, paper and paperboard	1.7194	0.1348	0.0013	0.0953	0.0091
26	Paper and paperboard articles	2.6701	0.1911	0.0009	0.0343	0.0087
27	Printed products	6.3898	0.3011	0.0039	0.0339	0.0108
28	Textiles and leather products	6.4610	0.2470	0.0026	0.0500	0.0084
29	Nonmetalic mineral products	3.5084	0.1979	0.0000	0.0923	0.0148
30	Primary and semifinished base metal forms and shapes	1.8497	0.1137	0.0005	0.0690	0.0082
31	Base metal products	4.2752	0.2144	0.0318	0.0737	0.0068
32	Machinery	2.3262	0.1401	0.0303	0.1060	0.0057
33	Electronic and electrical equipment and components	2.2478	0.1613	0.0001	0.0787	0.0056
34	Motorized vehicles (including parts)	1.0431	0.0770	0.0000	0.0009	0.0001
35	Transport equipment	1.9163	0.1681	0.0000	0.0583	0.0037
36	Precision instruments and apparatus	5.4511	0.2593	0.1115	0.1615	0.0039
37	Furniture, fixtures, lamps and lighting equipment	5.2304	0.2531	0.0335	0.0922	0.0048
38	Miscellaneous manufactured products	4.7633	0.2236	0.0959	0.1198	0.0172
39	Waste and scrap	0.0000	0.0000	0.0000	0.0000	0.0000

[175] Note: All conversion factors are per dollar of business sales (output) except for employment which is jobs per million dollars of business sales (2011 price levels).

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
40	Support activities for agriculture and forestry	28.4779	0.3487	0.6336	0.0000	0.0221
41	Support activities for mining	3.3464	0.1561	0.0022	0.1144	0.0127
42	Utilities	1.2738	0.1410	0.0027	0.2621	0.1099
43	Contract construction	9.4575	0.3485	0.1215	0.0478	0.0109
44	Support activities for printing	8.4704	0.4423	0.0055	0.0362	0.0194
45	Wholesale trade	5.8731	0.3717	0.0406	0.1538	0.1517
46	Retail stores	16.0150	0.3718	0.0733	0.1070	0.1341
47	Air transportation	4.1418	0.1475	0.0003	0.0505	0.0493
48	Rail transportation	2.5170	0.2383	0.0000	0.1810	0.0000
49	Water transportation	0.9114	0.0087	0.3447	0.3165	0.0471
50	Truck transportation	7.2042	0.2811	0.1071	0.0726	0.0118
51	Transit and ground passenger transportation	20.3599	0.4273	0.0664	0.0826	0.0226
52	Pipeline transportation	2.1521	0.2052	0.0057	0.0000	0.0391
53	Scenic, sightseeing and transportation support	11.2305	0.4729	0.0538	0.0000	0.0098
54	Postal service	12.4673	0.8537	0.0000	0.0000	0.0000
55	Couriers and messengers	8.8158	0.3425	0.0319	0.2602	0.0218
56	Warehousing and storage	12.1218	0.5131	0.0000	0.1481	0.0106
57	Publishing industries (except internet)	4.2284	0.2037	0.0006	0.1606	0.0055
58	Motion picture and sound recording industries	9.1365	0.1289	0.0091	0.1012	0.0133
59	Broadcasting (except internet)	7.3954	0.3404	0.0669	0.0000	0.0062
60	Telecommunications	1.7185	0.1547	0.0003	0.3401	0.0574
61	Data Processing, hosting and related services	3.8640	0.2176	0.0046	0.3535	0.0116
62	Other information services	6.8591	0.2823	0.0745	0.1019	0.0043
63	Monetary authorities and credit intermediation	3.6051	0.1935	0.0208	0.4102	0.0148
64	Securities, commodity contracts and other financial investments and related activities	7.3094	0.1781	0.0246	0.0076	0.0049
65	Insurance carriers and related activities	5.6252	0.3027	0.0331	0.2336	0.0270
66	Funds, trusts and other financial vehicles	4.0507	0.0631	0.0000	0.0932	0.0140
67	Real estate	2.9964	0.0246	0.0092	0.5544	0.0916
68	Rental and leasing services	7.0764	0.2246	0.2328	0.0928	0.0955
69	Lessors of nonfinancial intangible assets (except copyrighted works)	0.4368	0.0149	0.0008	0.7775	0.0175
70	Professional, scientific and technical services	9.3897	0.4245	0.1169	0.1185	0.0138
71	Management of companies and enterprises	5.3720	0.4999	0.0035	0.0529	0.0241
72	Administrative and support services	17.1802	0.5300	0.0561	0.0698	0.0108
73	Waste management and remediation services	5.2257	0.2438	0.0329	0.1637	0.0325
74	Educational services	18.0364	0.4457	0.0315	0.0765	0.0229
75	Ambulatory health care services	9.1027	0.4795	0.1310	0.0587	0.0116
76	Hospitals	8.0365	0.4505	0.0272	0.0401	0.0127
77	Nursing and residential care facilities	18.7480	0.5371	0.0088	0.0409	0.0430
78	Social assistance	28.1278	0.4343	0.1360	0.0242	0.0068
79	Performing arts, spectator sports and related industries	29.9499	0.1258	0.0813	0.0448	0.0237
80	Museums, historical sites and similar institutions	10.3671	0.2036	0.0014	0.2246	0.0214
81	Amusement, gambling and recreation industries	22.2664	0.3688	0.0140	0.0890	0.0654
82	Accommodation	11.3943	0.2229	0.0390	0.1081	0.0709

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
83	Food services and drinking places	18.5779	0.2945	0.0670	0.0959	0.0681
84	Repair and maintenance	11.1354	0.2850	0.2854	0.0430	0.0702
85	Personal and laundry services	15.9167	0.2662	0.3553	0.0158	0.0315
86	Religious, grantmaking, civic, professional and similar organizations	17.8061	0.5464	0.0105	0.0325	0.0156
87	Private households	72.8810	1.0000	0.0000	0.0000	0.0000
88	Public institutions	12.7085	0.8048	0.0000	0.1573	0.0000
	Total for all sectors	6.3078	0.2601	0.0382	0.1540	0.0300

Table A14 Impact Conversion Factors for Missouri[176]

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	Live animals and fish	9.8491	0.0535	0.0335	0.1914	0.0002
2	Cereal grains	18.5879	0.0195	0.1471	0.1463	0.0000
3	Other agricultural products	9.8362	0.0285	0.2318	0.1669	0.0000
4	Animal feed	0.7791	0.0664	0.0090	0.1656	0.0033
5	Meat, fish, seafood and preparations	2.9474	0.1185	0.0217	0.0292	0.0023
6	Milled grains and bakery products	2.2633	0.0999	0.0175	0.1127	0.0047
7	Other foodstuffs and fats and oils	1.3511	0.0729	0.0106	0.0567	0.0025
8	Alcoholic beverages	0.8183	0.0890	0.0004	0.1013	0.3024
9	Tobacco products	0.2779	0.0494	0.0002	0.4394	0.2857
10	Monument and building stone	4.0991	0.2253	0.0059	0.3885	0.0159
11	Natural sands, gravel and crushed stone	5.7241	0.3348	0.0102	0.1815	0.0165
12	Nonmetallic minerals, NEC	3.1566	0.2344	0.0176	0.2977	0.0236
13	Metallic ores and concentrates	1.0745	0.1262	0.0127	0.5447	0.0637
14	Coal	1.4416	0.3371	0.0249	0.2841	0.1083
15	Crude petroleum	4.2741	0.0028	0.0046	0.0148	0.0044
16	Gasoline, aviation turbine fuel and fuel oils	0.1014	0.0064	0.0015	0.0563	0.0014
17	Coal and petroleum products, NEC	0.7170	0.0816	0.0150	0.4130	0.0034
18	Basic chemicals	0.6308	0.0622	0.0165	0.0651	0.0106
19	Pharmaceuticals	1.1456	0.1152	0.0369	0.1629	0.0036
20	Fertilizers	0.7821	0.0559	0.0149	0.0398	0.0079
21	Chemical products and preparations, NEC	0.9597	0.0717	0.0187	0.1411	0.0042
22	Plastics and rubber products	3.3761	0.1865	0.0025	0.1270	0.0068
23	Logs and wood in the rough	6.0044	0.1084	0.0189	0.0160	0.0053
24	Wood products	6.9847	0.2464	0.0061	0.0315	0.0065
25	Pulp, newsprint, paper and paperboard	1.6899	0.1296	0.0122	0.1096	0.0093
26	Paper and paperboard articles	2.6647	0.1769	0.0105	0.0437	0.0076
27	Printed products	6.4025	0.2978	0.0061	0.0338	0.0107
28	Textiles and leather products	6.3630	0.2178	0.0022	0.0475	0.0088
29	Nonmetalic mineral products	3.5091	0.1987	0.0000	0.0906	0.0136

[176] Note: All conversion factors are per dollar of business sales (output) except for employment which is jobs per million dollars of business sales (2011 price levels).

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
30	Primary and semifinished base metal forms and shapes	1.6263	0.1073	0.0002	0.0633	0.0090
31	Base metal products	3.7848	0.2156	0.0174	0.0940	0.0069
32	Machinery	3.0483	0.1747	0.0874	0.0685	0.0083
33	Electronic and electrical equipment and components	2.5322	0.1674	0.0024	0.1159	0.0037
34	Motorized vehicles (including parts)	1.1963	0.0974	0.0000	0.0108	0.0006
35	Transport equipment	1.8891	0.1868	0.0000	0.0827	0.0058
36	Precision instruments and apparatus	4.2603	0.2311	0.1201	0.1814	0.0047
37	Furniture, fixtures, lamps and lighting equipment	4.8766	0.2088	0.1367	0.1114	0.0058
38	Miscellaneous manufactured products	3.4259	0.2052	0.0516	0.1669	0.0358
39	Waste and scrap	0.0000	0.0000	0.0000	0.0000	0.0000
40	Support activities for agriculture and forestry	42.6313	0.5982	0.2764	0.0000	0.0207
41	Support activities for mining	2.9297	0.1615	0.0013	0.0966	0.0100
42	Utilities	1.3831	0.1467	0.0020	0.2614	0.1060
43	Contract construction	9.2458	0.3377	0.1412	0.0452	0.0104
44	Support activities for printing	8.2515	0.4505	0.0088	0.0371	0.0199
45	Wholesale trade	5.8589	0.3716	0.0407	0.1542	0.1521
46	Retail stores	15.0706	0.3726	0.0638	0.1312	0.1369
47	Air transportation	3.2538	0.2440	0.0001	0.0834	0.0814
48	Rail transportation	2.5046	0.2397	0.0000	0.1823	0.0000
49	Water transportation	2.0181	0.1681	0.0017	0.1771	0.0264
50	Truck transportation	7.2640	0.2709	0.1138	0.0718	0.0117
51	Transit and ground passenger transportation	14.3050	0.3719	0.0705	0.0550	0.0150
52	Pipeline transportation	2.1213	0.2177	0.0033	0.0000	0.0410
53	Scenic, sightseeing and transportation support	11.9264	0.4744	0.0177	0.0000	0.0340
54	Postal service	11.2816	0.8794	0.0000	0.0000	0.0000
55	Couriers and messengers	9.0303	0.2824	0.0910	0.2534	0.0213
56	Warehousing and storage	11.7935	0.5057	0.0124	0.1486	0.0106
57	Publishing industries (except internet)	3.7944	0.2403	0.0004	0.1891	0.0064
58	Motion picture and sound recording industries	7.7684	0.1391	0.0173	0.1219	0.0151
59	Broadcasting (except internet)	2.7367	0.1453	0.7720	0.0000	0.0148
60	Telecommunications	1.8907	0.1393	0.0035	0.3122	0.0527
61	Data Processing, hosting and related services	2.3272	0.2820	0.0020	0.4527	0.0148
62	Other information services	6.4255	0.2884	0.0509	0.1367	0.0047
63	Monetary authorities and credit intermediation	3.7701	0.2089	0.0115	0.4063	0.0150
64	Securities, commodity contracts and other financial investments and related activities	6.7872	0.2394	0.0160	0.0097	0.0062
65	Insurance carriers and related activities	4.9498	0.2845	0.0446	0.2537	0.0327
66	Funds, trusts and other financial vehicles	3.5965	0.0815	0.0177	0.1427	0.0214
67	Real estate	3.2451	0.0280	0.0114	0.5557	0.0921
68	Rental and leasing services	7.0416	0.2314	0.1337	0.1096	0.0989
69	Lessors of nonfinancial intangible assets (except copyrighted works)	0.4249	0.0161	0.0007	0.7814	0.0175
70	Professional, scientific and technical services	7.9215	0.4235	0.1355	0.1488	0.0159
71	Management of companies and enterprises	5.0994	0.5215	0.0004	0.0548	0.0250
72	Administrative and support services	16.8108	0.4500	0.1220	0.0981	0.0110

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
73	Waste management and remediation services	5.1525	0.2482	0.0328	0.1663	0.0330
74	Educational services	15.9037	0.4896	0.0209	0.0460	0.0275
75	Ambulatory health care services	9.0800	0.5114	0.1055	0.0545	0.0116
76	Hospitals	7.9589	0.4734	0.0081	0.0407	0.0129
77	Nursing and residential care facilities	18.9093	0.5297	0.0136	0.0406	0.0427
78	Social assistance	26.9123	0.4727	0.1110	0.0348	0.0074
79	Performing arts, spectator sports and related industries	17.0807	0.4580	0.1537	0.0307	0.0629
80	Museums, historical sites and similar institutions	8.1717	0.2522	0.0061	0.2821	0.0269
81	Amusement, gambling and recreation industries	13.6798	0.3332	0.0044	0.1807	0.1335
82	Accommodation	10.3744	0.2766	0.0215	0.1186	0.0775
83	Food services and drinking places	18.7084	0.3299	0.0314	0.0940	0.0668
84	Repair and maintenance	12.7551	0.3226	0.2168	0.0357	0.0649
85	Personal and laundry services	14.7368	0.2760	0.3228	0.0155	0.0333
86	Religious, grantmaking, civic, professional and similar organizations	18.1218	0.5887	0.0206	0.0288	0.0177
87	Private households	74.5573	1.0000	0.0000	0.0000	0.0000
88	Public institutions	12.7788	0.8162	0.0000	0.1374	0.0000
	Total for all sectors	7.1375	0.2978	0.0467	0.1630	0.0390

Table A15 Impact Conversion Factors for Texas[177]

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	Live animals and fish	9.4011	0.0516	0.0228	0.1508	0.0039
2	Cereal grains	24.9330	0.0241	0.2424	0.0463	0.0000
3	Other agricultural products	7.5187	0.1168	0.4141	0.0369	0.0000
4	Animal feed	0.9251	0.0424	0.0040	0.0571	0.0023
5	Meat, fish, seafood and preparations	3.0617	0.1110	0.0117	0.0213	0.0020
6	Milled grains and bakery products	2.6247	0.1142	0.0112	0.0990	0.0047
7	Other foodstuffs and fats and oils	1.4708	0.0782	0.0069	0.0628	0.0031
8	Alcoholic beverages	0.9562	0.0795	0.0127	0.0974	0.2721
9	Tobacco products	0.6959	0.0251	0.0031	0.2469	0.1606
10	Monument and building stone	5.6991	0.2251	0.0104	0.2739	0.0140
11	Natural sands, gravel and crushed stone	6.2616	0.2943	0.0243	0.1664	0.0151
12	Nonmetallic minerals, NEC	3.3360	0.2024	0.0409	0.2832	0.0224
13	Metallic ores and concentrates	1.7702	0.1219	0.0457	0.4905	0.0408
14	Coal	2.9767	0.1988	0.0395	0.1843	0.0702
15	Crude petroleum	1.7664	0.1315	0.0178	0.3461	0.1024
16	Gasoline, aviation turbine fuel and fuel oils	0.0879	0.0183	0.0045	0.1634	0.0041
17	Coal and petroleum products, NEC	0.7237	0.0785	0.0173	0.4124	0.0034
18	Basic chemicals	0.1854	0.0255	0.0026	0.0799	0.0082
19	Pharmaceuticals	0.9890	0.1119	0.0122	0.1893	0.0039
20	Fertilizers	0.7977	0.0549	0.0049	0.0343	0.0068

[177] Note: All conversion factors are per dollar of business sales (output) except for employment which is jobs per million dollars of business sales (2011 price levels).

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
21	Chemical products and preparations, NEC	0.9673	0.0960	0.0091	0.1029	0.0071
22	Plastics and rubber products	3.0591	0.1740	0.0018	0.1283	0.0070
23	Logs and wood in the rough	5.5808	0.1903	0.0263	0.0477	0.0183
24	Wood products	6.2266	0.2518	0.0124	0.0389	0.0122
25	Pulp, newsprint, paper and paperboard	1.4590	0.1309	0.0310	0.1126	0.0122
26	Paper and paperboard articles	2.3685	0.1487	0.0207	0.0832	0.0069
27	Printed products	6.5085	0.2825	0.0121	0.0326	0.0104
28	Textiles and leather products	6.3634	0.2001	0.0015	0.0434	0.0117
29	Nonmetalic mineral products	3.6856	0.2058	0.0000	0.0959	0.0128
30	Primary and semifinished base metal forms and shapes	1.6125	0.1131	0.0038	0.0321	0.0056
31	Base metal products	3.7943	0.2281	0.0489	0.0990	0.0079
32	Machinery	2.2028	0.1926	0.0715	0.0763	0.0140
33	Electronic and electrical equipment and components	1.1673	0.1355	0.0013	0.1721	0.0069
34	Motorized vehicles (including parts)	1.2218	0.0817	0.0000	0.0259	0.0035
35	Transport equipment	2.0182	0.1986	0.0000	0.0657	0.0052
36	Precision instruments and apparatus	3.6967	0.1836	0.2033	0.2227	0.0046
37	Furniture, fixtures, lamps and lighting equipment	4.6390	0.2033	0.0670	0.1195	0.0047
38	Miscellaneous manufactured products	3.6259	0.2095	0.1363	0.1399	0.0236
39	Waste and scrap	0.0000	0.0000	0.0000	0.0000	0.0000
40	Support activities for agriculture and forestry	42.0874	0.6798	0.2022	0.0000	0.0211
41	Support activities for mining	2.7572	0.2494	0.0032	0.1783	0.0200
42	Utilities	1.2538	0.1340	0.0395	0.2980	0.1213
43	Contract construction	8.6549	0.3390	0.1589	0.0478	0.0110
44	Support activities for printing	9.2683	0.3904	0.0160	0.0327	0.0175
45	Wholesale trade	5.0256	0.3732	0.0631	0.1622	0.1600
46	Retail stores	14.3877	0.3811	0.0846	0.1083	0.1399
47	Air transportation	3.0450	0.2666	0.0001	0.0911	0.0890
48	Rail transportation	2.3646	0.2593	0.0000	0.1972	0.0000
49	Water transportation	1.8450	0.1916	0.0027	0.2026	0.0301
50	Truck transportation	7.3927	0.2577	0.1195	0.0702	0.0114
51	Transit and ground passenger transportation	11.7251	0.3724	0.1218	0.0595	0.0162
52	Pipeline transportation	1.2336	0.1988	0.3160	0.0000	0.0871
53	Scenic, sightseeing and transportation support	13.3304	0.4071	0.0273	0.0000	0.0286
54	Postal service	10.9666	0.8862	0.0000	0.0000	0.0000
55	Couriers and messengers	10.7093	0.3289	0.0017	0.2325	0.0195
56	Warehousing and storage	12.7459	0.4786	0.0199	0.1426	0.0102
57	Publishing industries (except internet)	3.2296	0.2351	0.0010	0.2113	0.0068
58	Motion picture and sound recording industries	5.7015	0.1654	0.0243	0.1716	0.0188
59	Broadcasting (except internet)	4.4688	0.2635	0.2934	0.0000	0.0093
60	Telecommunications	1.8524	0.1423	0.0032	0.3183	0.0537
61	Data Processing, hosting and related services	2.9938	0.2489	0.0089	0.4092	0.0134
62	Other information services	6.0621	0.3372	0.0576	0.0958	0.0048
63	Monetary authorities and credit intermediation	3.5262	0.2151	0.0633	0.4053	0.0168
64	Securities, commodity contracts and other	7.1570	0.1866	0.0315	0.0081	0.0053

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
	financial investments and related activities					
65	Insurance carriers and related activities	4.9017	0.2863	0.0379	0.2591	0.0344
66	Funds, trusts and other financial vehicles	3.5978	0.0973	0.0002	0.1440	0.0216
67	Real estate	2.8178	0.0391	0.0108	0.5792	0.0963
68	Rental and leasing services	5.0088	0.2182	0.2301	0.1257	0.1068
69	Lessors of nonfinancial intangible assets (except copyrighted works)	0.2443	0.0144	0.0034	0.8573	0.0192
70	Professional, scientific and technical services	7.6789	0.4421	0.1369	0.1364	0.0158
71	Management of companies and enterprises	5.5710	0.4868	0.0032	0.0514	0.0235
72	Administrative and support services	17.6045	0.5052	0.0825	0.0810	0.0105
73	Waste management and remediation services	4.6286	0.2666	0.0459	0.1841	0.0366
74	Educational services	17.2715	0.5063	0.0390	0.0678	0.0273
75	Ambulatory health care services	10.7551	0.4981	0.1255	0.0465	0.0113
76	Hospitals	7.0601	0.4337	0.0963	0.0437	0.0139
77	Nursing and residential care facilities	17.7502	0.5283	0.0360	0.0415	0.0437
78	Social assistance	26.5019	0.4466	0.1197	0.0535	0.0084
79	Performing arts, spectator sports and related industries	19.4947	0.2900	0.1712	0.0635	0.0469
80	Museums, historical sites and similar institutions	8.0627	0.2586	0.0020	0.2853	0.0272
81	Amusement, gambling and recreation industries	18.7179	0.4019	0.0211	0.0882	0.0648
82	Accommodation	9.6398	0.2695	0.0387	0.1313	0.0858
83	Food services and drinking places	17.7145	0.3319	0.0440	0.1004	0.0713
84	Repair and maintenance	9.9180	0.3038	0.2926	0.0518	0.0719
85	Personal and laundry services	13.2481	0.2457	0.4026	0.0165	0.0347
86	Religious, grantmaking, civic, professional and similar organizations	16.1687	0.5478	0.0228	0.0598	0.0161
87	Private households	82.3927	1.0000	0.0000	0.0000	0.0000
88	Public institutions	11.4370	0.8209	0.0000	0.1445	0.0000
	Total for all sectors	5.4438	0.2497	0.0480	0.1792	0.0393

Table A16 Impact Conversion Factors for Rest of the U.S.[178]

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
1	Live animals and fish	9.4011	0.0516	0.0228	0.1508	0.0039
2	Cereal grains	24.9330	0.0241	0.2424	0.0463	0.0000
3	Other agricultural products	7.5187	0.1168	0.4141	0.0369	0.0000
4	Animal feed	0.9251	0.0424	0.0040	0.0571	0.0023
5	Meat, fish, seafood and preparations	3.0617	0.1110	0.0117	0.0213	0.0020
6	Milled grains and bakery products	2.6247	0.1142	0.0112	0.0990	0.0047
7	Other foodstuffs and fats and oils	1.4708	0.0782	0.0069	0.0628	0.0031
8	Alcoholic beverages	0.9562	0.0795	0.0127	0.0974	0.2721
9	Tobacco products	0.6959	0.0251	0.0031	0.2469	0.1606
10	Monument and building stone	5.6991	0.2251	0.0104	0.2739	0.0140

[178] Note: All conversion factors are per dollar of business sales (output) except for employment which is jobs per million dollars of business sales (2011 price levels).

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
11	Natural sands, gravel and crushed stone	6.2616	0.2943	0.0243	0.1664	0.0151
12	Nonmetallic minerals, NEC	3.3360	0.2024	0.0409	0.2832	0.0224
13	Metallic ores and concentrates	1.7702	0.1219	0.0457	0.4905	0.0408
14	Coal	2.9767	0.1988	0.0395	0.1843	0.0702
15	Crude petroleum	1.7664	0.1315	0.0178	0.3461	0.1024
16	Gasoline, aviation turbine fuel and fuel oils	0.0879	0.0183	0.0045	0.1634	0.0041
17	Coal and petroleum products, NEC	0.7237	0.0785	0.0173	0.4124	0.0034
18	Basic chemicals	0.1854	0.0255	0.0026	0.0799	0.0082
19	Pharmaceuticals	0.9890	0.1119	0.0122	0.1893	0.0039
20	Fertilizers	0.7977	0.0549	0.0049	0.0343	0.0068
21	Chemical products and preparations, NEC	0.9673	0.0960	0.0091	0.1029	0.0071
22	Plastics and rubber products	3.0591	0.1740	0.0018	0.1283	0.0070
23	Logs and wood in the rough	5.5808	0.1903	0.0263	0.0477	0.0183
24	Wood products	6.2266	0.2518	0.0124	0.0389	0.0122
25	Pulp, newsprint, paper and paperboard	1.4590	0.1309	0.0310	0.1126	0.0122
26	Paper and paperboard articles	2.3685	0.1487	0.0207	0.0832	0.0069
27	Printed products	6.5085	0.2825	0.0121	0.0326	0.0104
28	Textiles and leather products	6.3634	0.2001	0.0015	0.0434	0.0117
29	Nonmetalic mineral products	3.6856	0.2058	0.0000	0.0959	0.0128
30	Primary and semifinished base metal forms and shapes	1.6125	0.1131	0.0038	0.0321	0.0056
31	Base metal products	3.7943	0.2281	0.0489	0.0990	0.0079
32	Machinery	2.2028	0.1926	0.0715	0.0763	0.0140
33	Electronic and electrical equipment and components	1.1673	0.1355	0.0013	0.1721	0.0069
34	Motorized vehicles (including parts)	1.2218	0.0817	0.0000	0.0259	0.0035
35	Transport equipment	2.0182	0.1986	0.0000	0.0657	0.0052
36	Precision instruments and apparatus	3.6967	0.1836	0.2033	0.2227	0.0046
37	Furniture, fixtures, lamps and lighting equipment	4.6390	0.2033	0.0670	0.1195	0.0047
38	Miscellaneous manufactured products	3.6259	0.2095	0.1363	0.1399	0.0236
39	Waste and scrap	0.0000	0.0000	0.0000	0.0000	0.0000
40	Support activities for agriculture and forestry	42.0874	0.6798	0.2022	0.0000	0.0211
41	Support activities for mining	2.7572	0.2494	0.0032	0.1783	0.0200
42	Utilities	1.2538	0.1340	0.0395	0.2980	0.1213
43	Contract construction	8.6549	0.3390	0.1589	0.0478	0.0110
44	Support activities for printing	9.2683	0.3904	0.0160	0.0327	0.0175
45	Wholesale trade	5.0256	0.3732	0.0631	0.1622	0.1600
46	Retail stores	14.3877	0.3811	0.0846	0.1083	0.1399
47	Air transportation	3.0450	0.2666	0.0001	0.0911	0.0890
48	Rail transportation	2.3646	0.2593	0.0000	0.1972	0.0000
49	Water transportation	1.8450	0.1916	0.0027	0.2026	0.0301
50	Truck transportation	7.3927	0.2577	0.1195	0.0702	0.0114
51	Transit and ground passenger transportation	11.7251	0.3724	0.1218	0.0595	0.0162
52	Pipeline transportation	1.2336	0.1988	0.3160	0.0000	0.0871
53	Scenic, sightseeing and transportation support	13.3304	0.4071	0.0273	0.0000	0.0286
54	Postal service	10.9666	0.8862	0.0000	0.0000	0.0000

Code	Industry	Employ ment	Employee Comp	Proprietors' Income	Property Income	Business Taxes
55	Couriers and messengers	10.7093	0.3289	0.0017	0.2325	0.0195
56	Warehousing and storage	12.7459	0.4786	0.0199	0.1426	0.0102
57	Publishing industries (except internet)	3.2296	0.2351	0.0010	0.2113	0.0068
58	Motion picture and sound recording industries	5.7015	0.1654	0.0243	0.1716	0.0188
59	Broadcasting (except internet)	4.4688	0.2635	0.2934	0.0000	0.0093
60	Telecommunications	1.8524	0.1423	0.0032	0.3183	0.0537
61	Data Processing, hosting and related services	2.9938	0.2489	0.0089	0.4092	0.0134
62	Other information services	6.0621	0.3372	0.0576	0.0958	0.0048
63	Monetary authorities and credit intermediation	3.5262	0.2151	0.0633	0.4053	0.0168
64	Securities, commodity contracts and other financial investments and related activities	7.1570	0.1866	0.0315	0.0081	0.0053
65	Insurance carriers and related activities	4.9017	0.2863	0.0379	0.2591	0.0344
66	Funds, trusts and other financial vehicles	3.5978	0.0973	0.0002	0.1440	0.0216
67	Real estate	2.8178	0.0391	0.0108	0.5792	0.0963
68	Rental and leasing services	5.0088	0.2182	0.2301	0.1257	0.1068
69	Lessors of nonfinancial intangible assets (except copyrighted works)	0.2443	0.0144	0.0034	0.8573	0.0192
70	Professional, scientific and technical services	7.6789	0.4421	0.1369	0.1364	0.0158
71	Management of companies and enterprises	5.5710	0.4868	0.0032	0.0514	0.0235
72	Administrative and support services	17.6045	0.5052	0.0825	0.0810	0.0105
73	Waste management and remediation services	4.6286	0.2666	0.0459	0.1841	0.0366
74	Educational services	17.2715	0.5063	0.0390	0.0678	0.0273
75	Ambulatory health care services	10.7551	0.4981	0.1255	0.0465	0.0113
76	Hospitals	7.0601	0.4337	0.0963	0.0437	0.0139
77	Nursing and residential care facilities	17.7502	0.5283	0.0360	0.0415	0.0437
78	Social assistance	26.5019	0.4466	0.1197	0.0535	0.0084
79	Performing arts, spectator sports and related industries	19.4947	0.2900	0.1712	0.0635	0.0469
80	Museums, historical sites and similar institutions	8.0627	0.2586	0.0020	0.2853	0.0272
81	Amusement, gambling and recreation industries	18.7179	0.4019	0.0211	0.0882	0.0648
82	Accommodation	9.6398	0.2695	0.0387	0.1313	0.0858
83	Food services and drinking places	17.7145	0.3319	0.0440	0.1004	0.0713
84	Repair and maintenance	9.9180	0.3038	0.2926	0.0518	0.0719
85	Personal and laundry services	13.2481	0.2457	0.4026	0.0165	0.0347
86	Religious, grantmaking, civic, professional and similar organizations	16.1687	0.5478	0.0228	0.0598	0.0161
87	Private households	82.3927	1.0000	0.0000	0.0000	0.0000
88	Public institutions	11.4370	0.8209	0.0000	0.1445	0.0000
	Total for all sectors	5.4438	0.2497	0.0480	0.1792	0.0393

General MKARNS MRSAM Impact (Performance Measures) Generation Steps. The following discussion is included to help explain how the MKARNS MRSAM impact multipliers and the impact conversion factors should be used to compute the economic effects of different project scenarios.

1. Determine the appropriate change in demand due to a project scenario ($\Delta fd_{i,R}$). Normally there will be spending for more than one item and these may occur in more than one region. As a consequence, these expenditure items will be configured as a vector of demand changes (ΔFD). This could be expenditures necessary to construct a navigation channel structure or an affected recreation activity.

2. Calculate gross sales or output due to the final demand change (ΔFD). Multiply the MKARNS MRSAM multiplier matrix (B or $(I - A)^{-1}$) by the demand change vector (ΔFD).

[A15] $$\Delta X = B \times \Delta FD = (I - A)^{-1} \times \Delta FD.$$

The resulting product (ΔX) will be a column vector of estimated direct, indirect, and induced sales, labor factor payments, and household distributions by region and by MKARNS MRSAM sector that are expected to be generated by project scenario.

The column vector ΔX will consist of six partitions (one for each of the MKARNS MRSAM model regions). Within each partition will be 89 elements referring to industrial sales, 2 elements for labor factor payments, and one for household institutions.

3. Convert the industry sales impacts to employment, employee compensation, property-type income, other property-type income, and indirect business tax impact estimates by industry. For each region's sector partition of ΔX, multiply the sector-specific impact conversion factors by the sector-specific change in sales estimates, or

[A16]
$$\begin{gathered}
Employment\left(EMP_{i,R}\right) = \Psi_{i,R}^{E} \times \Delta X_{i,R} \\
Employee\ Compensation\left(EC_{i,R}\right) = \Psi_{i,R}^{EC} \times \Delta X_{i,R} \\
Proprietors'Inome\ \left(PI_{i,R}\right) = \Psi_{i,R}^{PI} \times \Delta X_{i,R} \\
Other\ Property - Type\ Income\left(OPI_{i,R}\right) = \Psi_{i,R}^{OPI} \times \Delta X_{i,R} \\
Indirect\ Business\ Taxes\left(IBT_{i,R}\right) = \Psi_{i,R}^{IBT} \times \Delta X_{i,R} \\
Labor\ Income(LI_{iR}) = EC_{i,R} + PI_{i,R} \\
Gross\ Domestic\ Product\left(GDP_{i,R}\right) = EC_{i,R} + PI_{i,R} + OPI_{i,R} + IBT_{i,R}
\end{gathered}$$

4. Total impacts by model region are computed by adding the MKARNS MRSAM sector elements for each region,

[A17]

$$\begin{aligned}
EMP_{\bullet R} &= \textstyle\sum_{i=1}^{89} EMP_{i,R} \\
EC_{\bullet R} &= \textstyle\sum_{i=1}^{89} EC_{i,R} \\
PI_{\bullet R} &= \textstyle\sum_{i=1}^{89} PI_{i,R} \\
OPI_{\bullet R} &= \textstyle\sum_{i=1}^{89} OPI_{i,R} \\
IBT_{\bullet R} &= \textstyle\sum_{i=1}^{89} IBT_{i,R} \\
LI_{\bullet R} &= \textstyle\sum_{i=1}^{89} LI_{i,R} \\
GDP_{\bullet R} &= \textstyle\sum_{i=1}^{89} GDP_{i,R}
\end{aligned}$$

APPENDIX B: MULTIREGIONAL VARIABLE INPUT-OUTPUT MODEL WITH ENDOGENOUS HOUSEHOLD EFFECTS AND TRANSBOUNDARY INCOME AND EXPENDITURE PATTERNS

The idea that transportation infrastructure and investments in transportation can produce economic development benefits has a long historical pedigree. In classical location theory, Weber (1929) and Christaller (1933) suggested in one form of another that industries locate where transportation and factor costs are minimized. Transportation facilities, of all types, are fundamental and critical to regional economic development. Transportation infrastructure in a region often defines how that region can compete, what types of goods will be available as inputs for local industries, what types of goods and services will be reasonable for local sectors to produce. An improvement in the transportation system of a region can change the production costs of many goods and services produced in the region and can provide the benefited region with a competitive advantage in regional, national, and international markets. Weiss and Figura (2003) list a number of ways in which transportation improvements aid in the economic development of regions and communities. Transportation systems link regional centers to national markets making corridor areas more competitive for growth. As a result, they provide for more efficient flows of commerce through the region, support new business initiatives, enhance development potential of areas, and increase economic multiplier effects. Transport systems also facilitate the commutation of people to new jobs and public services and open up new sites for commercial and industrial development. In addition, transportation facilities provide local access roads to stimulate retail development, provide quality of life benefits by providing access to new services and employment opportunities, promote tourism and recreational development, and strengthen and diversify the local economies. Although these effects are cited as justification to support and implement most regional and local transportation projects, they are difficult to model and analyze correctly and they have been illusive to empirically demonstrate.

Transportation investments generate three types of regional economic impacts. First, some activities involve the direct expenditure of funds—like construction of transportation infrastructure facilities and their operations. The regional economic consequences of these types of activities are easily evaluated using commercially available economic impact software. These issues are discussed more fully below in the section entitled, “Regional Economic Effects of Project Related Spending”. Second, transportation infrastructure generates system efficiencies. For example, if transportation improvements are made, like extending rail links or deepening harbors, we can expect that hauling commodities will be cheaper and more efficient (i.e., have lower transportation rates). These types of transportation-related activities create modeling complications that are incompatible with any of the standard and commercially available regional economic impact software programs. The modeling complications and methods to address and evaluate the regional economic impacts of water resource-related savings are explained in the section below entitled, “Regional Economic Effects of Transportation-Savings Benefits”.

The first model is a dynamic nonlinear multiregional input-output model with transboundary income and expenditure patterns. The nonlinear part refers to its ability to directly address issues related to changes in transportation and resource costs (i.e., the direct benefits of transportation projects) that may be contemplated via the Council's regional economic development scenarios. The multiregional part allows the model to articulate and account for the economic effects initiated in one part of the region and expressed in any other part of the region. The transboundary income and expenditure patterns mean that the regional economic effects income generated where workers are employed and spent where they reside will be addressed (unlike the majority of regional economic impact assessment tools, such as IMPLAN, RIMS II, or REMI). In addition, this model will also be capable of computing the usual regional economic effects of project related spending. The second model is a small area employment and population growth model.

B.1 Regional Economic Effects of Project Related Spending: Multiregional Input-Output Analysis

To introduce regional economic effects of transportation project spending, one can think of a household with one wage earner. Obviously, the household's income and its standard-of-living increases and decreases as the wages earned by the head fluctuate. Just like the household, one can envision a local economy that has a great dependence on external sources of demand for the level of its internal welfare; in other words, it is an "open" economy. The regional economic multiplier process provides a simple framework in which to analyze such situations. Local economic activity can be split into two general categories; either into an export or into a service sector. The export sector includes those firms that sell their products to businesses and households outside the boundaries of the local economy. In addition, establishments within the local economy which cause funds to flow into the study area by their activities (such as tourist activities and federal government facilities) are also considered part of the export sector. The local service sector, in contrast, is made up of those firms that sell their goods and services within the local economy; either to firms in the export sector or to the local populace.

The model works to the extent that, external changes resulting in increases (decreases) in export activity cause increases (decreases) in the payroll of export firms which are then transmitted to the local service sector establishments. Furthermore, the inflow or outflow of money causes changes in local services to change by a multiple of the original change (i.e., the regional economic multiplier) as the influx of funds is spent and re-spent in the local economy or as the initial withdrawal of funds causes decreases in local sales which, in turn, causes further decreases in local sales as payrolls and employment shrink. For expansions, recirculation continues until the leakages from the system (such as imports, savings, and taxes) exhaust the amount of initial influx. In cases of decreases in export activity, the cumulative decline is halted by decreases in imports, savings, and taxes. Note that export base models predict that, without "new" injections of funds to the local economy through its export sector, the local economy will stagnate because service activities can only respond to changes in local economic conditions.

B.2 Regional Economic Effects of Transportation-Savings Benefits: Multiregional Variable Input-Output Model with Endogenous Households and Transboundary Income and Expenditure Distributions

The spending effects just discussed do not consider (by assumption) the effects that occur due to system efficiencies brought about by transportation infrastructure investments such as highway, waterway, or rail developments. Nothing in the standard input-output accounts or the subsequent standard model solution, equation [2] above, is able to address the economic expansion effects resulting from the efficiencies of improved transportation systems. For example, the standard input-output solution, above, is incapable of estimating the economic impacts that can occur because of reductions in transportation or production costs. A reduction in costs in the delivery or production of commodities creates a type of "substitution" effect which conventional regional economic impact models (RIMS II, REMI, and IMPLAN) fail to capture. In fact, the effects of cost reductions are ruled out by assumption. This substitution effect plays a crucial role in determining the technical and trading patterns in an economy both temporally and spatially. These types of changes also have industrial repercussions that can be measured in terms of output (sales), employment, and income.

To render the input-output model more flexible or variable, many analysts have investigated the possibility of varying the regional technical coefficients and trading patterns. Rose (1984) reviewed twelve methods of accounting for technological change in an input-output framework.[179] These procedures include such ad hoc changes in technical coefficients, mechanical devices like the RAS procedure, and explicitly modeling production functions. Following the work of Sandberg (1973), Hudson and Jorgenson (1974) and their KLEM model, Liew and Liew (1985), Liew (2000), Liew and Robinson (2001), Sandberg (1974), and West and Jackson (2004) have developed nonlinear, equilibrium input-output approaches that determine both price and quantity for each commodity in all regions.[180] In these models, regional technical and trade coefficients are endogenous on production costs such as transportation fees, wage rates, and the service price for capital. This is accomplished by couching the MRIO system in terms consistent with neoclassical theory of the firm. The nonlinear MRIO model is derived from the duality between production and price frontiers. The price frontiers are solved and expressed in terms of input elasticities, wage rates, the service price of capital, transportation costs, tax rates, technical progress parameters, and quantities of commodities. These equilibrium prices then determine the equilibrium multiregional input-output technical, trade, and primary input coefficients. As a consequence, changes in such costs as transporting commodities induces price changes which, in turn, alters the purchasing patterns of commodities throughout the economic system.

[179] See the discussions by Arrow (1951), Koopmans (1951), and Samuelson (1951) on the reasons for the possibility of technical substitution in Leontief models.

[180] West and Jackson (2004) suggest that these types of nonlinear input-output models are preferable to the more complex and time consuming process of constructing models such as computable general equilibrium (CGE) models.

B.2.1 Model Specification

One way to approach the nonlinear MRIO model is to maximize “system-wide” profits subject to a technical production requirement and a consumption balancing constraint;[181] for example,

[B1] **System-wide profits:**

$$\Pi = \sum_{r=1}^{m}\sum_{j=1}^{n}\left[p_j^{r*}X_j^r - \sum_{s=1}^{m}\sum_{i=1}^{n}p_{ij}^{sr}X_{ij}^{sr} - \sum_{s=1}^{m}\sum_{k=1}^{2}w_{kj}^{r}L_{kj}^{sr} - \sum_{s=1}^{m}v_j^r K_j^{sr}\right]$$

Here, X_j^r is the level of output produced by sector j in region r; X_{ij}^{sr} is the amount of intermediate commodity i purchased by sector j in region r produced in region s; L_{kj}^{sr} is the resource k (workers or proprietors) located in region s employed by sector j in region r; and K_j^{sr} is the capital located in region s employed by sector j in region r. Given producer prices (p_j^{r*}), purchaser prices of intermediate inputs (p_{ij}^{sr}), wage rates (w_{kj}^r), and interest rates (v_j^r) sectors produce levels of output (X_j^r), purchase intermediate inputs (X_{ij}^{sr}), employ resources, L_{kj}^{sr} and use capital goods (K_j^{sr}). The typical production function for sector j in region r is assumed to be linear in a logarithmic format, or

[B2] **Production function:**

$$lnX_j^r = \beta_{0j}^r + \sum_{s=1}^{m}\sum_{i=1}^{n}\beta_{ij}^{sr}lnX_{ij}^{sr} + \sum_{s=1}^{m}\sum_{k=1}^{2}\omega_{kj}^{sr}lnL_{kj}^{sr} + \sum_{s=1}^{m}\theta_j^{sr}lnK_j^{sr}.$$

The coefficients β_{0j}^r, β_{ij}^{sr}, ω_{kj}^{sr}, and θ_j^{sr} are the technical parameters of the production functions. Note that: $\sum_{s=1}^{m}\sum_{i=1}^{n}\beta_{ij}^{sr} + \sum_{s=1}^{m}\sum_{k=1}^{2}\omega_{kj}^{sr} + \sum_{s=1}^{m}\theta_j^{sr} = 1$, which means that equation [B2] is homogeneous of degree one.

Generating a Lagrangian function consistent with the profit maximizing problem (equations [B1] and [B2]) and differentiating with respect to output, intermediate purchases, resource requirements, and the constraint parameter (i.e., the Lagrangian multipliers—λ_j^r) for each industry of every region yields the typical set of necessary conditions. Significant simplification of these solution requirements can be gained if we interpret the Lagrangian multiplier of the technical constraints as the shadow prices which ensure market clearing conditions.[182] Now we can express key unknown variables of interest (X_{ij}^{sr}, X_j^r, L_{kj}^{sr}, and K_j^{sr}) in terms of p_j^r, w_j^r, v_j^r, β_{ij}^{sr}, ω_{kj}^{sr}, and θ_j^{sr}; that is, the profit-maximizing resource demands are

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181 The model development is based on that presented by Liew and Liew (1985) but extended here to capture the income generation and household expenditure effects.

182 That is, the producer prices for commodities (p_j^{r*}) do not guarantee that markets will clear. Since, λ_j^r is solved for in the model, $p_j^{r*} + \lambda_j^r$ becomes the equilibrium purchaser price (P_j^r) which equates the demand for and supply of X_j^r. Likewise, $p_{ij}^{sr} + \lambda_i^s$ is the equilibrium purchaser price of commodity i produced in region s that is purchased by industry j in region r. Assuming that the equilibrium purchase price in the region in which it is produced plus the cost of bringing one unit of the commodity from the producing region to the consuming region, then the equilibrium

[B3] $$X_{ij}^{sr} = \frac{\beta_{ij}^{sr} p_j^r X_j^r}{\tau_i^{sr} p_i^s},\ L_{kj}^{sr} = \frac{\omega_{kj}^{sr} p_j^r X_j^r}{w_{kj}^r}, \text{ and } K_j^{sr} = \frac{\theta_j^{sr} p_j^r X_j^r}{v_j^r}$$

Extending Liew and Liew (1988) to consider a multi-region case, we assume that a typical household in region r has a linear logarithmic indirect utility function (lnU^r) that is homogeneous of degree one:

[B4] **Utility function:** $$lnU^r = \sum_{s=1}^{m} lnE^{sr} - \sum_{s=1}^{m} \sum_{i=1}^{n} \gamma_i^r lnp_i^s, \text{ where } \sum_{i=1}^{n} \gamma_i^r = 1.$$

Commuter cost adjusted expenditures of households located in region r from region s is E^{sr} (see below). The coefficient γ_i^r is a household's industry (i's) expenditure distribution factor for consumers in region r. Consequently, the utility-maximizing household demand for commodity i purchased by households residing in region r from producers in region s is derived from [B4] by the use of "Roy's Identity" (Roy, 1947):

[B5] $$C_i^{sr} = \frac{\gamma_i^r E^{sr}}{p_i^s}.$$

Effective household expenditures residing in region r for commodities produced in region s (E^{sr}) is a simple linear proportion of income earned (δ^{sr}) by local households:

[B6] $$E^{sr} = \delta^{sr} \left(\sum_{j=1}^{n} \sum_{k=1}^{2} \frac{w_{kj}^r L_{kj}^{sr}}{\sigma_k^{sr}} \right), \text{ where } \sum_{s=1}^{m} \delta^{sr} = 1.$$

The coefficient σ_k^{sr} represents the commuting cost parameter for resource k residing in region r and working in region s. For the base year of the model $\sigma_k^{sr} = 1$. An increase in commuting costs would be expressed as a percentage increase; e.g., a 5% increase would be expressed as $\sigma_k^{sr} = 1.05$. In turn a 5% decrease in commuting costs would be expressed as $\sigma_k^{sr} = 0.95$. We assume that σ_k^{sr} is unique to the k^{th} resource, but not to which sector employs the resource. Note that the coefficient σ_k^{sr} is larger and the "effective" wage ($\sigma_k^{sr} w_{kj}^r$) is lower than the paid wage in region r (the region of employment) the longer or the more congested the commute between regions s and r.

B.2.2 Model Solution

Equilibrium prices: A linear-logarithmic price frontier equation is formed by substituting the profit-maximizing resource demands (from equations [B3]) into the technical production requirement (equation [B2] above):

[B7] $$lnp_j^r - \sum_{s-1}^{m} \sum_{i=1}^{n} \beta_{ij}^{sr} ln\tau_i^{sr} - \sum_{s=1}^{m} \sum_{i=1}^{n} \beta_{ij}^{sr} lnp_i^s - \sum_{s=1}^{m} \sum_{k=1}^{2} \omega_{kj}^{sr} lnw_{kj}^r - \sum_{s=1}^{m} \theta_j^{sr} lnv_j^r = d_j^r$$

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purchase price for commodity i produced in region s and consumed by sector j located in region r can be written as $p_{ij}^{sr} + \lambda_i^s = p_i^s + u_i^{sr} = (1 + \theta_i^{sr})p_i^s = \tau_i^{sr} p_i^s$. The unit cost of bringing a commodity to market (u_i^{sr}) is expressed as a constant proportion of its equilibrium value in the producing region ($u_i^{sr} = \theta_i^{sr} p_i^s$). This can be interpreted as the transportation cost of bringing a commodity to market. However, usual practice in input-output accounting and modeling shows that products are not only handled by transporters but also by wholesale and retail handling charges.

Where $d_j^r = -\left(\beta_{0j}^r + \sum_{s-1}^m \sum_{i=1}^n \beta_{ij}^{sr} ln\beta_{ij}^{sr} + \sum_{s=1}^m \sum_{k=1}^2 \omega_{kj}^{sr} ln\omega_{kj}^{sr} + \sum_{s=1}^m \theta_j^{sr} ln\theta_j^{sr}\right)$.

Furthermore, we can derive equilibrium price levels in matrix form from equation as

[B8] $$lnP = (I - B)^{-1}\left(\sum_{k=1}^2 \Psi_k lnW_k + \Theta lnV + \Lambda lnT + D\right).$$

The equilibrium solution matrices are defined as

$$lnP = \begin{bmatrix} lnP^1 \\ \vdots \\ lnP^m \end{bmatrix} \quad lnP^r = \begin{bmatrix} lnp_1^r \\ \vdots \\ lnp_n^r \end{bmatrix} \qquad B = \begin{bmatrix} B^{11} & \cdots & B^{m1} \\ \vdots & \ddots & \vdots \\ B^{1m} & \cdots & B^{mm} \end{bmatrix} \qquad B^{sr} = \begin{bmatrix} \beta_{11}^{sr} & \cdots & \beta_{n1}^{sr} \\ \vdots & \ddots & \vdots \\ \beta_{1n}^{sr} & \cdots & \beta_{nn}^{sr} \end{bmatrix}$$

$$\Psi_k = \begin{bmatrix} \Psi_k^1 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \Psi_k^m \end{bmatrix} \quad \Psi_k^r = \begin{bmatrix} \omega_{k1}^r & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \omega_{kn}^r \end{bmatrix} \quad lnW_k = \begin{bmatrix} lnW_k^1 \\ \vdots \\ lnW_k^m \end{bmatrix} \qquad lnW_k^r = \begin{bmatrix} lnw_{k1}^r \\ \vdots \\ lnw_{kn}^r \end{bmatrix}$$

$$\Theta = \begin{bmatrix} \Theta^1 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \Theta^m \end{bmatrix} \qquad \Theta^r = \begin{bmatrix} \theta_1^r & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \theta_n^r \end{bmatrix} \qquad lnV = \begin{bmatrix} lnV^1 \\ \vdots \\ lnV^m \end{bmatrix} \qquad lnV^r = \begin{bmatrix} lnv_1^r \\ \vdots \\ lnv_n^r \end{bmatrix}$$

$$\Lambda = \begin{bmatrix} \Lambda^1 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \Lambda^m \end{bmatrix} \qquad \Lambda^r = \begin{bmatrix} \beta_{11}^{1r} & \cdots & \beta_{n1}^{1r} & \cdots & \beta_{11}^{mr} & \cdots & \beta_{n1}^{mr} \\ \vdots & \ddots & \vdots & \cdots & \vdots & \ddots & \vdots \\ \beta_{1n}^{1r} & \cdots & \beta_{nn}^{1r} & \cdots & \beta_{1n}^{mr} & \cdots & \beta_{nn}^{mr} \end{bmatrix} \qquad lnT = \begin{bmatrix} ln\tau_1^{11} \\ \vdots \\ ln\tau_n^{11} \\ \vdots \\ ln\tau_1^{mr} \\ \vdots \\ ln\tau_n^{mr} \end{bmatrix}$$

$$D = \begin{bmatrix} D^1 \\ \vdots \\ D^m \end{bmatrix} \qquad D^r = \begin{bmatrix} d_1^r \\ \vdots \\ d_n^r \end{bmatrix}$$

Equilibrium Output: The equilibrium price formulation above (equation [10]) provides a very practical way of implementing a more general and flexible solution to the MRIO model. Thus we have developed a way of deriving the relationships between the multiregional technical coefficients, input elasticities, relative prices of goods and services, and the costs of factors of production such as labor, capital, and transportation services. We can account for changes in multiregional technical coefficients, ΔTA, and assess the effects on the economic system exerted by those changes, which occur because of changes in transportation efficiencies or due to changes in resource costs.

Like all types of input-output models, demand must equal supply. That is, the amount of commodity i produced in region r (supply or X_i^r) must equal the amount of commodity i sold to intermediate producers ($\sum_{s=1}^m \sum_{j=1}^n X_{ij}^{sr}$), the amount of commodity i sold households residing in region r that are produced in region s (C_i^{sr}), and the amount of commodity i sold to final demand purchasers (Y_i^r) other than households,[183]

[B9] **Balancing equation:** $\sum_{s=1}^{m}\sum_{j=1}^{n} X_{ij}^{sr} + \sum_{s=1}^{m} C_i^{sr} + Y_i^r = X_i^r$.

We can transform the balancing equation, [B9], using equations [B3], [B5], and [B6]:

$$\sum_{s=1}^{m}\sum_{j=1}^{n}\frac{\beta_{ij}^{sr}p_j^r X_j^r}{\tau_i^{sr}p_i^s} + \sum_{s=1}^{m}\sum_{j=1}^{n}\frac{\delta^{sr}\gamma_i^r\left(\sum_{k=1}^{2}\frac{\omega_{kj}^{sr}}{\sigma_k^{sr}}\right)p_j^r X_j^r}{p_i^s} + Y_i^r = X_i^r \text{, or}$$

[B10] $$X_i^r = \sum_{s=1}^{m}\sum_{j=1}^{n}\left[\frac{p_j^r}{p_i^s}\left(\frac{\beta_{ij}^{sr}}{\tau_i^{sr}} + \delta^{sr}\gamma_i^r\sum_{k=1}^{2}\frac{\omega_{kj}^{sr}}{\sigma_k^{sr}}\right)\right]X_j^r + Y_i^r.$$

The terms inside the bracket of equation [B10] are the nonlinear multiregional social accounts matrix technical coefficients adjusted for household interactions ($\widetilde{TA}$).

[B11] $$\widetilde{TA} = \left[\alpha_{ij}^{sr}\right] = \left[\frac{p_j^r}{p_i^s}\left(\frac{\beta_{ij}^{sr}}{\tau_i^{sr}} + \delta^{sr}\gamma_i^r\sum_{k=1}^{2}\frac{\omega_{kj}^{sr}}{\sigma_k^{sr}}\right)\right].$$

B.2.3 Final Demand Price Elasticities of Demand

Running the nonlinear multiregional social accounting matrix model to evaluate the regional economic impacts of transportation projects and other scenarios that cause changes in production costs (for example, resource costs) requires the use of price elasticities of demand: one for the change in demand that results from a one percent change in price. For example, extending the rail line to Yellow Bend Port in Arkansas will cause a reduction in transportation costs that will, in turn, lower the price for the good shipped (assuming a competitive economic system). The reduction in the price for the shipped goods should increase their demands. A price elasticity for a good is a way of determining the extent of the increase in the demand for the commodity.

The price elasticity of final demand has to be estimated using econometric techniques. Let Y_i^r be the final demand for a sub-industry i ($i = 1, \cdots, n$) located in region r and let p_i be the corresponding price index for industry i as of current price levels (for example, the base year of the model). Let $\bar{p}$ be the average of the industry-specific price indexes, p_i. Then a final demand equation corresponding to the industries and regions is

[B12] $lnY_i^r = a\ ln\left({}^{p_i}/_{\bar{p}}\right) + \sum_{j=1}^{J} b_j\ IndJ_j + \sum_{s=1}^{m} c_s\ RegS_s + e_i$, where $i = 1, \cdots, n$ and $s = 1, \cdots, m$,

$IndJ_j = 1$ if sub-industry i is part of sector j, 0 otherwise,

[183] Final demand purchases other than to households would include goods and services sold to governments (local, state, and federal levels), investors (inventory change and capital goods), and foreign buyers (exports).

$RegS_s = 1$ if region is s, 0 otherwise,

a, b_j, c_s are estimated parameters, and

e_i is an i.i.d. regression error term.

$IndJ_j$ is defined as an aggregation of the sub-industries. Each of the sub-industries are assigned to one of the aggregate sectors ($IndJ_j$) and all of the sub-industries are assigned. The average price variable ($\bar{p}$) should be a quantity weighted average over all industries. However, the use of equation [B12] only involves the slope coefficient for prices; i.e., "*only the prices change*". If $\bar{p}$ is the quantity weighted average, the only effect that this would have on equation [YY] is to alter the industry and region slopes (i.e., the b's and c's). The reason is that we only have one cross section of data and the average prices, however defined, do not change the price elasticities for final demand. That is, the results do not depend on the way that the sub-industry prices are averaged. It is expected that a will be negative.

B.3 Model Uses and Applications

In symbolic matrix form, the nonlinear multiregional input-output model with transboundary household income and expenditure patterns may be expressed as

[B13] $$X = \left(\widetilde{TA}_I + \widetilde{TA_H}\right)X + Y.$$

Much of the restrictive nature of the assumptions underlying the standard version of the input-output model can be overcome by totally differencing equation [B13] and then solving for changes in output levels with respect to changes in technological and trading patterns and with respect to changes in final demand (Robinson, 1990); i.e.,

$$\Delta X = \Delta\widetilde{TA}_I\, X + \widetilde{TA}_I\, \Delta X + \Delta\widetilde{TA}_I\, \Delta X + \Delta\widetilde{TA_H}\, X + \widetilde{TA_H}\, \Delta X + \Delta\widetilde{TA_H}\, \Delta X + \Delta Y$$

$$\Delta X - \left(\widetilde{TA}_I + \widetilde{TA_H}\right)\Delta X - \left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)\Delta X = \left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)X + \Delta Y$$

$$\left[I - \left(\widetilde{TA}_I + \widetilde{TA_H}\right) - \left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)\right]\Delta X = \left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)X + \Delta Y$$

[B14] $$\Delta X = \left[I - \left(\widetilde{TA}_I + \widetilde{TA_H}\right) - \left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)\right]^{-1}\left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)X$$

$$+ \left[I - \left(\widetilde{TA}_I + \widetilde{TA_H}\right) - \left(\Delta\widetilde{TA}_I + \Delta\widetilde{TA_H}\right)\right]^{-1}\Delta Y$$

Equation [B14] is the most general solution to the input-output model (in contrast to the more restrictive standard version). Not only does this solution account for those effects due to changes in project-related spending, but it also evaluates those effects resulting from reductions in transport costs. Not only does this solution involve those impact scenarios, generated by changes in final demand (ΔY), but it also indicates how changes in technological and trading patterns can be expected to alter production and subsequent employment and income levels ($\Delta TA\, X$). The first part of the right-hand side of equation [B14] is called the MRIO "substitution" or "variable" effect (due to ΔTA) and the second part may be referred to as the MRIO final demand effect (due to ΔY) (Liew and Liew, 1985). The more general input-output solution is more complex than the standard approach. However, this additional complexity permits a much higher degree of flexibility and applicability for the model.

Most applications of the nonlinear multiregional input-output model with transboundary household income and expenditure patterns will involve the consequences of changes in transportation or resource costs (the τ_i^{sr} or the w_{jk}^r). This will signal changes in equilibrium prices for each region and industry (the vector P) using equation [B8]. In turn, the interindustry technical relationships and final demand will vary (the α_{ij}^{sr} and Y_i^r) using equations [B11] and [B12]. Changes in equilibrium output are computed using equation [B14]. Equilibrium demands for intermediate goods and resources resulting from these changes are derived from equation [B3]. Commuting cost changes will involve changes in the interindustry technical coefficients (equation [B11]), then changes in equilibrium output (equation [B4]), and then changes in intermediate goods and resources (equation [B3]). More detailed discussion of the procedures for using the nonlinear multiregional input-output model is provided below.

B.3.1 Changes in Project-Related Spending

Transportation projects often involve spending money to construct, repair, maintain, and operate infrastructure facilities. Although the usual regional economic assessment tools are available to analyze the economic effects of these expenditures, equation [B14] is quite capable of also analyzing the regional economic impacts of transportation project spending. In fact there is a very good reason to consider the nonlinear multiregional input-output model with transboundary household income and expenditure patterns over the usual multiregional input-output model. That is, the nonlinear multiregional input-output model with transboundary household income and expenditure patterns explicitly accounts for worker commuting and household expenditure patterns that are unique to each region within the geographic system. Note that equation [B14] simplifies by assuming that there are no effects on the technical and trading patterns in the model (i.e., $\Delta\widetilde{TA} = \Delta\widetilde{TA_I} + \Delta\widetilde{TA_H} = 0$) and the prices, transportation and commuting costs are at their base year value (setting p_i^s, p_j^r τ_i^s, and $\sigma_k^{sr} = 1$); i.e., using equation [B11] we have

[B15] $$\widetilde{TA} = \left[\alpha_{ij}^{sr}\right] = \left[\left(\beta_{ij}^{sr} + \delta^{sr}\gamma_i^r \textstyle\sum_{k=1}^{2} \omega_{kj}^{sr}\right)\right].$$

Notice that multiregional input-output technical coefficients adjusted for transboundary household income and expenditure patterns (α_{ij}^{sr}) are larger than the usual multiregional input-output technical coefficients (β_{ij}^{sr}) by the positive factors of regional spending propensities (δ^{sr}), industrial consumption distributions (γ_i^r), and value added coefficients (ω_{kj}^{sr}).

B.3.2 Changes in Equilibrium Prices

Equation [B8] provides a flexible method of determining the effects of transportation and resource costs on the prices of commodities. The percentage changes in the input and output prices (P) due to percentage changes in transportation costs are derived by totally differentiating equation [B8] and assuming that only the costs of delivering commodities (T) change; i.e.,

[B16] $$d(lnP) = (I - B)^{-1}\Lambda d(lnT).$$

In a similar fashion, the percentage changes in the input and output prices (P) due to percentage changes in resource costs are computed by totally differentiating equation [B8] and assuming that only resource costs (W_k) change; i.e.,

[B17] $$d(lnP) = (I - B)^{-1}\Psi_k d(lnW_k).$$

B.3.3 Changes in Technical Relationships

The terms inside the parentheses on the right-hand side of equation [B13] are nonlinear multiregional input-output technical coefficients adjusted for transboundary household income and expenditure patterns from equation [B11] (slightly rearranged),

[B18] $$\widetilde{TA} = \widetilde{TA}_I + \sum_{k=1}^{3}\widetilde{TA_{H_k}} = \left[\alpha_{ij}^{sr}\right] = \left[\frac{p_j^r}{p_i^s}\frac{\beta_{ij}^{sr}}{\tau_i^{sr}} + \frac{\delta^{sr}\gamma_i^r p_j^r}{p_i^s}\sum_{k=1}^{2}\frac{\omega_{kj}^{sr}}{\sigma_k^{sr}}\right]$$, or

$$\widetilde{TA} = \widetilde{TA}_I + \sum_{k=1}^{3}\widetilde{TA_{H_k}} = \left[\alpha_{ij}^{sr}\right] = \left[\frac{p_j^r}{p_i^s}\frac{\beta_{ij}^{sr}}{\tau_i^{sr}} + \frac{p_j^r\delta^{sr}\gamma_i^r\omega_{1j}^{sr}}{p_i^s\sigma_1^{sr}} + \frac{p_j^r\delta^{sr}\gamma_i^r\omega_{2j}^{sr}}{p_i^s\sigma_2^{sr}}\right]$$

Note that the typical element of industrial nonlinear multiregional input-output technical coefficient is $\widetilde{TA}_I = \left[\frac{p_j^r}{p_i^s}\frac{\beta_{ij}^{sr}}{\tau_i^{sr}}\right]$ and the typical element of the transboundary nonlinear multiregional input-output transboundary household income and expenditure coefficient for resource k is $\widetilde{TA_{H_k}} = \left[\frac{p_j^r\delta^{sr}\gamma_i^r\omega_{kj}^{sr}}{p_i^s\sigma_k^{sr}}\right]$.

Changes in the technical coefficients in the nonlinear multiregional input-output model with transboundary household income and expenditure patterns can be calculated by first expressing each of the components of the technical coefficients (i.e., $\widetilde{TA}_I = \left[\frac{p_j^r}{p_i^s}\frac{\beta_{ij}^{sr}}{\tau_i^{sr}}\right]$ and $\widetilde{TA_{H_k}} = \left[\frac{p_j^r\delta^{sr}\gamma_i^r\omega_{kj}^{sr}}{p_i^s\sigma_k^{sr}}\right]$) and then totally differentiating each component:[184]

[B19] $$d\left(ln\widetilde{TA}_I\right) = d\left(lnp_j^r\right) - d(ln\tau_i^{sr}) - d(lnp_i^s),$$ [185] and

[B20] $$d\left(ln\widetilde{TA_{H_k}}\right) = d\left(lnp_j^r\right) - d(ln\sigma_k^{sr}) - d(lnp_i^s).$$ [186]

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[184] Note that these percentage changes in the multiregional technical coefficients are measured like index numbers with their base year being the same as for the MRIO model. The use of index numbers to measure changes in input-output coefficients has been suggested by Moses (1974) and others.

[185] Please observe that the input elasticity, β_{ij}^{sr}, drops out of the differentiation process because it is assumed to be a parameter of the equilibrium production frontier and, therefore, assumed constant.

[186] Similarly, the parameters $\delta^{sr}\gamma_i^r\omega_{1j}^{sr}$ drop out of the differentiation process, because they are assumed to be elements of the equilibrium production frontier and assumed constant.

Equation [B19] shows that the percentage changes in the nonlinear multiregional industrial technical coefficients ($\widetilde{TA}_I$) are inversely related to the percentage changes in the cost of delivering an input commodity from the region of production to the regional of consumption and positively related to the output price of the good produced relative to the input price (p_j^r/p_i^s). Equation [B20] indicates nonlinear multiregional household technical coefficients for resource k ($\widetilde{TA_{H_k}}$) are inversely related to the commuting costs of resource k between regions s and r and positively related to the output price of the good produced relative to the input price (p_j^r/p_i^s).

The nonlinear multiregional input-output model with transboundary household income and expenditure patterns solution has at least three analytical advantages. First, it permits an analysis that focuses just on those impacts related to changes in transportation costs and the factors associated with resource payments and resource acquisition. Second, this solution relaxes the “fixity” of the multiregional technical coefficients. Third, even though the steps of the analytical procedure for calculating the impacts of this model proceed in a particular order, they were developed via a solution to a system of simultaneous equations.

B.3.4 Changes in Final Demand

Changes in relative prices should signal final consumers to change their demand for goods and services. Equation [B12] provides a method (price elasticity of demand) of evaluating changes in final demand due to changes in equilibrium prices (equations [B16] and [B17]).

B.3.5 Changes in Industrial Output

Changes in industrial output are computed by equation [B14]. However, it should be expanded to accommodate equation [B19], that is

[B21] $$\Delta X = \left[I - \left(\widetilde{TA}_I + \sum_{k=1}^{2} \widetilde{TA_{H_k}}\right) - \left(\Delta\widetilde{TA}_I + \sum_{k=1}^{2} \Delta\widetilde{TA_{H_k}}\right)\right]^{-1}\left(\Delta\widetilde{TA}_I + \sum_{k=1}^{2} \Delta\widetilde{TA_{H_k}}\right)X$$
$$+\left[I - \left(\widetilde{TA}_I + \sum_{k=1}^{2} \widetilde{TA_{H_k}}\right) - \left(\Delta\widetilde{TA}_I + \sum_{k=1}^{2} \widetilde{TA_{H_k}}\right)\right]^{-1}\Delta Y,$$

which can be computed after evaluating the changes in

a) Equilibrium prices (p_i^r) due to changes in either transportation costs (τ_i^{sr}) or resource costs (w_{kj}^r) using equations [B16] and [B17];
b) Technical relationships ($\widetilde{TA}_I$ and $\widetilde{TA_{H_k}}$) due to changes in prices (p_i^r), transportation costs (τ_i^{sr}), and/or commuting costs (σ_k^{sr}) using equations [B18] and [B19]; and
c) Final demand (Y_i^r) due to using equation [B12].

APPENDIX C: INFRASTRUCTURE PRODUCTIVITY ASSESSMENT MODEL

In addition to water resource cost savings effects, there are also broader induced productivity effects generated by water resources investments. The basic premise is that transportation improvements reduce the delivery costs of capital, materials, energy, and even labor inputs used by firms, as well as, the transportation costs to deliver the products produced. Directly, the transportation improvement reduces the cost of the flow of goods and services between regions. Such delivery cost reductions, *ceteris paribus*, should be reflected in lower factor and product costs. In addition, one should also anticipate indirect systems interactions that spread quite readily within and between industries and regions depending on the competitiveness of the economic system. Factor cost reductions themselves should lead to lower production costs. Lower production costs in some firms relative to others should lead, in a competitive industry, to relative price changes for their goods and services. These changes in relative prices, in turn, should cause some goods and services to be consumed more, and others less. This chain of events is likely to change trading patterns among firms and, thus, between regions. It would also be expected to alter the factor mix in production processes within firms (i.e., technological change).

However, from a general equilibrium point of view, decreases in transportation costs generate widespread effects in a variety of sectors within a region (Rietveld, 1989). For example, transportation improvements are not often confined to a single commodity. In areas that experience transportation cost reductions, the cost reductions not only reduce production costs for exported goods but also reduce the cost of imported products. When the price of imported goods declines consumers and producers will tend to substitute the imported products for the relatively more expensive domestically produced goods. Even in areas that do not benefit from transportation cost reductions, the more expensive imported goods will cause local consumers and producers to use the more relatively more expensive imported goods less intensively and the less expensive domestic products more intensively. Further enhancing the spread effect is that improvements in one mode of transportation are also transferred to other modes via competition. For example, barge rate reductions created by improvements in waterway infrastructures often cause rail rate reduction when the two modes are competing for traffic serving the same routes (sometimes called “compelled” rate reductions).

In addition, transportation cost reductions have complicated effects on intermediate deliveries—those goods that are used to produce other goods (e.g., the steel used to produce cars). Reductions in the transportation cost of the intermediate products will affect the prices of local goods and services and will alter the mix of goods and services used by producers.[187] In

[187] Recent empirical evidence by Hillberry and Hummels (2005) suggest that intermediate demand helps explain the variation in industry expenditures across regions. For example, consumption varies considerably across regions and this is well predicted by the industrial structure and the demand for intermediate inputs.

addition, there will also be an expansive effect on production. In addition, firms will have an incentive to increase its production levels due to the reduced production costs.

C.1 Transportation Infrastructure Investment and Economic Change

There should be an inverse relationship between investments in transportation infrastructure and delivery costs and product prices.

It is worth repeating the basic economic logic behind improving transportation facilities and systems. Transportation plays a fundamental and critical role regional economic development. The availability of well integrated transportation networks often defines how that region can compete, what types of goods will be available as inputs for local industries, what types of goods and services will be reasonable for local sectors to produce. An improvement in the transportation system of a region can change the production costs of many goods and services produced in the region and can provide the benefited region with a competitive advantage in regional, national, and international markets. Transportation of goods on the inland waterway system occurs because this mode of transportation provides the lowest cost means of movement for such heavy and bulky goods as grain, grain mill products, lumber, paper products, chemicals, petroleum, coal, stone, iron, and steel. When a new waterway is opened, the reduction in transportation costs reduces the cost of producing other goods. Reductions in transport costs make indigenous industries more competitive, thereby leading to firm expansions. The firms are able to lower costs and participate in new markets. This helps to increase region output, employment, and income.

The unique feature of these functions is that their benefits are, in one form or another, valued in terms of efficiency gains or cost savings. The complicating factor in evaluating the regional economic effects of these cost savings is that improvements in these activities (i.e., reductions in transportation costs) affect both industrial producers and final consumers (i.e., households, governments and foreign residents). How one analyzes and computes the regional economic impacts of project functions that generate system-wide efficiencies is not as straightforward as for project-related spending. Much goes on between regions of an economic system, between firms within regions, and within the firms themselves. Some effects are compensating while others are complementary, however, they all occur approximately during the same timeframe.

C.2 Transportation Infrastructure Investment in the United States

Recently, two major research efforts have been undertaken to determine the economic value of the state of the nation's highway and navigation systems. Figure C 1 presents the highway (Fraumeni, 2007a and 2007b) and navigation (see Dunning and Horrie, 2013) capital stocks from 1960 to 2005 in thousands of 2011 dollars.[188]

[188] Highway capital stock is the sum of interstate highways, non-interstate state highways, and local roads. The navigation capital stock includes navigation, dredging, and part of Mississippi and Tributaries

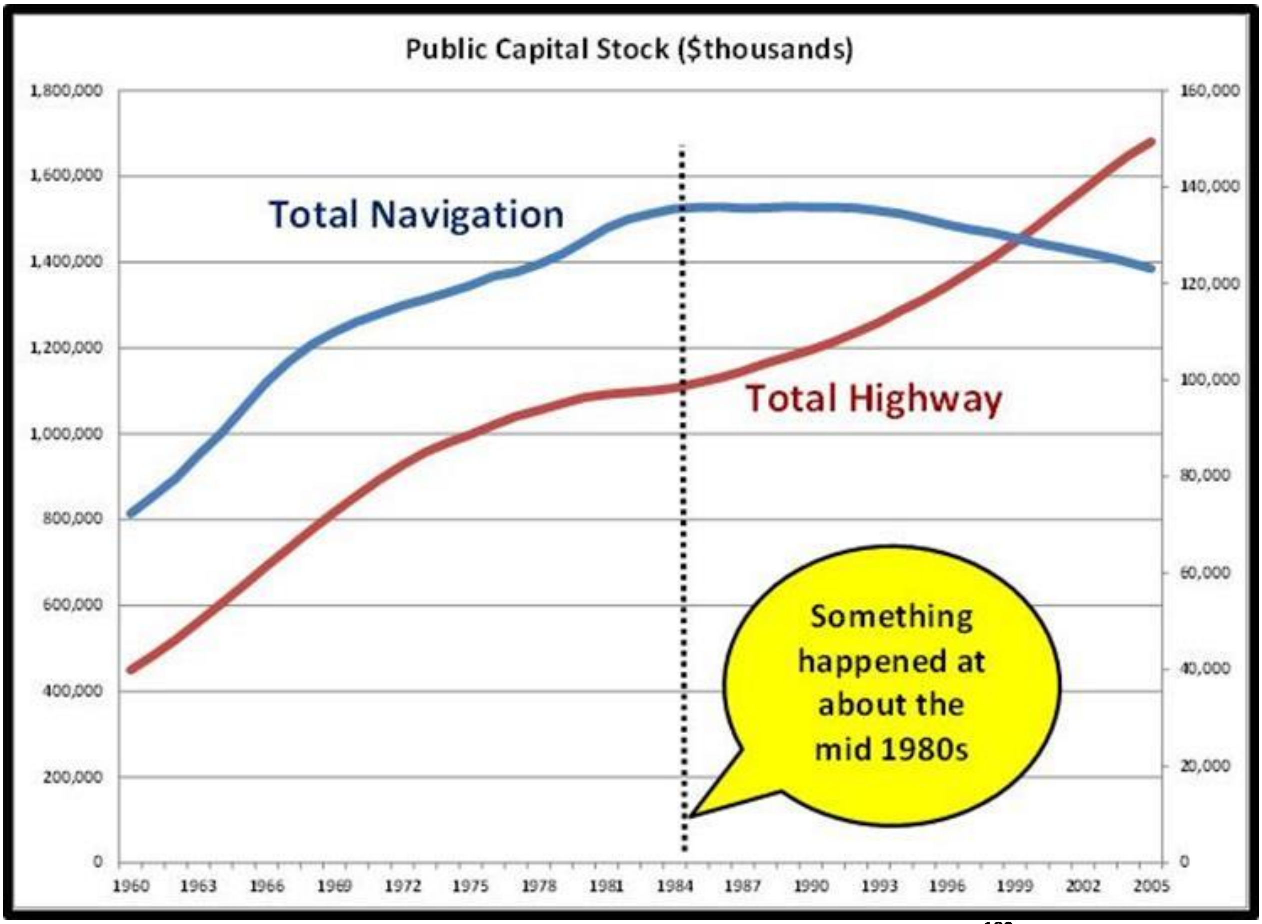

Figure C1 U.S. Highway and Navigation Capital Stock[189]

The main point of Figure C1 is that it appears that the mid 1980s marked a significant change in the funding policies for both the U.S. Department of Transportation (USDOT) and U.S. Army Corps of Engineers. According to Figure C1, both the Corps and USDOT seem to have completed and improved their major transportation infrastructure function by the early 1980s.[190] After that, the Corps navigation capital stock value has deteriorated and, in more recent year, substantially so. However, the value of the highway capital stock has improved and continues to do so.

(20% based on historical Corps' budgeting practice). The interested reader should see the cited references for the details of the construction of these capital stock data.

[189] Sources are the Federal Highway Administration (U.S. Department of Transportation) and the Institute For Water Resources (U.S. Army Corps of Engineers).

[190] In the case of the Corps, there have been few, if any major navigation improvement projects undertaken. For USDOT, the end of the construction of the interstate highway system was completed.

C.3 Estimating the Relationship between Infrastructure and Economic Change

The great majority of studies analyzing the transportation infrastructure productivity effects have ignored these resource cost effects in their models and estimation procedures.[191] Kelejian and Robinson (2000) specifically analyzed the productivity effects of resource cost effects due to infrastructure investment, simultaneously, for both navigation and highway capital investments. One result of their investigation was the development of industry-specific navigation capital investment final demand elasticity estimates. An industrial final demand elasticity of navigation capital investment is the percentage change in final demand for a sector due to a one-percent (1%) change in navigation capital investment. They also evaluated the short- and long-run effects of navigation capital investments. The methodology employed by Kelejian and Robinson (2000) is to conjoin an econometrically estimated model of resource prices (for labor, energy, and materials) in relation to transportation infrastructure capital investments (i.e., highways and navigation) with a variable input-output (VIO) model of the U.S. economy. Kelejian and Robinson (2006) further refined their econometric resource price model to state economies, which can be then conjoined with a state-level MRVIO model.

The basic premise of transportation cost savings is that improvements in transportation systems reduce the delivery costs of capital, materials, and energy inputs used by firms, as well as, the transportation costs to deliver the products produced—that is, reduces the cost of the flow of goods and services between regions. Such delivery cost reductions, *ceteris paribus*, should be reflected in lower factor and product costs. In addition, one should also expect indirect systems interactions that will spread quite readily within and between regions depending on the competitiveness of the economic system. Factor cost reductions themselves should also lead to lower production costs. Lower production costs in some firms relative to others should lead, in a competitive industry, to relative price reductions for their goods and services. These changes in relative prices, in turn, should cause some goods and services to be consumed more, and others less. This chain of events is likely to change trading patterns among firms and, thus, between regions. It would also be expected to alter the factor mix in production processes within firms (i.e., technological change).

C.3.1 Equation Specification and Estimation Results

Our equation specification follows that of Kelejian and Robinson (2000). We statistically relate the price of a resource (labor, materials, or energy) used by an industry to its lagged value ($\boldsymbol{PJ_{it}}$), a cubic time trend ($\boldsymbol{t}$, $\boldsymbol{t^2}$, and $\boldsymbol{t^3}$), the lagged value of navigation capital stock ($\boldsymbol{NAV_t}$), and the lagged value of highway capital stock ($\boldsymbol{HWY_t}$). The values of prices and capital stock are expressed in natural logarithms.

[C1] $$\boldsymbol{ln(PJ_{it}) = \alpha_{i0}^J + \alpha_{i1}^J ln(PJ_{it-1}) + \alpha_{i2}^J t + \alpha_{i3}^J t^2 + \alpha_{i4}^J t^3}$$

[191] The resource cost effects of transportation infrastructure development and the consequences of ignoring them for infrastructure productivity modeling are further discussed by Dalenberg and Partridge (1997), Haughwout (1998), and Kelejian and Robinson (2000).

$$+\alpha_{i5}^{J}\ln(NAV_{t-1}) + \alpha_{i6}^{J}\ln(HWY_{t-1}) + \epsilon_{it}^{J}$$

PJ_{it}	price of resource J: L for labor, M for materials, and E for energy,
t, t^2, t^3	cubic time trend variables(where t is equal to 1 in 1960 and 45 in 2005),
NAV_t	navigation capital stock (thousands of 2011 dollars),
HWY_t	highway capital stock (thousands of 2011 dollars),
ϵ_{it}^{J}	regression error term (assumed to be *i.i.d.*),
i, t	industry and time indices, and
$ln(\bullet)$	natural logarithm function.

Our time period for estimation is 1960 to 2005 (corresponding to the available highway and navigation capital stock estimates described above). The number of sectors is 35 shown in Table C1. The source for the resource prices is Dale Jorgenson KLEM database (Jorgenson, 2007). We used ordinary least squares procedures to estimate our equations.

Table C1 KLEM Sectors

##	Sector	##	Sector
1	**Agriculture, forestry, fisheries**	**19**	**Stone, clay and glass products**
2	**Metal mining**	**20**	**Primary metals**
3	**Coal mining**	**21**	**Fabricated metal products**
4	**Crude oil and gas extraction**	**22**	**Non-electrical machinery**
5	**Non-metallic mineral mining**	**23**	**Electrical machinery**
6	**Construction**	**24**	**Motor vehicles**
7	**Food and kindred products**	**25**	**Other transportation equipment**
8	**Tobacco manufactures**	**26**	**Instruments**
9	**Textile mill products**	**27**	**Miscellaneous manufacturing**
10	**Apparel and other textile products**	**28**	**Transportation and warehousing**
11	**Lumber and wood products**	**29**	**Communications**
12	**Furniture and fixtures**	**30**	**Electric utilities (services)**
13	**Paper and allied products**	**31**	**Gas utilities (services)**
14	**Printing and publishing**	**32**	**Wholesale and retail trade**
15	**Chemicals and allied products**	**33**	**Finance, insurance and real estate**
16	**Petroleum refining**	**34**	**Personal and business services**
17	**Rubber and plastic products**	**35**	**Government enterprises**
18	**Leather and leather products**		

We use a cubic time trend for several reasons. The resource prices have very complex inflationary relationships and a multitude of variables (e.g., inflation and interest rates, etc.) would have to be employed to accurately capture these effects. We view the cubic time trend as a "proxy" measure for the net effects of inflation in our equations. In addition, the dependent variables have not been deflated using factor price indexes in our equations because satisfactory resource price indices do not exist for the industries considered here.

Our main focus of the estimated equations is the parameter values for the two infrastructure variables. ($\boldsymbol{\alpha^J_{i5}}$ for navigation capital stock and $\boldsymbol{\alpha^J_{i6}}$ for highway capital stock). They should both be significant and negative (i.e., $\boldsymbol{\alpha^J_{i5}}$ and $\boldsymbol{\alpha^J_{i6} < 0}$). Tables C2 through C4 provide the estimated parameter values and related statistics for our infrastructure productivity model of resource prices (labor, materials, and energy). In general we note that the estimated parameter values for the navigation capital stock variable are mostly negative as our assumed logic indicates (and most often statistically significant), however, the estimated parameter values for the highway capital stock are mostly positive and not statistically significant.

Table C2 Estimated Sector Infrastructure Productivity Equations for Labor: Model A[192]

Variable	Industry 1		Industry 2		Industry 3		Industry 4		Industry 5	
lnPI lagged	0.371407	*	0.914424	***	0.893168	***	0.961854	***	0.906731	***
t	0.078084		0.016726		0.046555		-0.004155		0.034087	
t^2	-0.001444		-8.6E-05		-0.00131		0.000391		-0.000786	
t^3	1.81E-05		-6.87E-06		9.62E-06		-1.03E-05		3.78E-06	
lnNAV lagged	0.494808		-1.170347	***	-0.90106	***	-0.966582	***	-0.840258	***
lnHWY lagged	-0.57112		0.741878	*	0.434276		0.750914		0.350764	
Constant	3.271047		3.634298		4.600828		1.183743		5.055775	
nobs	45		45		45		45		45	
R^2	0.9972		0.9987		0.9981		0.9985		0.9989	
RMSE	0.0442		0.0300		0.0327		0.0322		0.0246	

Variable	Industry 6		Industry 7		Industry 8		Industry 9		Industry 10	
lnPI lagged	0.875771	***	0.994174	***	0.743593	***	0.888344	***	0.865298	***
t	0.034397		-0.000817		0.159249	***	0.066761	***	0.10345	
t^2	-0.000929		-7.14E-05		-0.00429	**	-0.001913	***	-0.003202	*
t^3	8.48E-06		-8.99E-07		4.36E-05	**	1.95E-05	***	3.57E-05	*
lnNAV lagged	-0.320782		-0.412645	*	-0.72739	**	-0.414951	***	-0.524159	**
lnHWY lagged	0.057034		0.420546		-0.74625		-0.220717		-0.466075	
Constant	3.149589		-0.831115		18.08221	**	7.707054	**	12.14719	
nobs	45		45		45		45		45	
R^2	0.9993		0.9994		0.9987		0.9997		0.9982	
RMSE	0.0176		0.0183		0.0352		0.0120		0.0281	

Variable	Industry 11		Industry 12		Industry 13		Industry 14		Industry 15	
lnPI lagged	0.957804	***	0.875572	***	0.96731	***	0.791449	***	0.956733	***
t	0.008642		0.091027		0.009032		0.087067	**	0.013966	
t^2	-0.000394		-0.002656		-0.00029		-0.002477	**	-0.000418	
t^3	3.78E-06		2.74E-05		7.07E-07		2.78E-05	**	2.88E-06	
lnNAV lagged	-0.229569		-0.636756	***	-0.51523	**	-0.056718		-0.365556	
lnHWY lagged	0.261793		-0.292082		0.417863		-0.614234	*	0.275613	

192 Legend: * p<.1; ** p<.05;*** p<.01

Constant	-0.738891		11.10583		0.394927		9.071387	**	0.580325	
nobs	45		45		45		45		45	
R^2	0.9995		0.9985		0.9989		0.9994		0.9993	
RMSE	0.0153		0.0278		0.0258		0.0164		0.0228	

Variable	Industry 16		Industry 17		Industry 18		Industry 19		Industry 20	
lnPI lagged	0.909692	***	0.974484	***	0.857344	***	0.975295	***	0.882521	***
t	0.102134		0.007		0.065866		0.007396		0.052489	
t^2	-0.003048		-0.000214		-0.00187		-0.000255		-0.001365	
t^3	2.96E-05		-3.36E-08		1.92E-05		7.66E-07		1.03E-05	
lnNAV lagged	-1.188237	***	-0.451251	**	-0.58739	***	-0.427226	*	-0.840475	**
lnHWY lagged	0.028748		0.370204	*	-0.07148		0.335634		0.243853	
Constant	12.94784		0.287258		7.78936		0.485285		6.448205	
nobs	45		45		45		45		45	
R^2	0.9971		0.9995		0.9985		0.9995		0.9988	
RMSE	0.0446		0.0161		0.0285		0.0173		0.0246	

Variable	Industry 21		Industry 22		Industry 23		Industry 24		Industry 25	
lnPI lagged	0.928013	***	0.881235	***	0.7961	***	0.528638	**	0.537689	
t	0.03809		0.06478		0.048087		0.239348	*	0.202863	
t^2	-0.001073		-0.001782		-0.00098		-0.006174	*	-0.005477	
t^3	9.12E-06		1.69E-05		7.15E-06		5.93E-05		6.1E-05	
lnNAV lagged	-0.533372	**	-0.596929	*	-0.42688		-1.230212	**	0.185488	
lnHWY lagged	0.120616		-0.0689		0.003965		-1.155991		-1.772675	
Constant	4.542913		7.778345		5.156685		29.62631	*	21.84878	
nobs	45		45		45		45		45	
R^2	0.9993		0.9989		0.9985		0.9924		0.9935	
RMSE	0.0185		0.0258		0.0327		0.0668		0.0613	

Variable	Industry 26		Industry 27		Industry 28		Industry 29		Industry 30	
lnPI lagged	0.975146	***	0.935132	***	0.964698	***	0.908196	***	0.782481	***
t	0.025815		0.036708		-0.01066		0.014114		0.151015	
t^2	-0.000799		-0.001163		0.000337		-0.000215		-0.003916	
t^3	7.09E-06		1.21E-05		-6.75E-06		-1.02E-06		3.67E-05	
lnNAV lagged	-0.406015	**	-0.254288		-0.50988	***	-0.478836	**	-1.279077	**
lnHWY lagged	0.127526		0.003351		0.589971	***	0.322281		-0.531384	
Constant	2.918532		2.898865		-1.83812		1.392333		21.53327	
nobs	45		45		45		45		45	
R^2	0.9993		0.9989		0.9993		0.9994		0.9988	
RMSE	0.0210		0.0245		0.0191		0.0205		0.0287	

Variable	Industry 31		Industry 32		Industry 33		Industry 34		Industry 35	
lnPI lagged	0.674479	***	0.945957	***	0.736377	***	0.762547	***	0.84293	***
t	0.1417		0.024576		0.08735	**	0.067864	*	0.083129	

t^2	-0.003799		-0.000657		-0.00199	*	-0.001698	*	-0.001895	
t^3	3.98E-05		4.97E-06		1.93E-05	*	1.79E-05	*	1.32E-05	
lnNAV lagged	-0.357491		-0.404989	***	-0.29789	**	0.003187		-1.083176	***
lnHWY lagged	-0.670766		0.134976		-0.48255		-0.403995	*	0.061264	
Constant	13.14783		2.895537		10.07734	*	5.686233		11.52492	*
nobs	45		45		45		45		45	
R^2	0.9973		0.9997		0.9994		0.9996		0.9993	
RMSE	0.0495		0.0131		0.0223		0.0177		0.0255	

Table C3 Estimated Sector Infrastructure Productivity Equations for Materials: Model A[193]

Variable	Industry 1		Industry 2		Industry 3		Industry 4		Industry 5	
lnPm lagged	0.621825	***	0.749527	***	0.898769	***	0.891326	***	0.856531	***
t	0.141956	***	0.231836	***	0.062734	**	0.069326	*	0.088581	**
t^2	-0.003415	**	-0.006624	***	-0.00169	**	-0.001781	**	-0.002332	***
t^3	0.000027	*	6.57E-05	***	1.43E-05	*	1.47E-05	*	1.98E-05	**
lnNAV lagged	-1.585764	***	-1.848134	***	-0.66528	***	-0.800605	***	-0.883703	***
lnHWY lagged	-0.168704		-0.840072		-0.06569		-0.047649		-0.17275	
Constant	20.88852	***	31.95398	***	8.508864	**	9.764177	*	12.43166	**
nobs	45		45		45		45		45	
R^2	0.9963		0.9950		0.9989		0.9992		0.9983	
RMSE	0.0320		0.0402		0.0170		0.0195		0.0211	

Variable	Industry 6		Industry 7		Industry 8		Industry 9		Industry 10	
lnPm lagged	0.881544	***	0.645415	***	0.784292	***	0.76392	***	0.745019	***
t	0.071996	**	0.138566	**	0.06036		0.126097	***	0.097834	***
t^2	-0.001932	**	-0.003355	**	-0.00119		-0.003233	***	-0.002411	***
t^3	1.68E-05	**	2.64E-05	*	7.02E-06		2.85E-05	***	2.07E-05	**
lnNAV lagged	-0.759932	***	-1.589549	***	-0.8771	***	-1.187388	***	-0.796283	***
lnHWY lagged	-0.073369		-0.132284		0.083913		-0.362777		-0.347339	
Constant	9.682674	**	20.38437	***	9.240064	*	18.53385	***	14.10167	***
nobs	45		45		45		45		45	
R^2	0.9993		0.9965		0.9987		0.9979		0.9985	
RMSE	0.0155		0.0314		0.0260		0.0243		0.0189	

Variable	Industry 11		Industry 12		Industry 13		Industry 14		Industry 15	
lnPm lagged	0.671555	***	0.80654	***	0.73495	***	0.775311	***	0.791527	***
t	0.096232	**	0.098148	***	0.136404	***	0.104577	***	0.146076	***
t^2	-0.002035	*	-0.002523	***	-0.00337	***	-0.002521	***	-0.003767	***
t^3	1.29E-05		2.2E-05	**	2.88E-05	**	2.12E-05	**	3.33E-05	**
lnNAV lagged	-1.251886	***	-0.94532	***	-1.24595	***	-0.913445	***	-1.438514	***

193 Legend: * p<.1; ** p<.05;*** p<.01

lnHWY lagged	0.035155		-0.204393		-0.41517		-0.327524		-0.402391	
Constant	14.36738	**	13.64368	***	19.88741	***	14.94816	***	21.67867	***
nobs	45		45		45		45		45	
R^2	0.9977		0.9990		0.9980		0.9988		0.9978	
RMSE	0.0284		0.0185		0.0274		0.0225		0.0306	

Variable	Industry 16		Industry 17		Industry 18		Industry 19		Industry 20	
lnPm lagged	0.906149	***	0.803836	***	0.789488	***	0.886869	***	0.746902	***
t	0.063933	*	0.137695	***	0.10437	***	0.079468	**	0.194545	***
t^2	-0.001728	*	-0.003589	***	-0.00258	***	-0.002101	**	-0.005385	***
t^3	1.51E-05		3.19E-05	**	2.14E-05	**	1.77E-05	*	5.19E-05	**
lnNAV lagged	-0.740485	***	-1.346304	***	-1.01709	***	-0.965203	***	-1.493801	***
lnHWY lagged	-0.027143		-0.374124		-0.25579		-0.024517		-0.72188	
Constant	8.80217	*	20.27007	***	15.16494	***	11.30643	**	26.50378	**
nobs	45		45		45		45		45	
R^2	0.9990		0.9978		0.9990		0.9988		0.9967	
RMSE	0.0190		0.0289		0.0191		0.0210		0.0339	

Variable	Industry 21		Industry 22		Industry 23		Industry 24		Industry 25	
lnPm lagged	0.722032	***	0.848007	***	0.86693	***	0.884454	***	0.949246	***
t	0.194712	**	0.121043	**	0.117714	**	0.082376	**	0.059771	
t^2	-0.005287	**	-0.003434	***	-0.00338	**	-0.002251	**	-0.00177	*
t^3	5.03E-05	**	3.22E-05	**	3.25E-05	**	2.01E-05	**	1.62E-05	*
lnNAV lagged	-1.481521	***	-0.960179	***	-0.87638	***	-0.815037	***	-0.709707	***
lnHWY lagged	-0.741023		-0.396023		-0.42467		-0.145176		0.020959	
Constant	26.68467	**	16.17952	**	15.54044	**	11.21303	**	7.704224	
nobs	45		45		45		45		45	
R^2	0.9969		0.9968		0.9976		0.9988		0.9989	
RMSE	0.0340		0.0246		0.0233		0.0190		0.0188	

Variable	Industry 26		Industry 27		Industry 28		Industry 29		Industry 30	
lnPm lagged	0.889819	***	0.805031	***	0.914969	***	1.052547	***	0.952778	***
t	0.096225	**	0.123403	***	0.051432		0.017161		0.034927	
t^2	-0.002741	**	-0.003248	***	-0.00133		-0.000655		-0.000974	
t^3	2.6E-05	**	2.93E-05	***	1.05E-05		5.83E-06		7.77E-06	
lnNAV lagged	-0.786083	***	-1.094726	***	-0.66404	***	-0.323064	**	-0.524325	***
lnHWY lagged	-0.290396		-0.359398		0.036622		0.129464		0.11792	
Constant	12.74247	**	17.28224	***	7.113347		1.72675		4.406257	
nobs	45		45		45		45		45	
R^2	0.9984		0.9986		0.9991		0.9996		0.9995	
RMSE	0.0200		0.0225		0.0184		0.0117		0.0135	

Variable	Industry 31		Industry 32		Industry 33		Industry 34		Industry 35	
lnPm lagged	0.951659	***	0.964673	***	1.067696	***	1.008936	***	0.947045	***

t	0.037518		0.025847		0.005568		0.022637		0.037687	
t^2	-0.001063		-0.000713		-0.00037		-0.000726		-0.001034	
t^3	9.02E-06		5.31E-06		3.18E-06		5.94E-06		8.17E-06	
lnNAV lagged	-0.490852	***	-0.421466	***	-0.24822	***	-0.406784	***	-0.590508	***
lnHWY lagged	0.070139		0.121286		0.193155		0.14061		0.139079	
Constant	4.652837		3.198026		0.061465		2.65403		4.879414	
nobs	45		45		45		45		45	
R^2	0.9996		0.9997		0.9999		0.9998		0.9995	
RMSE	0.0121		0.0106		0.0076		0.0101		0.0152	

Table C4 Estimated Sector Infrastructure Productivity Equations for Energy: Model A[194]

Variable	Industry 1		Industry 2		Industry 3		Industry 4		Industry 5	
lnPe lagged	0.831712	***	0.898253	***	0.713274	***	0.822798	***	0.882043	***
t	0.315691	**	0.191014	*	0.352161		0.405063	**	0.228921	*
t^2	-0.009056	**	-0.005484	*	-0.00986		-0.011429	*	-0.006604	*
t^3	8.71E-05	*	5.16E-05		8.93E-05		0.000105	*	6.27E-05	
lnNAV lagged	-3.373686	***	-2.265776	***	-3.80163	*	-4.713818	***	-2.685262	***
lnHWY lagged	-0.622836		-0.18301		-0.49193		-0.535715		-0.245603	
Constant	45.6638	**	27.61835	**	49.03761		59.27838	**	33.08993	**
nobs	45		45		45		45		45	
R^2	0.9899		0.9959		0.9889		0.9854		0.9942	
RMSE	0.0856		0.0521		0.0766		0.1255		0.0637	

Variable	Industry 6		Industry 7		Industry 8		Industry 9		Industry 10	
lnPe lagged	0.791812	***	0.937676	***	0.858514	***	0.948678	***	0.949508	***
t	0.4112	**	0.146392		0.22947	*	0.122865		0.127729	
t^2	-0.011807	**	-0.004223		-0.00655	*	-0.00354		-0.003679	
t^3	0.000114	*	3.8E-05		6.15E-05		3.13E-05		3.25E-05	
lnNAV lagged	-4.366056	***	-2.143975	***	-2.62944	***	-1.873844	***	-1.952394	***
lnHWY lagged	-0.850911		0.171083		-0.26787		0.210964		0.215973	
Constant	59.6459	**	21.62519	*	32.81787	**	18.10176		18.90202	*
nobs	45		45		45		45		45	
R^2	0.9828		0.9967		0.9944		0.9975		0.9974	
RMSE	0.1158		0.0471		0.0609		0.0405		0.0424	

Variable	Industry 11		Industry 12		Industry 13		Industry 14		Industry 15	
lnPe lagged	0.885506	***	0.893233	***	0.925274	***	0.922436	***	0.889172	***
t	0.217136	**	0.208754	*	0.147135		0.164982	*	0.217457	*
t^2	-0.006194	*	-0.006013	*	-0.00421		-0.004725	*	-0.00616	*
t^3	5.78E-05		5.68E-05		3.77E-05		4.32E-05		5.57E-05	

[194] Legend: * p<.1; ** p<.05;*** p<.01

lnNAV lagged	-2.61109	***	-2.478432	***	-2.10164	***	-2.189161	***	-2.897448	***
lnHWY lagged	-0.203309		-0.204577		0.14669		0.013775		-0.000489	
Constant	31.72371	**	30.25518	**	21.49814	*	24.18089	*	32.26947	**
nobs	45		45		45		45		45	
R^2	0.9948		0.9950		0.9968		0.9966		0.9937	
RMSE	0.0604		0.0582		0.0467		0.0490		0.0685	

Variable	Industry 16		Industry 17		Industry 18		Industry 19		Industry 20	
lnPe lagged	0.825639	***	0.955622	***	0.91871	***	0.930517	***	0.912968	***
t	0.400965	**	0.114651		0.171451	*	0.141586		0.128352	
t^2	-0.011435	*	-0.003284		-0.00498	*	-0.004068		-0.0036	
t^3	0.000107	*	2.83E-05		4.71E-05		3.6E-05		3.09E-05	
lnNAV lagged	-4.588683	***	-1.831033	***	-2.09206	***	-2.136795	***	-1.908763	***
lnHWY lagged	-0.57611		0.256177		-0.109		0.232492		0.209791	
Constant	58.43032	**	17.03035		24.69647	*	20.77032		18.58938	
nobs	45		45		45		45		45	
R^2	0.9847		0.9978		0.9964		0.9968		0.9972	
RMSE	0.1217		0.0385		0.0484		0.0469		0.0425	

Variable	Industry 21		Industry 22		Industry 23		Industry 24		Industry 25	
lnPe lagged	0.952639	***	0.940719	***	0.940535	***	0.93233	***	0.921541	***
t	0.122887		0.139368		0.133418		0.145182		0.1592	*
t^2	-0.003526		-0.004008		-0.00381		-0.004142		-0.004562	*
t^3	3.06E-05		3.6E-05		3.37E-05		3.69E-05		4.18E-05	
lnNAV lagged	-1.95405	***	-2.002214	***	-1.96507	***	-2.079405	***	-2.096061	***
lnHWY lagged	0.262803		0.13592		0.162651		0.132609		0.007808	
Constant	18.31133		20.50191	*	19.75286	*	21.41864	*	23.23343	*
nobs	45		45		45		45		45	
R^2	0.9975		0.9972		0.9973		0.9971		0.9968	
RMSE	0.0414		0.0435		0.0423		0.0447		0.0466	

Variable	Industry 26		Industry 27		Industry 28		Industry 29		Industry 30	
lnPe lagged	0.93131	***	0.895901	***	0.7935	***	0.914696	***	0.833625	***
t	0.140001		0.208032	*	0.406061	**	0.16095	*	0.253729	
t^2	-0.004016		-0.005993	*	-0.01166	**	-0.004601	*	-0.007108	
t^3	3.63E-05		5.65E-05		0.000112	*	4.25E-05		6.31E-05	
lnNAV lagged	-1.921132	***	-2.498751	***	-4.36003	***	-2.022008	***	-3.24932	**
lnHWY lagged	0.080987		-0.185982		-0.80529		-0.067191		-0.025776	
Constant	20.33386	*	30.23465	**	58.99234	**	23.40122	**	36.6056	
nobs	45		45		45		45		45	
R^2	0.9974		0.9949		0.9829		0.9967		0.9918	
RMSE	0.0420		0.0592		0.1149		0.0461		0.0754	

Variable	Industry 31		Industry 32		Industry 33		Industry 34		Industry 35	

lnPe lagged	0.867865	***	0.910393	***	0.952413	***	0.909149	***	0.899175	***
t	0.304048	*	0.175506	*	0.112732		0.187288	*	0.20785	*
t^2	-0.008676	*	-0.004995	*	-0.00321		-0.005351	*	-0.005964	*
t^3	8E-05		4.58E-05		2.76E-05		4.95E-05		5.56E-05	
lnNAV lagged	-3.7881	***	-2.247787	***	-1.75888	***	-2.350137	***	-2.601993	***
lnHWY lagged	-0.207836		-0.053219		0.219599		-0.094141		-0.120613	
Constant	44.79137	**	25.72145	**	16.71335		27.3751	**	30.53013	**
nobs	45		45		45		45		45	
R^2	0.9892		0.9964		0.9978		0.9962		0.9948	
RMSE	0.0968		0.0501		0.0379		0.0529		0.0604	

C.3.2 What Happened to the Highway Capital Stock Variable?

What happened to our highway capital stock variable? Kelejian and Robinson (2000) found that both the navigation and other (the majority of was highway) capital stock variables had significant and negative effects on resource prices. Also, having a positive coefficient value for the highway capital stock implies that highway investments will cause resource prices to rise, contrary to our theoretical framework.

Figure C1 appears to provide a hint to our mystery. Prior to the early 1980s both the navigation and highway capital stocks were increasing in value (rising). However, since the mid-1980s the highway capital stock rose (increased in value) while the navigation capital stock fell (decrease in value). The reasons behind this divergence of trends are not fully known but are likely to be due to governmental policies favoring highway investments over navigation interests.

A simple way to possibly capture the diverging trends of highway and navigation capital stocks in our estimation process is to add squared terms for our capital stock variables (equation [C2]). The additional squared terms also have the capability to address possible congestion effects within our transportation system.

[C2] $$\boldsymbol{ln(PJ_{it}) = \alpha^J_{i0} + \alpha^J_{i1} ln(PJ_{it-1}) + \alpha^J_{i2} t + \alpha^J_{i3} t^2 + \alpha^J_{i4} t^3}$$

$$\boldsymbol{+\alpha^J_{i5} ln(NAV_{t-1}) + \alpha^J_{i6} ln(HWY_{t-1}) + \alpha^J_{i7} [ln(NAV_{t-1})]^2 + \alpha^J_{i8} [ln(HWY_{t-1})]^2 + \epsilon^J_{it}}$$

Interpreting the relationships between capital stock and resource prices is more complex due to the possible combinations of parameter values that the linear and squared capital stock variables can have (four possible combinations).

However, there two combinations of parameter values that imply interesting relationships between investments in transportation capital stock and resource prices. First, positive linear terms ($\boldsymbol{\alpha^J_{i5}}$or $\boldsymbol{\alpha^J_{i6}}$) and negative squared terms ($\boldsymbol{\alpha^J_{i7}}$**or** $\boldsymbol{\alpha^J_{i8}}$) indicate a “hill” relationship between transportation capital stock investment and resource prices (Figure C 2)—increasing capital stock past **CS*** will lead to lower resource prices (efficiencies in transportation system). Second, negative linear terms and positive squared terms indicate "bowl" relationship between transportation capital stock investment and resource prices (Figure C3)—increasing capital stock past **CS*** will lead to higher resource prices (inefficiencies in transportation system).

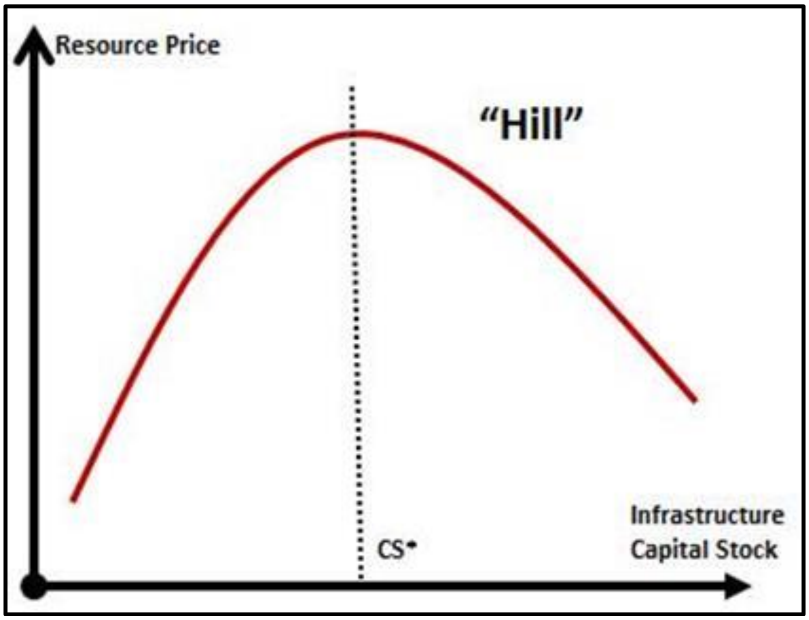

Figure C2"Hill" Relationship between Capital Stock Investment and Resource Price

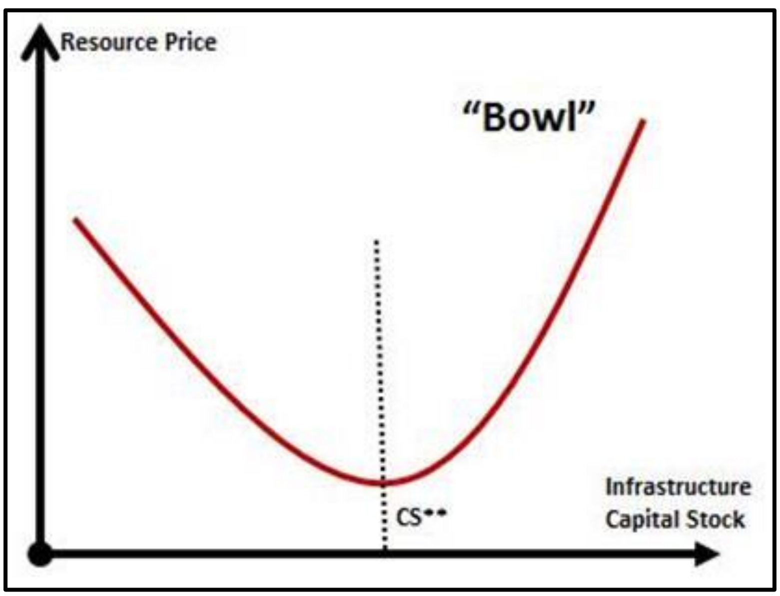

Figure C3"Bowl" Relationship between Capital Stock Investment and Resource Price

Tables C5 through C7 provide the estimated parameter values and related statistics for our Model B infrastructure productivity model of resource prices (labor, materials, and energy). Note that the navigation capital stock has a "hill" relationship with resource prices and that highway capital stock has a "bowl" relationship with resources prices.

Table C5 Estimated Sector Infrastructure Productivity Equations for Labor: Model B[195]

Variable	Industry 1		Industry 2		Industry 3		Industry 4		Industry 5	
lnPI lagged	0.257169		0.728386	***	0.640424	***	0.702495	***	0.622227	***
t	0.108417	*	0.058575		0.129684	**	0.075515		0.108586	**
t^2	-0.001121		6.07E-05		-0.00263		-0.000901		-0.001817	
t^3	1.96E-06		-2.78E-05	*	5.24E-06		-1.08E-05		-1.22E-06	
lnNAV lagged	97.9471	*	143.8042	***	129.4919	***	116.4496	***	117.6398	***
$\ln NAV^2$ lagged	-4.188894	*	-6.181979	***	-5.54546	***	-4.991194	***	-5.045159	***
lnHWY lagged	-39.72583		-88.12663	***	-92.4628	***	-79.4754	***	-77.73365	***
$\ln HWY^2$ lagged	1.406877		3.209387	***	3.35026	***	2.885861	***	2.812814	***
Constant	-291.241	**	-231.1188	***	-117.967		-131.854	*	-148.516	***
nobs	45		45		45		45		45	
R^2	0.9976		0.9990		0.9985		0.9988		0.9992	
RMSE	0.0424		0.0267		0.0304		0.0297		0.0218	

Variable	Industry 6		Industry 7		Industry 8		Industry 9		Industry 10	
lnPI lagged	0.551757	***	0.594366	***	0.439826	***	0.493723	***	0.471298	***
t	0.078634	**	0.113383	*	0.20084	***	0.144985	***	0.206768	***
t^2	-0.001532		-0.002491		-0.0044	**	-0.003276	***	-0.00599	***
t^3	6.52E-06		1.43E-05		3.19E-05		2.58E-05	***	6.19E-05	**
lnNAV lagged	49.21689	**	63.76595	***	97.36126	**	49.49893	***	56.76879	***
$\ln NAV^2$ lagged	-2.095697	**	-2.718876	***	-4.14524	**	-2.114281	***	-2.398902	***
lnHWY lagged	-41.78872	***	-55.62791	***	-76.321	***	-39.90591	***	-55.81474	***
$\ln HWY^2$ lagged	1.51229	***	2.006035	***	2.727816	***	1.419958	***	1.978567	***
Constant	0.559927		12.06216		-38.2906		-9.162653		57.6482	
nobs	45		45		45		45		45	
R^2	0.9995		0.9996		0.9989		0.9998		0.9988	
RMSE	0.0159		0.0159		0.0325		0.0102		0.0238	

Variable	Industry 11		Industry 12		Industry 13		Industry 14		Industry 15	
lnPI lagged	0.578784	***	0.589264	***	0.490253	***	0.415158	***	0.366284	*
t	0.104099	***	0.150799	**	0.170766	**	0.118691	***	0.162995	**
t^2	-0.002344	***	-0.003813	**	-0.00403	*	-0.003246	***	-0.003572	**
t^3	1.36E-05	*	3.23E-05		2.91E-05		3.85E-05	***	2.69E-05	
lnNAV lagged	53.76558	**	64.78499	**	78.07121	***	-16.1241		56.11393	**
$\ln NAV^2$ lagged	-2.290834	**	-2.760193	**	-3.32214	***	0.728191		-2.373395	**
lnHWY lagged	-50.09348	***	-54.0552	***	-72.2839	***	-7.673926		-63.44419	***
$\ln HWY^2$ lagged	1.811244	***	1.931763	***	2.596261	***	0.247717		2.276868	***
Constant	31.3973		-2.098719		44.47013		148.6349	**	110.677	
nobs	45		45		45		45		45	
R^2	0.9997		0.9989		0.9992		0.9996		0.9995	

[195] Legend: * p<.1; ** p<.05;*** p<.01

RMSE	0.0126		0.0248		0.0225		0.0138		0.0190	

Variable	Industry 16		Industry 17		Industry 18		Industry 19		Industry 20	
lnPI lagged	0.578382	***	0.836111	***	0.436219	***	0.685673	***	0.665384	***
t	0.214747	**	0.028497		0.169168	**	0.072515		0.089745	*
t^2	-0.005486	*	-8.66E-05		-0.00419	*	-0.00137		-0.001731	
t^3	4.12E-05		-1.13E-05		3.49E-05		3.17E-06		3.43E-06	
lnNAV lagged	108.5653	**	73.9565	***	97.90118	***	57.04895	***	60.84378	**
lnNAV^2 lagged	-4.638084	**	-3.170062	***	-4.16655	***	-2.436858	***	-2.618724	**
lnHWY lagged	-94.18629	***	-45.1749	***	-76.9766	***	-45.59947	***	-49.45718	***
lnHWY^2 lagged	3.388461	***	1.643525	***	2.761726	***	1.651813	***	1.798429	***
Constant	18.55331		-120.6446	**	-38.4305		-18.80999		-13.08756	
nobs	45		45		45		45		45	
R^2	0.9977		0.9996		0.9989		0.9996		0.9990	
RMSE	0.0411		0.0138		0.0248		0.0152		0.0230	

Variable	Industry 21		Industry 22		Industry 23		Industry 24		Industry 25	
lnPI lagged	0.652742	***	0.456935	**	0.560077	***	0.366669		0.224835	
t	0.093799	*	0.140197	*	0.04044		0.193955		0.177434	
t^2	-0.001988		-0.002985		-0.00038		-0.004604		-0.006059	
t^3	1.03E-05		1.87E-05		-3.24E-06		3.64E-05		8.69E-05	
lnNAV lagged	49.75205	**	71.65747	***	24.68602		51.67698		-137.3171	*
lnNAV^2 lagged	-2.130295	**	-3.050903	***	-1.0325		-2.197293		5.984516	*
lnHWY lagged	-40.76833	***	-63.6387	***	-33.191	*	-55.84734		30.07692	
lnHWY^2 lagged	1.471111	***	2.288985	***	1.210662	*	1.996419		-1.147778	
Constant	-7.742875		21.96928		81.02684		86.96868		592.0457	**
nobs	45		45		45		45		45	
R^2	0.9995		0.9992		0.9988		0.9932		0.9955	
RMSE	0.0169		0.0219		0.0303		0.0649		0.0528	

Variable	Industry 26		Industry 27		Industry 28		Industry 29		Industry 30	
lnPI lagged	0.657468	***	0.613126	***	0.838483	***	0.729008	***	0.490248	***
t	0.092228		0.081517		0.020244		0.036244		0.234279	**
t^2	-0.002026		-0.001713		3.64E-05		-0.000449		-0.005703	*
t^3	1.38E-05		9.12E-06		-1.2E-05		-3.15E-06		4.95E-05	
lnNAV lagged	50.13383	**	68.74092	***	62.44224	***	23.79847		50.53204	
lnNAV^2 lagged	-2.128592	**	-2.904858	***	-2.68121	***	-1.021602		-2.186676	
lnHWY lagged	-42.41366	***	-58.61422	***	-40.3596	***	-23.8047	*	-45.91343	**
lnHWY^2 lagged	1.521911	***	2.111059	***	1.477338	***	0.873595	*	1.621121	**
Constant	0.539311		0.775155		-87.515		24.11255		32.275	
nobs	45		45		45		45		45	
R^2	0.9995		0.9993		0.9994		0.9995		0.9990	
RMSE	0.0187		0.0205		0.0180		0.0199		0.0267	

Variable	Industry 31		Industry 32		Industry 33		Industry 34		Industry 35	
lnPl lagged	-0.016461		0.693296	***	0.30625	*	0.580515	***	0.71694	***
t	0.198181	***	0.068658	**	0.107785	***	0.057422	*	0.098407	*
t^2	-0.00501	**	-0.001211		-0.00152	*	-0.00098		-0.002118	
t^3	4.84E-05	**	3.61E-06		8.20E-06		6.66E-06		1.34E-05	
lnNAV lagged	5.368849		46.55818	***	44.61795	***	24.41791		4.752763	
$\ln NAV^2$ lagged	-0.123957		-1.994608	***	-1.873	***	-1.016471		-0.230111	
lnHWY lagged	-69.84257		-33.78279	***	-43.1518	***	-22.97559	**	-15.23714	
$\ln HWY^2$ lagged	2.517184		1.219001	***	1.53899	***	0.82213	**	0.554269	
Constant	440.0215	**	-37.28849		37.66478		14.74944		80.52445	
nobs	45		45		45		45		45	
R^2	0.9985		0.9998		0.9996		0.9996		0.9994	
RMSE	0.0374		0.0119		0.0188		0.0165		0.0247	

Table C6 Estimated Sector Infrastructure Productivity Equations for Materials: Model B[196]

Variable	Industry 1		Industry 2		Industry 3		Industry 4		Industry 5	
lnPm lagged	0.470781	***	0.601338	***	0.733905	***	0.694547	***	0.67679	***
t	0.135123	***	0.251037	***	0.07245	***	0.087272	***	0.103606	***
t^2	-0.00298	**	-0.006249	***	-0.00131	*	-0.001471	*	-0.001996	**
t^3	1.77E-05		4.72E-05	*	1.71E-06		1.66E-06		5.90E-06	
lnNAV lagged	19.39268		101.1067	*	50.24026	**	63.03301	**	61.02277	**
$\ln NAV^2$ lagged	-0.876824		-4.389446	*	-2.16453	**	-2.713355	**	-2.633294	**
lnHWY lagged	-25.54421		-65.33402	**	-33.9584	***	-42.83608	***	-41.34318	***
$\ln HWY^2$ lagged	0.92826		2.334015	*	1.225332	***	1.544658	***	1.487525	***
Constant	69.5025		-125.9811		-55.9858		-68.96225		-66.11816	
nobs	45		45		45		45		45	
R^2	0.9967		0.9954		0.9990		0.9993		0.9985	
RMSE	0.0310		0.0396		0.0162		0.0183		0.0202	

Variable	Industry 6		Industry 7		Industry 8		Industry 9		Industry 10	
lnPm lagged	0.727744	***	0.484953	***	0.630105	***	0.629522	***	0.561344	***
t	0.089015	***	0.137501	***	0.065627	*	0.13465	***	0.106827	***
t^2	-0.001936	***	-0.003034	**	-0.00084		-0.002992	***	-0.002194	***
t^3	1.07E-05		1.75E-05		-2.57E-06		1.93E-05	*	1.28E-05	
lnNAV lagged	31.50885		24.12069		41.03598		40.99184		30.55376	
$\ln NAV^2$ lagged	-1.370412		-1.080345		-1.77615		-1.79173		-1.327465	
lnHWY lagged	-24.90532	**	-28.34787		-31.7818	*	-30.34274		-24.98128	
$\ln HWY^2$ lagged	0.897112	**	1.030129		1.155081	*	1.084601		0.890762	
Constant	-8.106113		61.26128		-17.8191		-22.17598		-0.126499	

196 Legend: * p<.1; ** p<.05;*** p<.01

nobs	45		45		45		45		45	
R^2	0.9994		0.9969		0.9988		0.9981		0.9986	
RMSE	0.0151		0.0304		0.0256		0.0241		0.0184	

Variable	Industry 11		Industry 12		Industry 13		Industry 14		Industry 15	
lnPm lagged	0.596695	***	0.654823	***	0.500432	***	0.481406	***	0.594483	***
t	0.086674	**	0.112095	***	0.158244	***	0.135046	***	0.171804	***
t^2	-0.001459		-0.002421	***	-0.00293	***	-0.00228	***	-0.003468	***
t^3	2.40E-06		1.44E-05		1.04E-05		6.15E-06		1.65E-05	
lnNAV lagged	22.95141		34.11657		84.88736	***	76.27951	***	94.45744	*
$\ln NAV^2$ lagged	-1.026951		-1.490479		-3.66774	***	-3.281784	***	-4.083546	*
lnHWY lagged	-18.41985		-26.59382	*	-57.5869	***	-53.45807	***	-61.77607	**
$\ln HWY^2$ lagged	0.674252		0.95506	*	2.06663	***	1.916284	***	2.2151	**
Constant	-1.628819		-9.912803		-89.9386		-70.15308		-115.9178	
nobs	45		45		45		45		45	
R^2	0.9978		0.9991		0.9983		0.9991		0.9981	
RMSE	0.0288		0.0182		0.0261		0.0208		0.0294	

Variable	Industry 16		Industry 17		Industry 18		Industry 19		Industry 20	
lnPm lagged	0.703599	***	0.609728	***	0.576679	***	0.654237	***	0.55644	***
t	0.083986	**	0.160204	***	0.129761	***	0.116407	***	0.217411	***
t^2	-0.001563	*	-0.003289	***	-0.00247	***	-0.002264	**	-0.005317	***
t^3	4.25E-06		1.62E-05		1.01E-05		7.79E-06		4.01E-05	**
lnNAV lagged	60.81409	**	84.75866	*	59.80043	*	74.5647	**	66.05409	
$\ln NAV^2$ lagged	-2.615291	**	-3.66459	**	-2.59008	*	-3.212387	**	-2.869558	
lnHWY lagged	-42.22793	***	-56.793	**	-41.1536	**	-52.32441	***	-50.80965	*
$\ln HWY^2$ lagged	1.52324	***	2.036896	**	1.475947	**	1.885185	***	1.81262	*
Constant	-60.67601		-94.51237		-58.1409		-69.58867		-24.5953	
nobs	45		45		45		45		45	
R^2	0.9992		0.9980		0.9991		0.9991		0.9971	
RMSE	0.0177		0.0279		0.0182		0.0195		0.0331	

Variable	Industry 21		Industry 22		Industry 23		Industry 24		Industry 25	
lnPm lagged	0.509136	**	0.726243	***	0.734062	***	0.67866	***	0.754654	***
t	0.218568	***	0.128648	***	0.127411	***	0.108629	***	0.090268	**
t^2	-0.005213	***	-0.003228	***	-0.00329	***	-0.002294	***	-0.002046	**
t^3	3.83E-05	**	2.34E-05	*	2.64E-05	**	1.14E-05		1.12E-05	
lnNAV lagged	64.80699		34.02487		24.37558		52.13637	**	45.14691	**
$\ln NAV^2$ lagged	-2.814047		-1.483114		-1.06485		-2.249732	**	-1.944572	**
lnHWY lagged	-51.51766	**	-26.85475		-22.7582		-38.15954	***	-34.79458	***
$\ln HWY^2$ lagged	1.837757	**	0.957766		0.807372		1.370663	***	1.253322	***
Constant	-12.49887		-7.03432		20.67901		-36.38315		-20.51895	
nobs	45		45		45		45		45	

R^2	0.9972		0.9970		0.9978		0.9990		0.9990	
RMSE	0.0330		0.0245		0.0230		0.0181		0.0181	

Variable	Industry 26		Industry 27		Industry 28		Industry 29		Industry 30	
lnPm lagged	0.722758	***	0.622616	***	0.732456	***	0.739204	***	0.735301	***
t	0.114122	***	0.145151	***	0.062216	*	0.050723	*	0.059847	**
t^2	-0.00276	***	-0.003136	***	-0.00087		-0.001014		-0.000997	
t^3	1.97E-05	*	1.85E-05	*	-3.73E-06		5.80E-06		1.37E-07	
lnNAV lagged	33.45039		57.3176	*	61.90496	**	11.67377		44.3634	**
lnNAV^2 lagged	-1.44927		-2.484938	*	-2.65901	**	-0.495845		-1.905964	**
lnHWY lagged	-27.46458	*	-40.57625	**	-41.292	***	-14.74914		-32.87309	***
lnHWY^2 lagged	0.979847	*	1.452384	**	1.493445	***	0.526695		1.189557	***
Constant	-0.644987		-47.24394		-74.6012		34.96904		-30.7087	
nobs	45		45		45		45		45	
R^2	0.9986		0.9988		0.9993		0.9997		0.9996	
RMSE	0.0195		0.0218		0.0171		0.0107		0.0124	

Variable	Industry 31		Industry 32		Industry 33		Industry 34		Industry 35	
lnPm lagged	0.75304	***	0.727773	***	0.77903	***	0.766968	***	0.736193	***
t	0.06009	**	0.055534	***	0.037909	**	0.053479	**	0.064344	**
t^2	-0.001118	*	-0.000968	**	-0.00055		-0.000928	*	-0.001102	
t^3	3.15E-06		2.42E-06		-5.59E-07		1.92E-06		7.74E-07	
lnNAV lagged	34.0133	**	25.80556	*	26.22081	***	31.66149	**	49.20453	**
lnNAV^2 lagged	-1.464436	**	-1.111348	*	-1.11996	***	-1.359622	**	-2.114483	**
lnHWY lagged	-26.11719	***	-21.76741	***	-21.0947	***	-24.2856	***	-36.09613	***
lnHWY^2 lagged	0.943922	***	0.786357	***	0.761813	***	0.875993	***	1.30659	***
Constant	-16.55817		1.240401		-7.06875		-15.73555		-36.67791	
nobs	45		45		45		45		45	
R^2	0.9997		0.9998		0.9999		0.9998		0.9996	
RMSE	0.0113		0.0099		0.0064		0.0092		0.0140	

Table C7 Estimated Sector Infrastructure Productivity Equations for Energy: Model B[197]

Variable	Industry 1		Industry 2		Industry 3		Industry 4		Industry 5	
lnPe lagged	0.643841	***	0.72406	***	0.470236	*	0.657166	***	0.703084	***
t	0.366879	**	0.245508	**	0.454596	*	0.437144	**	0.290103	**
t^2	-0.009266	**	-0.006376	**	-0.01293	**	-0.010622	*	-0.00758	**
t^3	6.5E-05		4.88E-05		0.000112	*	6.25E-05		5.74E-05	
lnNAV lagged	194.7162	*	93.44715		17.02829		261.3049	*	121.5076	
lnNAV^2 lagged	-8.406273	*	-4.050038		-0.84827		-11.2878	*	-5.259744	
lnHWY lagged	-141.4777	**	-76.11394	*	-64.9862		-188.9849	**	-96.50711	**

[197] Legend: * p<.1; ** p<.05;*** p<.01

lnHWY² lagged	5.08981	**	2.735982	*	2.342277		6.821292	**	3.47201	**
Constant	-146.7806		-11.03803		365.4618		-206.3985		-32.84572	
nobs	45		45		45		45		45	
R^2	0.9910		0.9963		0.9912		0.9868		0.9948	
RMSE	0.0832		0.0507		0.0701		0.1225		0.0620	

Variable	Industry 6		Industry 7		Industry 8		Industry 9		Industry 10	
lnPe lagged	0.596776	***	0.775519	***	0.665954	***	0.788888	***	0.79108	***
t	0.455537	**	0.204771	**	0.2997	**	0.176721	**	0.181856	**
t^2	-0.011336	**	-0.005332	*	-0.00796	**	-0.004617	*	-0.004709	*
t^3	7.38E-05		3.92E-05		6.28E-05		3.44E-05		3.44E-05	
lnNAV lagged	281.6106	*	80.58601		96.39157		60.03315		67.80539	
lnNAV² lagged	-12.14553	*	-3.497434		-4.18645		-2.611761		-2.946228	
lnHWY lagged	-198.3685	**	-67.58821	*	-85.6591	*	-53.94884	*	-58.27111	*
lnHWY² lagged	7.146602	**	2.438461	*	3.080032	*	1.946991	*	2.103061	*
Constant	-258.9109		3.047245		39.11084		27.88307		12.58863	
nobs	45		45		45		45		45	
R^2	0.9847		0.9971		0.9950		0.9978		0.9976	
RMSE	0.1121		0.0458		0.0588		0.0394		0.0413	

Variable	Industry 11		Industry 12		Industry 13		Industry 14		Industry 15	
lnPe lagged	0.713078	***	0.717684	***	0.760141	***	0.757504	***	0.730412	***
t	0.271886	**	0.265958	**	0.206998	**	0.219635	**	0.265922	**
t^2	-0.006884	**	-0.006902	**	-0.00546	*	-0.00564	**	-0.006639	*
t^3	4.91E-05		5.2E-05		4.15E-05		4.14E-05		4.31E-05	
lnNAV lagged	124.8656		111.2998		67.32737		87.20084		135.0301	
lnNAV² lagged	-5.40414		-4.818038		-2.93		-3.781904		-5.846386	
lnHWY lagged	-94.88533	**	-87.99092	**	-61.4665	*	-70.82738	*	-102.732	**
lnHWY² lagged	3.41496	**	3.164757	**	2.217269	*	2.550519	*	3.70939	**
Constant	-63.7872		-32.71483		38.18812		-12.16368		-69.94807	
nobs	45		45		45		45		45	
R^2	0.9954		0.9955		0.9971		0.9969		0.9943	
RMSE	0.0589		0.0567		0.0453		0.0478		0.0669	

Variable	Industry 16		Industry 17		Industry 18		Industry 19		Industry 20	
lnPe lagged	0.662193	***	0.796693	***	0.744816	***	0.767285	***	0.739301	***
t	0.432371	**	0.168264	*	0.227377	**	0.204907	**	0.192634	*
t^2	-0.010733	*	-0.004324	*	-0.006	**	-0.005478	*	-0.005152	*
t^3	6.72E-05		3.11E-05		4.72E-05		4.22E-05		4.05E-05	
lnNAV lagged	250.1855	*	59.51017		82.8518		61.91694		38.34919	
lnNAV² lagged	-10.81023	*	-2.588912		-3.5907		-2.699464		-1.686522	
lnHWY lagged	-181.3591	**	-52.60182	*	-69.284	*	-59.71009	*	-47.01987	
lnHWY² lagged	6.543935	**	1.899252	*	2.490182	*	2.156674	*	1.698334	

Constant	-193.9997		21.41593		2.734583		57.25324		106.7209	
nobs	45		45		45		45		45	
R^2	0.9862		0.9981		0.9967		0.9972		0.9976	
RMSE	0.1189		0.0373		0.0471		0.0453		0.0405	

Variable	Industry 21		Industry 22		Industry 23		Industry 24		Industry 25	
lnPe lagged	0.79728	***	0.777808	***	0.78066	***	0.769561	***	0.754726	***
t	0.176443	**	0.194815	**	0.185637	**	0.201541	**	0.213676	**
t^2	-0.00452	*	-0.005032	*	-0.00474	*	-0.00518	*	-0.005517	**
t^3	3.19E-05		3.71E-05		3.4E-05		3.77E-05		4.12E-05	
lnNAV lagged	68.95806		73.19195		71.57428		75.18791		80.29806	
$\ln NAV^2$ lagged	-2.996571		-3.178051		-3.10852		-3.266383		-3.484462	
lnHWY lagged	-58.31231	*	-61.71844	*	-60.0027	*	-63.54464	*	-66.68601	*
$\ln HWY^2$ lagged	2.10631	*	2.224706	*	2.16442	*	2.291126	*	2.400859	*
Constant	5.96925		5.614501		2.90459		6.863853		-0.688725	
nobs	45		45		45		45		45	
R^2	0.9978		0.9975		0.9976		0.9974		0.9971	
RMSE	0.0402		0.0423		0.0412		0.0434		0.0453	

Variable	Industry 26		Industry 27		Industry 28		Industry 29		Industry 30	
lnPe lagged	0.760382	***	0.721942	***	0.602231	***	0.745318	***	0.65218	***
t	0.198894	**	0.264096	**	0.448658	**	0.210706	**	0.323053	**
t^2	-0.00522	**	-0.006811	**	-0.01115	**	-0.005402	**	-0.008614	*
t^3	4.04E-05		5.04E-05		7.23E-05		4.02E-05		6.41E-05	
lnNAV lagged	60.83229		116.7921		277.6302	*	80.94321		92.14584	
$\ln NAV^2$ lagged	-2.647055		-5.053174		-11.9772	*	-3.509075		-4.025126	
lnHWY lagged	-55.99338	*	-90.69546	**	-195.219	**	-66.30615	*	-91.77447	*
$\ln HWY^2$ lagged	2.015715	*	3.263192	**	7.034842	**	2.385294	*	3.31783	*
Constant	38.36208		-46.21373		-257.507		-7.091908		105.7165	
nobs	45		45		45		45		45	
R^2	0.9976		0.9954		0.9848		0.9970		0.9928	
RMSE	0.0407		0.0577		0.1114		0.0449		0.0726	

Variable	Industry 31		Industry 32		Industry 33		Industry 34		Industry 35	
lnPe lagged	0.712795	***	0.742427	***	0.789798	***	0.735335	***	0.729296	***
t	0.343375	**	0.229617	**	0.164233	*	0.247134	**	0.263809	**
t^2	-0.008538	*	-0.00583	**	-0.00416	*	-0.006313	**	-0.006713	**
t^3	5.31E-05		4.22E-05		2.95E-05		4.64E-05		4.77E-05	
lnNAV lagged	195.7711	*	94.46719		59.34079		101.9332		125.7774	
$\ln NAV^2$ lagged	-8.463333	*	-4.094984		-2.57923		-4.41563		-5.441472	
lnHWY lagged	-143.9404	**	-74.99758	*	-51.8214		-80.73286	*	-95.3903	**
$\ln HWY^2$ lagged	5.197424	**	2.699465	*	1.869879		2.903935	*	3.435311	**
Constant	-137.8204		-25.20218		16.94709		-28.60881		-66.2118	

nobs	45		45		45		45		45	
R^2	0.9902		0.9968		0.9981		0.9966		0.9953	
RMSE	0.0946		0.0489		0.0368		0.0515		0.0588	

Both the "hill" and "bowl" relationships between transportation capital stock and resource prices imply an "optimal" transportation capital stock level (**CS*** and **CS**** in Figures C2 and C3). In the case of a "hill" relationship, capital stock values less than **CS*** means that the capital stock is not large enough to keep up with the demand for transportation infrastructure (hence, "congestion" and rising resource prices). Increasing the capital stock beyond **CS*** will reduce congestion and lower resource prices. On the other hand, a "bowl" relationship implies that capital stock values less that **CS**** means that the capital stock is greater than the demand for transportation infrastructure (hence "no congestion and lowering resource prices). Increasing the capital stock beyond **CS**** will tend to "crowd" the transportation system with too much infrastructure, increasing congestion and raising resource prices. It should be noted that both the "hill" and "bowl" relationships between transportation capital stock and resource prices have sections that imply a negative relationship between capital stock and resource prices and sections that imply a positive relationship between capital stock and resource prices—just depends on whether the existing capital stock value is greater or less than the optimal capital stock values (**CS* or CS****).

Table C8 Optimum Navigation and Highway Capital Stock and Dates[198]

	Optimum Capital Stock*		Optimum Year	
Resource Price	**Navigation**	**Highway**	**Navigation**	**Highway**
Labor	$122,314	$1,201,018	1977	1990
Materials	$103,213	$1,095,356	1967	1982
Energy	$99,109	$1,059,978	1966	1978

Table C8 shows the optimum navigation and highway capital stock values and dates for labor, materials, and energy resources.[199] In terms of labor prices the optimal navigation capital stock occurred in 1977 and the optimal highway capital stock happened during 1990. For materials, the optimum capital stocks were during 1967 (navigation) and 1982 (highway). For energy, the optimum capital stocks were during 1966 (navigation) and 1978 (highway). For all resource prices, the approximate optimum navigation capital stocks occur during 1970 and approximate optimal highway capital stock happened in the early 1980s. Figure C4 shows the

[198] *Thousands of 2011 dollars.

[199] The optimum capital stock values are the industrial averages for each of the resource types. The dates were determined by comparing the optimum capital stock values with the actual capital stock values.

levels and approximate optimum dates on line graphs of highway and navigation capital stock values.

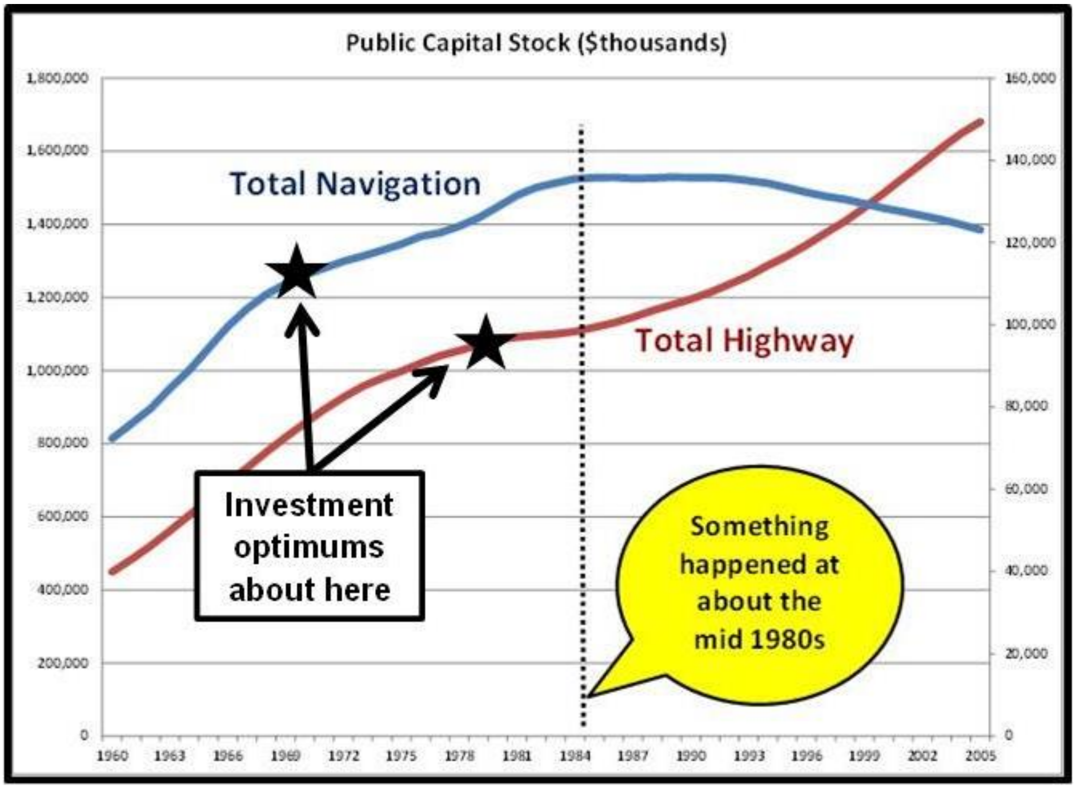

Figure C4 Optimal Highway and Navigation Capital Stock Values and Dates

There is another interpretation of these results, even though the analysis above appears to point to an underinvestment in navigation infrastructure and an overinvestment in highways. Thinking from the point of view of "system-wide" transportation planning, analysis could be pointing toward an overuse of highways for freight traffic and an underutilization of waterways. Implied is that freight traffic might be better served if more of the commodity traffic were to be shifted to rail or barge from highways where it is more efficiently transported (where this is possible). Also implied, Congressional policies to increase highway investment and reduce navigation investment have the compounded effect of increasing business costs due to transport inefficiencies.

APPENDIX D: DETAILED MKARNS WATERBORNE COMMERCE GROWTH POTENTIAL TABLES

Table D1 Industries within an Approximate 25 Mile Radius of the Ports of Catoosa and Muskogee[200]

NAICS	Description	2013 Establishments	Employment 2008	2009	2010	2011	2012	2013	2014	2008 - 2014 Change	2008 - 2014 % Change
2111	Oil and Gas Extraction	288	11,603	11,209	13,077	11,561	11,691	11,379	11,795	192	1.7%
2123	Nonmetallic Mineral Mining and Quarrying	15	414	347	414	483	388	455	453	39	9.4%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	5	200	253	287	300	368	446	523	323	161.5%
3273	Cement and Concrete Product Manufacturing	35	672	737	790	785	812	877	983	311	46.3%
3312	Steel Product Manufacturing from Purchased Steel	7	264	157	149	557	642	618	703	439	166.3%
3324	Boiler, Tank, and Shipping Container Manufacturing	44	3,109	2,793	3,085	3,425	3,917	4,005	4,228	1,119	36.0%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	192	2,291	1,862	1,838	2,210	2,632	2,849	2,994	703	30.7%
3328	Coating, Engraving, Heat Treating, and Allied Activities	47	1,002	846	859	901	1,006	1,088	1,091	89	8.9%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	65	2,524	2,024	2,000	2,383	3,049	3,183	3,439	915	36.3%
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	18	2,375	2,309	2,020	2,177	2,131	2,371	2,410	35	1.5%
3339	Other General Purpose Machinery Manufacturing	69	5,430	5,035	4,268	4,664	5,291	5,388	5,475	45	0.8%

[200] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D2 Location Quotients for Industries within an Approximate 25 Mile Radius of the Ports of Catoosa and Muskogee[201]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	6.25	5.98	5.84	6.01	5.81	5.63	5.56
2123	Nonmetallic Mineral Mining and Quarrying	1.01	0.95	1.11	1.33	1.04	1.21	1.20
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	1.59	2.04	2.41	2.48	2.98	3.56	4.13
3273	Cement and Concrete Product Manufacturing	0.92	1.20	1.41	1.44	1.49	1.58	1.71
3312	Steel Product Manufacturing from Purchased Steel	1.32	0.93	0.87	3.04	3.36	3.28	3.65
3324	Boiler, Tank, and Shipping Container Manufacturing	9.84	9.82	11.23	11.98	12.81	13.11	13.55
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	1.83	1.72	1.71	1.87	2.11	2.26	2.31
3328	Coating, Engraving, Heat Treating, and Allied Activities	2.08	2.08	2.13	2.10	2.24	2.42	2.37
3331	Agriculture, Construction, and Mining Machinery Manufacturing	3.23	2.92	2.97	3.23	3.78	3.92	4.16
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	4.85	5.38	4.88	5.17	5.17	5.72	5.79
3339	Other General Purpose Machinery Manufacturing	5.92	6.32	5.64	5.85	6.31	6.35	6.33

[201] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D3 Export Percentages for Industries within an Approximate 25 Mile Radius of the Ports of Catoosa and Muskogee[202]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	84.0%	83.3%	82.9%	83.4%	82.8%	82.2%	82.0%
2123	Nonmetallic Mineral Mining and Quarrying	1.0%	-5.6%	10.2%	24.8%	3.9%	17.6%	16.9%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	37.1%	51.0%	58.5%	59.7%	66.4%	71.9%	75.8%
3273	Cement and Concrete Product Manufacturing	-8.3%	16.9%	29.0%	30.7%	32.9%	36.8%	41.6%
3312	Steel Product Manufacturing from Purchased Steel	24.2%	-7.5%	-15.5%	67.1%	70.2%	69.6%	72.6%
3324	Boiler, Tank, and Shipping Container Manufacturing	89.8%	89.8%	91.1%	91.7%	92.2%	92.4%	92.6%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	45.2%	42.0%	41.4%	46.5%	52.5%	55.7%	56.8%
3328	Coating, Engraving, Heat Treating, and Allied Activities	51.9%	51.9%	53.0%	52.3%	55.4%	58.7%	57.9%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	69.1%	65.8%	66.3%	69.0%	73.5%	74.5%	75.9%
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	79.4%	81.4%	79.5%	80.7%	80.6%	82.5%	82.7%
3339	Other General Purpose Machinery Manufacturing	83.1%	84.2%	82.3%	82.9%	84.1%	84.2%	84.2%

[202] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D4 Industries within an Approximate 25 to 50 Mile Radius of the Ports of Catoosa and Muskogee[203]

NAICS	Description	2013 Establishments	Employment 2008	2009	2010	2011	2012	2013	2014	2008 - 2014 Change	2008 - 2014 % Change
2111	Oil and Gas Extraction	141	8,082	8,342	9,741	9,029	9,172	9,222	9,354	1,272	15.7%
2123	Nonmetallic Mineral Mining and Quarrying	16	256	276	286	265	284	276	267	11	4.3%
3312	Steel Product Manufacturing from Purchased Steel	5	459	193	258	660	659	680	792	333	72.5%
3315	Foundries	6	186	173	175	177	185	197	208	22	11.8%
3324	Boiler, Tank, and Shipping Container Manufacturing	11	494	868	390	500	553	519	518	24	4.9%
3326	Spring and Wire Product Manufacturing	2	115	21	43	61	52	125	127	12	10.4%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	49	633	627	613	720	788	709	749	116	18.3%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	17	506	426	443	632	734	835	903	397	78.5%
3339	Other General Purpose Machinery Manufacturing	17	564	580	678	696	735	746	771	207	36.7%

[203] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D5 Location Quotients for Industries within an Approximate 25 to 50 Mile Radius of the Ports of Catoosa and Muskogee[204]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	16.00	16.16	15.89	17.03	16.75	16.69	16.16
2123	Nonmetallic Mineral Mining and Quarrying	2.29	2.73	2.81	2.64	2.80	2.70	2.60
3312	Steel Product Manufacturing from Purchased Steel	8.43	4.15	5.46	13.06	12.68	13.22	15.06
3315	Foundries	1.40	1.65	1.73	1.61	1.63	1.78	1.88
3324	Boiler, Tank, and Shipping Container Manufacturing	5.75	11.07	5.18	6.34	6.65	6.22	6.08
3326	Spring and Wire Product Manufacturing	2.46	0.52	1.12	1.64	1.41	3.34	3.47
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	1.85	2.11	2.08	2.21	2.32	2.05	2.12
3331	Agriculture, Construction, and Mining Machinery Manufacturing	2.38	2.23	2.40	3.10	3.35	3.76	4.00
3339	Other General Purpose Machinery Manufacturing	2.26	2.64	3.27	3.16	3.22	3.22	3.26

[204] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D6 Export Percentages for Industries within an Approximate 25 to 50 Mile Radius of the Ports of Catoosa and Muskogee[205]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	93.7%	93.8%	93.7%	94.1%	94.0%	94.0%	93.8%
2123	Nonmetallic Mineral Mining and Quarrying	56.4%	63.3%	64.5%	62.2%	64.3%	63.0%	61.5%
3312	Steel Product Manufacturing from Purchased Steel	88.1%	75.9%	81.7%	92.3%	92.1%	92.4%	93.4%
3315	Foundries	28.8%	39.4%	42.2%	38.0%	38.6%	43.7%	46.9%
3324	Boiler, Tank, and Shipping Container Manufacturing	82.6%	91.0%	80.7%	84.2%	85.0%	83.9%	83.5%
3326	Spring and Wire Product Manufacturing	59.4%	-90.7%	10.7%	39.1%	28.9%	70.0%	71.2%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	46.1%	52.6%	51.8%	54.8%	56.8%	51.3%	52.8%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	58.0%	55.2%	58.4%	67.8%	70.1%	73.4%	75.0%
3339	Other General Purpose Machinery Manufacturing	55.7%	62.1%	69.4%	68.4%	68.9%	68.9%	69.4%

[205] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D7 Industries within an Approximate 50 to 75 Mile Radius of the Ports of Catoosa and Muskogee[206]

NAICS	Description	2013 Establishments	Employment 2008	2009	2010	2011	2012	2013	2014	2008 - 2014 Change	2008 - 2014 % Change
3111	Animal Food Manufacturing	27	902	1,027	1,176	1,287	1,424	1,288	1,325	423	46.9%
3241	Petroleum and Coal Products Manufacturing	11	348	492	481	443	445	451	458	110	31.6%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	4	202	221	199	231	232	234	233	31	15.3%
3262	Rubber Product Manufacturing	11	476	525	470	536	683	662	684	208	43.7%
3279	Other Nonmetallic Mineral Product Manufacturing	16	385	357	355	371	354	411	444	59	15.3%
3315	Foundries	6	581	493	497	623	1,375	1,441	1,563	982	169.0%
3324	Boiler, Tank, and Shipping Container Manufacturing	11	715	764	718	934	1,140	1,081	1,145	430	60.1%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	35	940	1,045	1,034	1,100	1,087	1,037	1,049	109	11.6%

[206] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D8 Location Quotients for Industries within an Approximate 50 to 75 Mile Radius of the Ports of Catoosa and Muskogee[207]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
3111	Animal Food Manufacturing	5.46	6.18	7.09	7.76	8.54	7.61	7.89
3241	Petroleum and Coal Products Manufacturing	0.95	1.36	1.37	1.24	1.29	1.31	1.31
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	1.67	1.85	1.73	1.97	1.96	1.96	1.94
3262	Rubber Product Manufacturing	1.04	1.35	1.23	1.36	1.72	1.67	1.74
3279	Other Nonmetallic Mineral Product Manufacturing	1.55	1.64	1.63	1.65	1.55	1.76	1.79
3315	Foundries	1.24	1.35	1.39	1.63	3.44	3.72	4.06
3324	Boiler, Tank, and Shipping Container Manufacturing	2.36	2.80	2.71	3.39	3.90	3.71	3.87
3331	Agriculture, Construction, and Mining Machinery Manufacturing	1.26	1.57	1.59	1.54	1.41	1.34	1.34

[207] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D9 Export Percentages for Industries within an Approximate 50 to 75 Mile Radius of the Ports of Catoosa and Muskogee[208]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
3111	Animal Food Manufacturing	81.7%	83.8%	85.9%	87.1%	88.3%	86.9%	87.3%
3241	Petroleum and Coal Products Manufacturing	-5.4%	26.3%	27.0%	19.1%	22.4%	23.6%	23.5%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	40.2%	46.1%	42.3%	49.3%	48.9%	49.0%	48.5%
3262	Rubber Product Manufacturing	3.5%	26.0%	18.6%	26.5%	41.7%	40.2%	42.6%
3279	Other Nonmetallic Mineral Product Manufacturing	35.4%	39.1%	38.8%	39.5%	35.6%	43.1%	44.1%
3315	Foundries	19.7%	26.2%	28.2%	38.6%	70.9%	73.1%	75.4%
3324	Boiler, Tank, and Shipping Container Manufacturing	57.6%	64.3%	63.1%	70.5%	74.4%	73.1%	74.1%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	20.4%	36.4%	37.2%	35.2%	29.1%	25.3%	25.1%

[208] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D10 Industries within an Approximate 75 to 100 Mile Radius of the Ports of Catoosa and Muskogee[209]

NAICS	Description	2013 Establishments	Employment 2008	2009	2010	2011	2012	2013	2014	2008 - 2014 Change	2008 - 2014 % Change
2111	Oil and Gas Extraction	141	8,082	8,342	9,741	9,029	9,172	9,222	9,354	1,272	15.7%
2123	Nonmetallic Mineral Mining and Quarrying	16	256	276	286	265	284	276	267	11	4.3%
3312	Steel Product Manufacturing from Purchased Steel	5	459	193	258	660	659	680	792	333	72.5%
3315	Foundries	6	186	173	175	177	185	197	208	22	11.8%
3324	Boiler, Tank, and Shipping Container Manufacturing	11	494	868	390	500	553	519	518	24	4.9%
3326	Spring and Wire Product Manufacturing	2	115	21	43	61	52	125	127	12	10.4%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	49	633	627	613	720	788	709	749	116	18.3%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	17	506	426	443	632	734	835	903	397	78.5%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	76	3,923	3,291	3,080	3,624	4,079	4,075	4,150	227	5.8%
3339	Other General Purpose Machinery Manufacturing	43	3,254	2,638	2,498	2,775	3,221	3,248	3,281	27	0.8%

[209] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D11 Location Quotients for Industries within an Approximate 75 to 100 Mile Radius of the Ports of Catoosa and Muskogee[210]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	8.36	8.26	7.86	8.15	8.37	8.35	7.99
3111	Animal Food Manufacturing	5.45	5.13	5.72	5.63	5.34	5.22	5.24
3241	Petroleum and Coal Products Manufacturing	1.05	1.44	1.54	1.56	1.36	1.19	1.16
3271	Clay Product and Refractory Manufacturing	0.95	1.01	1.11	0.94	1.79	1.93	2.02
3312	Steel Product Manufacturing from Purchased Steel	0.62	0.68	0.33	1.99	1.59	1.67	1.95
3314	Nonferrous Metal (except Aluminum) Production and Processing	1.19	1.15	1.22	1.33	1.48	1.47	1.51
3324	Boiler, Tank, and Shipping Container Manufacturing	1.83	2.15	1.78	2.17	2.11	1.93	1.82
3329	Other Fabricated Metal Product Manufacturing	1.55	1.87	1.84	1.97	2.24	2.13	2.03
3331	Agriculture, Construction, and Mining Machinery Manufacturing	3.52	3.31	3.16	3.36	3.47	3.44	3.44
3339	Other General Purpose Machinery Manufacturing	2.48	2.31	2.28	2.38	2.64	2.63	2.60

[210] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D12 Export Percentages for Industries within an Approximate 75 to 100 Mile Radius of the Ports of Catoosa and Muskogee[211]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	88.0%	87.9%	87.3%	87.7%	88.0%	88.0%	87.5%
3111	Animal Food Manufacturing	81.6%	80.5%	82.5%	82.2%	81.3%	80.9%	80.9%
3241	Petroleum and Coal Products Manufacturing	5.0%	30.6%	35.2%	35.8%	26.3%	16.1%	14.1%
3271	Clay Product and Refractory Manufacturing	-4.7%	1.4%	10.3%	-6.8%	44.3%	48.1%	50.5%
3312	Steel Product Manufacturing from Purchased Steel	-61.7%	-46.7%	-204.5%	49.8%	37.2%	40.3%	48.8%
3314	Nonferrous Metal (except Aluminum) Production and Processing	16.3%	13.3%	17.9%	24.7%	32.6%	32.0%	33.8%
3324	Boiler, Tank, and Shipping Container Manufacturing	45.4%	53.5%	43.8%	53.9%	52.6%	48.3%	45.1%
3329	Other Fabricated Metal Product Manufacturing	35.4%	46.7%	45.6%	49.2%	55.4%	52.9%	50.7%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	71.6%	69.8%	68.4%	70.2%	71.2%	70.9%	70.9%
3339	Other General Purpose Machinery Manufacturing	59.7%	56.6%	56.2%	58.0%	62.1%	61.9%	61.5%

[211] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D13 Industries within an Approximate 100 Mile Radius of the Ports of Catoosa and Muskogee[212]

NAICS	Description	2013 Establishments	Employment 2008	2009	2010	2011	2012	2013	2014	2008 - 2014 Change	2008 - 2014 % Change
2111	Oil and Gas Extraction	141	8,082	8,342	9,741	9,029	9,172	9,222	9,354	1,272	15.7%
3111	Animal Food Manufacturing	60	2,650	2,637	2,988	3,056	3,014	2,830	2,868	218	8.2%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	12	546	598	549	651	698	820	908	362	66.3%
3271	Clay Product and Refractory Manufacturing	27	1,515	1,420	1,416	1,404	1,448	1,502	1,599	85	5.6%
3312	Steel Product Manufacturing from Purchased Steel	22	1,200	716	674	1,877	1,907	1,908	2,196	996	83.0%
3315	Foundries	31	1,895	1,532	1,496	1,761	2,610	2,658	2,860	965	50.9%
3324	Boiler, Tank, and Shipping Container Manufacturing	82	5,145	5,304	4,900	5,764	6,550	6,466	6,721	1,575	30.6%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	452	5,796	4,783	4,688	5,203	5,821	6,251	6,468	672	11.6%
3328	Coating, Engraving, Heat Treating, and Allied Activities	111	1,986	1,605	1,725	1,750	1,980	2,075	2,053	67	3.4%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	193	7,892	6,786	6,557	7,740	8,949	9,130	9,541	1,648	20.9%
3339	Other General Purpose Machinery Manufacturing	152	9,888	8,813	8,052	8,822	9,987	10,085	10,254	366	3.7%

[212] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D14 Location Quotients for Industries within an Approximate 100 Mile Radius of the Ports of Catoosa and Muskogee[213]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	7.05	6.94	6.75	6.98	6.91	6.83	6.63
3111	Animal Food Manufacturing	4.20	4.15	4.72	4.80	4.69	4.33	4.40
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	1.19	1.31	1.25	1.45	1.53	1.78	1.95
3271	Clay Product and Refractory Manufacturing	2.23	2.48	2.52	2.35	2.46	2.55	2.68
3312	Steel Product Manufacturing from Purchased Steel	1.64	1.16	1.06	2.77	2.71	2.75	3.10
3315	Foundries	1.06	1.10	1.10	1.20	1.69	1.78	1.92
3324	Boiler, Tank, and Shipping Container Manufacturing	4.45	5.08	4.84	5.45	5.81	5.74	5.85
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	1.26	1.21	1.18	1.19	1.26	1.34	1.36
3328	Coating, Engraving, Heat Treating, and Allied Activities	1.13	1.08	1.16	1.10	1.20	1.25	1.21
3331	Agriculture, Construction, and Mining Machinery Manufacturing	2.76	2.67	2.64	2.83	3.01	3.05	3.13
3339	Other General Purpose Machinery Manufacturing	2.95	3.01	2.89	2.99	3.23	3.23	3.22

[213] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

Table D15 Export Percentages for Industries within an Approximate 100 Mile Radius of the Ports of Catoosa and Muskogee[214]

NAICS	Description	2008	2009	2010	2011	2012	2013	2014
2111	Oil and Gas Extraction	85.8%	85.6%	85.2%	85.7%	85.5%	85.4%	84.9%
3111	Animal Food Manufacturing	76.2%	75.9%	78.8%	79.2%	78.7%	76.9%	77.3%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	15.8%	23.9%	20.1%	31.1%	34.8%	43.8%	48.8%
3271	Clay Product and Refractory Manufacturing	55.2%	59.7%	60.3%	57.4%	59.4%	60.8%	62.6%
3312	Steel Product Manufacturing from Purchased Steel	38.9%	13.5%	5.7%	63.8%	63.1%	63.7%	67.7%
3315	Foundries	6.0%	9.0%	8.8%	16.6%	41.0%	43.7%	47.8%
3324	Boiler, Tank, and Shipping Container Manufacturing	77.5%	80.3%	79.3%	81.6%	82.8%	82.6%	82.9%
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	20.7%	17.1%	15.3%	15.9%	20.9%	25.6%	26.3%
3328	Coating, Engraving, Heat Treating, and Allied Activities	11.2%	7.0%	13.7%	9.2%	16.6%	20.2%	17.6%
3331	Agriculture, Construction, and Mining Machinery Manufacturing	63.8%	62.5%	62.2%	64.7%	66.8%	67.2%	68.1%
3339	Other General Purpose Machinery Manufacturing	66.1%	66.8%	65.4%	66.5%	69.0%	69.0%	68.9%

[214] Source: Economic Modeling Systems, Incorporated (EMSI). 2014.3 – QCEW Employees, Non-QCEW Employees, Self-Employed, and Extended Proprietors (http://www.economicmodeling.com).

APPENDIX E: TULSA DISTRICT CIVIL WORKS PROJECT PERTINENT DATA SHEETS FOR SELECTED PROJECTS

E.1 Oklahoma McClellan-Kerr Arkansas River Navigation System Projects

The projects listed in Table E 1 are the Oklahoma Corps projects on in the McClellan-Kerr Arkansas River Navigation System managed by the Tulsa District. The following are the project pertinent data sheets for each of the listed projects taken from the *Tulsa District Civil Works Projects Pertinent Data Sheets* (Tulsa District, 2003, U.S. Army Corps of Engineers).

Table E 1 Oklahoma McClellan-Kerr Arkansas River Navigation System Projects

1	**Arkansas River Bank Stabilization and Channel Rectification, OK**
2	**Chouteau Lock and Dam (#17)**
3	**Newt Graham Lock and Dam (#18)**
4	**Robert S. Kerr Lock and Dam (#15) and Reservoir**
5	**Robert S. Kerr Marine Terminal**
6	**Sans Bois Navigation Channel**
7	**W. D. Mayo Lock and Dam (#14)**
8	**Webbers Falls Lock and Dam (#16) and Reservoir**

ARKANSAS RIVER BANK STABILIZATION AND CHANNEL RECTIFICATION

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946, Public Law 79-525; Project Document HD 758, 79th Congress, 2d Session.

Location: The McClellan-Kerr Arkansas River Navigation System provides a navigation route from the Mississippi River through Arkansas and Oklahoma to the head of navigation at Catoosa near Tulsa, Oklahoma. The Tulsa District, Corps of Engineers' area of responsibility extends from the head of navigation (navigation mile 444.8) downstream via the Verdigris River, through the Newt Graham Lock and Dam (navigation mile 421.6) and the Chouteau Lock and Dam (navigation mile 401.4) to the confluence with the Arkansas River (navigation mile 395.0). From there, it continues through the Webbers Falls Lock and Dam (navigation mile 366.6), the Robert S. Kerr Lock and Dam (navigation mile 336.2), and the W. D. Mayo Lock and Dam (navigation mile 319.6) to the border of Oklahoma and Arkansas at Fort Smith, Arkansas (approximately navigation mile 308.5).

Purpose: Flood control and navigation.

Status: Complete.

History of Construction: Construction was initiated in May 1952 and completed in December 1969. The waterway was completed to Fort Smith, Arkansas, in 1969, and was open for navigation to Catoosa in 1970.

Type of Structure: The project consists of bank stabilization and channel rectification as required for stabilization of the river channel and for establishment of a navigation channel with a minimum depth of 9 feet and a minimum width of 250 feet. Bank stabilization also protects the critical location on the right bank of the Arkansas River in the vicinity of Braden's Bend, Oklahoma, as authorized by the Flood Control Act of June 30, 1948, Public Law 80-858.

CHOUTEAU LOCK AND DAM (#17) OKLAHOMA

Authorization: A part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946; Project Document HD 758, 79th Congress, 2d Session.

Location: The lock is on the Verdigris River at McClellan-Kerr navigation mile 401.4, about 4 miles northwest of Okay in Wagoner County, Oklahoma. The dam is in the old river channel at navigation mile 401.4.

Purpose: Navigation, recreation, and fish and wildlife.

Status: Complete.

History of Construction: Construction began in July 1966 and impoundment began on December 2, 1970. The lock and dam became operational for navigation on December 26, 1970.

Type of Structure: The structure is a combined earth-filled and concrete-gravity dam. The total dam length is 11,690 feet.

Lock: The lock has a 110- by 600-foot chamber of the single-lift type with miter gates. The lock has a 21-foot normal lift and a 24-foot maximum lift.

Spillway and Outlet Works: The spillway is a gated, concrete, ogee weir with a crest elevation of 485.0 and with left and right uncontrolled overflow sections. The spillway has a total width of 386 feet with a net flow width of 346 feet. The left and right uncontrolled overflow sections of the spillway are separated by three 60- by 27-foot tainter gates with 10-foot-wide concrete piers. In addition, the left and right embankments are designed to overflow with lengths of 280 and 2,700 feet, respectively. A 24-foot-wide service bridge is constructed on the piers for access to the lock.

PROJECT DATA:[215]

	Elevation (feet)	Area (acres)	Capacity* (acre-feet)
Top of Spillway Gates	512.0	-	-
Top of Upper Pool	511.0	2,270	23,340
Top of Lower Pool (normal)	490.0	-	-
Minimum Lower Pool	487.0	-	-
Spillway Crest	485.0	-	-

[215] *Run-of-river operation.

NEWT GRAHAM LOCK AND DAM (#18) OKLAHOMA

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946; Project Document HD 758, 79th Congress, 2d Session.

Location: On the Verdigris River at McClellan-Kerr navigation mile 421.6, about 8 miles southwest of Inola in Wagoner County, Oklahoma.

Purpose: Navigation, recreation, and fish and wildlife.

Status: Complete.

History of Construction: Construction began in October 1966. Closure occurred on September 9, 1970, and the project was placed in useful operation. The lock and dam became operational for navigation on December 26, 1970.

Type of Structure: The 1,630-foot embankment is a combined earth-filled and concrete-gravity dam. The spillway is a gated, concrete ogee weir with a crest elevation of 506.0. Total width of the spillway is 220 feet with a net flow width of 180 feet. There are three 60- by 27-foot-high tainter gates with 10-foot- wide concrete piers. The right bank overflow section is 596 feet at crest elevation 533.5, and the left bank overflow section is 813 feet at crest elevation 542.0. A 5-foot-wide service bridge is constructed on the piers for personnel access to the gates.

Lock: The lock is a 110- by 600-foot chamber of the single-lift type with miter gates. The lock has a 21-foot normal lift.

PROJECT DATA: [216]

Feature	Elevation (feet)	Area (acres)	Capacity [(1)] (acre-feet)
Top of Spillway Gates	533.0	-	-
Top of Upper Pool	532.0	1,490	23,500
Top of Lower Pool (normal)	511.0	-	-
Spillway Crest	506.0	-	-

[216] *Run-of-river operation.

ROBERT S. KERR LOCK AND DAM (#15) AND RESERVOIR OKLAHOMA

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946; Project Document HD 758, 79th Congress, 2d Session. Public Law 88-62, approved July 8, 1963, changed the name from Short Mountain Lock and Dam to Robert S. Kerr Lock and Dam.

Location: On the Arkansas River at navigation mile 336.2, about 8 miles south of Sallisaw in LeFlore County, Oklahoma.

Purpose: Navigation, hydroelectric power, and recreation.

Status: Complete.

History of Construction: Construction began in April 1964. Closure occurred in October 1970. The lock and dam became operational for navigation in December 1970. Power units 1, 2, 3, and 4 were placed on line on October 5, July 27, September 1, and November 2, 1971, respectively.

Type of Structure: The dam is constructed of rolled earth-filled material. The total length of the structure, including the spillway, powerhouse intake, and navigation lock, is 7,230 feet. The maximum height is 75 feet above the streambed. There is a service road to the right embankment and an access road to the lock in the left embankment.

Spillway and Outlet Works: A gated, concrete, ogee weir type spillway extends partly across the existing river channel and a portion of the right bank between the power improvements and the navigation lock. The spillway weir has a net length of 900 feet and is surmounted by eighteen 50- by 44-foot-high tainter gates. The gates are separated by seventeen 10-foot piers, which support a 5-foot-wide service roadway bridge. The spillway has a capacity of 1,542,000 cfs at the maximum pool elevation (19.5 feet above the top of the power pool).

Lock: The lock, located on the left of the spillway, is a single-lift, Ohio River type with culvert and port filling system and has a chamber 110 feet wide by 600 feet long with a normal lift of 48 feet.

Powerhouse: The powerhouse is an integral-type structure with four 27,500-kW Kaplan-type units having a total capacity of 110,000 kW.

Hydrologic Data: The flood of record occurred in May 1943 with an estimated peak discharge at the dam site of 810,000 cfs.

PROJECT DATA:[217]

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Top of Dam	483.5	-	-
Top of Overflow Section	468.5	-	-
Top of Power Pool (extends to Webbers Falls Lock and Dam)	460.0	32,800	525,700
Power Pondage	458.0 – 460.0	-	84,700
Weir Crest	417.0	-	-
Top of Normal Lower Pool	412.0	-	-

POWER DATA:[218]

Item	Amount
Required Flow for Prime Power, average cfs	4,600
Average Net Power Heads, feet	
Four Units Operating	40.5
Critical Hydroyear	40.5
Continuous Power, kW	13,640
Installed Capacity, kW	110,000
Annual Prime Energy Output, kWh	119,500,000
Average Annual Potential Energy, kWh	459,000,000

[217] Based on 1976 sedimentation survey. Note: The drainage area above the dam site is 147,756 square miles with 22,241 square miles not contributing to flows.

[218] Based on 1956 critical hydro-year. Crediting 15% overload capacity.

ROBERT S. KERR MARINE TERMINAL OKLAHOMA

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946; Project Document HD 758, 79th Congress, 2d Session.

Location: On the Arkansas River 5 miles south of Sallisaw in Sequoyah County, Oklahoma, on the left side of the Robert S. Kerr Reservoir; adjacent to the Applegate Cove public-use area, 3 miles northwest of Robert S. Kerr Lock and Dam.

Purpose: Navigation.

Status: Complete.

History of Construction: Construction began in April 1964 and the terminal became operational in October 1970.

Project Data: The project consists of a terminal office, storage building, and separate storage areas for the Corps and the Coast Guard; about 83,000 square feet of wharf (33,000 for Coast Guard use); and 8 dolphins for storage tie up of the floating plant.

SANS BOIS NAVIGATION CHANNEL OKLAHOMA

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946, HD 758, 79th Congress, 2d Session; and Public Law 91-439 approved October 7, 1970, 91st Congress, HR 18127.

Location: On the Sans Bois Creek arm of the Robert S. Kerr Reservoir in Haskell County, Oklahoma.

Purpose: Navigation.

Status: Complete.

Project Data: The project begins near navigation mile 342 in the Robert S. Kerr Reservoir and extends about 14 miles along Sans Bois Creek to a turning basin 400 feet wide and 1,000 feet long. The channel varies in width from 225 to 250 feet and has a minimum depth of 9 feet.

W. D. MAYO LOCK AND DAM (#14) OKLAHOMA

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946, Project Document HD 758, 79th Congress, 2d Session. Section 1117 of the Water Resources Development Act of 1986, Public Law 99-662, authorized the Cherokee Nation of Oklahoma to design and construct hydroelectric generating facilities at W. D. Mayo Lock and Dam.

Location: On the Arkansas River at navigation mile 319.6, about 9 miles southwest of Fort Smith, Arkansas, in LeFlore and Sequoyah counties, Oklahoma.

Purpose: Navigation.

Status: Complete.

History of Construction: Construction began in May 1966. Closure was completed on October 15, 1970, and the project was placed in useful operation. The lock and dam became operational for navigation in December 1970.

Type of Structure: The 7,400-foot-long dam consists of a low concrete apron and sill surmounted by tainter gates separated by 10-foot concrete piers. The gates are operated with machinery constructed on the piers. Twelve 60- by 21-foot tainter gates are provided for the structure.

Lock: The lock has a 110- by 600-foot chamber of the single-lift type with miter gates. The lock has a 20-foot normal lift and 22-foot maximum lift.

PROJECT DATA:[219]

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Top of Overflow Section (left bank)	414.0	-	-
Top of Spillway Gates	413.0	-	-
Top of Upper Pool	413.0	1,595	15,800
Bottom of Upper Pool	411.0	-	-
Weir Crest	392.0	-	-
Top of Lower Pool	392.0	-	-
Bottom of Lower Pool	391.0	-	-

[219] Note: The drainage area above the dam site is 148,084 square miles.

WEBBERS FALLS LOCK AND DAM (#16) AND RESERVOIR OKLAHOMA

Authorization: Authorized as a part of the McClellan-Kerr Arkansas River Navigation System in the River and Harbor Act approved July 24, 1946; Project Document HD 758, 79th Congress, 2d Session.

Location: On the Arkansas River at navigation mile 366.6, about 5 miles northwest of Webbers Falls in Muskogee County, Oklahoma.

Purpose: Navigation and hydroelectric power.

Status: Complete.

History of Construction: Construction began in January 1965. Closure was completed in November 1970, and the project was placed in useful operation. The lock and dam became operational for navigation in December 1970. Power units 1, 2, and 3 were placed in operation in August, September, and November 1973, respectively.

Type of Structure: The dam is constructed of rolled-earth material. The total crest length of the structures, including the spillway, powerhouse intake, and the navigation lock, is 4,370 feet. The maximum height is 87 feet above the streambed. A service road is provided across the top of the dam.

Spillway and Outlet Works: The spillway extends across the left half of the existing river channel with the powerhouse structure in the right half of the river channel. The spillway is a gated, concrete, ogee weir. The crest of the weir is 66.8 and 40.0 feet below the tops of the maximum and power pools, respectively. The weir is surmounted by twelve 50- by 41-foot-high tainter gates. The gates are separated by eleven 10-foot intermediate piers, which also support a 5-foot-wide service roadway bridge. Spillway capacity at maximum pool (elevation 516.8) is 1,200,000 cfs.

Lock: The lock is a 30-foot normal lift, Ohio River-type, with a culvert and port filling system and side outlet discharge. The lock is located in the left overbank with excavated approach channels. The chamber is 110 feet wide by 600 feet long.

Powerhouse: The powerhouse is an integral-type structure with three inclined-axis type units having a total capacity of 60 MW.

Hydrologic Data: The flood of record occurred in May 1943 with an estimated peak discharge at the dam site of 720,000 cfs.

PROJECT DATA: Based on 1976 sedimentation survey.[220]

	Elevation (feet)	Area (acres)	Capacity * (acre-feet)
Top of Dam	520.8	-	-
Top of Overflow Section	499.0	-	-
Top of Upper Pool	490.0	11,640	170,100
Power Pondage	487.0-490.0	-	32,420
Top of Lower Pool	460.0	-	-
Weir Crest	450.0	-	-

POWER DATA:[221]

Item	Amount
Required Flow for Prime Power, average cfs (1)	2,150
Average Net Power Heads, feet	
One Unit Operating	29.5
Three Units Operating	26.5
Critical Hydroyear (1)	26.5
Continuous Power, kW (1)	4,000
Installed Capacity, kW	60,000
Annual Prime Energy Output, kWh	35,000,000
Average Annual Potential Energy, kWh (2)	213,300,000

220 * The drainage area above the dam site is 97,033 square miles.

221 Based on 1956 critical hydro-year. Crediting 15% overload capacity.

E.2 Supporting McClellan-kerr Arkansas River Navigation System Projects in Oklahoma

The projects listed in Table E 2 are the Oklahoma Corps projects that support the McClellan-Kerr Arkansas River Navigation System. The following are the project pertinent data sheets for each of the listed projects taken from the *Tulsa District Civil Works Projects Pertinent Data Sheets* (Tulsa District, 2003, U.S. Army Corps of Engineers).

Table E 2 Oklahoma MKARNS-Related Corps-Managed Projects

Other Tulsa District Navigation Projects	
1	**Big and Little Sallisaw Creeks Navigation Project, OK**
2	**Poteau River Navigation Project, OK and AR**
Multi-Purpose Projects Having MKARNS-Related Functions	
1	**Copan Lake**
2	**Eufaula Lake**
3	**Fort Gibson Lake**
4	**Grand Lake O' the Cherokees (Pensacola Dam)**
5	**Hulah Lake**
6	**Kaw Dam**
7	**Keystone Lake**
8	**Lake Hudson (Markham Ferry Dam)**
9	**Oologah Lake**
10	**Tenkiller Ferry Lake**
11	**Wister Lake**

Big and LITTLE SALLISAW CREEKS NAVIGATION PROJECT OKLAHOMA

Authorization: The River and Harbor Act of 1946, Public Law 525, 79th Congress, 2d Session; Authorizing Document HD 6407, as amended by the Water Resources Development Act of October 22, 1976, Public Law 94-587.

Location: About 3 miles southwest of Sallisaw in Sequoyah County, Oklahoma. The navigation channel would begin at navigation mile 341.6 of the McClellan-Kerr Arkansas River Navigation System and would extend up the Big and Little Sallisaw Creek arms of the Robert S. Kerr Reservoir.

Purpose: Navigation.

Status: Deauthorized April 16, 2002.

Project Data: The navigation channel would consist of a hydraulically dredged channel approximately 5 miles long and 100 feet wide, with a 9-foot minimum design depth. The south bank dike would be approximately 4,900 feet long, and the wetlands disposal dike would be approximately 6,000 feet long. A 400- by 500-foot turning basin would be located near U.S. Highway 59.

POTEAU RIVER NAVIGATION PROJECT OKLAHOMA AND ARKANSAS

Authorization: Section 107, Public Law 86-645.

Location: On the Poteau River at Fort Smith in Crawford County, Arkansas.

Purpose: Navigation.

Status: Complete.

History of Construction: Construction began in March 1979 and was completed in October 1979.

Type of Structure: A 130- by 9-foot channel on the Poteau River extends 1.7 miles upstream from its confluence with the Arkansas River to the Port of Fort Smith. A turning basin is located a short distance upstream of the port. The Fort Smith Port Authority owns terminal facilities.

COPAN LAKE OKLAHOMA

Authorization: Flood Control Act approved 0ctober 23, 1962; Project Document HD 563, 87th Congress, 2d Session.

Location: At river mile 7.4 on the Little Caney River, a tributary of the Caney River in the Verdigris River watershed; about 2 miles west of Copan and about 9 miles north of Bartlesville in Washington County, Oklahoma.

Purpose: Flood control, water supply, water quality control, recreation, and fish and wildlife.

Status: Complete.

History of Construction: Construction began in November 1972 and the project was placed in useful operation in April 1983.

Type of Structure: The rolled earth-filled dam is about 7,730 feet long, including the spillway; rises about 73 feet above the streambed; and has a top width of 32 feet. A 17,100-foot-long levee provides flood protection for the town of Caney, Kansas. A 24-foot roadway with 4-foot shoulders was provided across the dam for the relocation of Oklahoma Highway 10. The spillway bridge has a 28-foot roadway and 4-foot sidewalks.

Spillway and Outlet Works: The spillway is a gate-controlled, concrete-gravity, ogee weir with four 50- by 35.5-foot tainter gates and a stilling basin. Total length of the spillway is 495 feet. Maximum discharge of the spillway is 199,070 cfs. Concrete, non-overflow sections 263 feet long connect the spillway with the embankment. A 36-inch-diameter low-flow pipe and a 12-inch-diameter pipe for future water supply extend through the spillway. Channel capacity below the dam site is about 3,000 cfs.

Hydrologic Data: The flood of record occurred September 29 to October 14, 1986, and had a volume of 369,000 acre-feet, which is equivalent to 13.71 inches of runoff, with a peak inflow to the lake of 102,000 cfs.

LAKE DATA:[222]

Feature	levation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	745.0	-	-	-
Maximum Pool	739.1	17,850	338,200	12.57
Top of Flood Control Pool	732.0	13,380	227,700	8.45
Flood Control Storage	710.0-732.0	-	184,300	6.84
Top of Conservation Pool	710.0	4,449	34,634	1.61
Conservation Storage	687.5-710.0	-	33,887 (2)	1.59
Spillway Crest	696.5	1,080	4,700	0.17
Top of Inactive Pool	687.5	110	747	0.02

[222] Drainage area is 505 square miles. Includes 7,500 acre-feet for water supply (3.0 mgd yield), 26,100 acre-feet for water quality control (16 mgd yield), and 9,200 acre-feet for sediment.

EUFAULA LAKE OKLAHOMA

Authorization: River and Harbor Act approved July 24, 1946; Project Document HD 758, 79th Congress, 2d Session.

Location: On the Canadian River at river mile 27.0, about 12 miles east of Eufaula in McIntosh County, Oklahoma.

Purpose: Flood control, water supply, hydroelectric power, and navigation.

Status: Complete.

History of Construction: Construction began in December 1956 and embankment closure was completed in February 1964. Power was first generated in July 1964; the last of the three generators started producing commercial power in September 1964. The project was completed for full flood control operation on February 10, 1964.

Type of Structure: The dam is a rolled earth structure 3,200 feet long, including the spillway and powerhouse intake, and rises to a maximum height of 114 feet above the streambed. Oklahoma State Highway 71 crosses the crest of the dam.

Spillway and Outlet Works: The spillway is a concrete-gravity ogee weir with eleven 40- by 32-foot electrically-operated tainter gates. The gates are separated by ten 8-foot-wide piers, which support a bridge across the top of the structure. The spillway has a gross width of 520 feet and a net width of 440 feet and is located across a portion of the existing river channel. Spillway capacity at maximum pool is 465,000 cfs. Bank-full capacity below the dam is about 40,000 cfs and on the Arkansas River at Van Buren, Arkansas, is about 150,000 cfs. The outlet works, an integral part of the spillway structure, is a 5-foot 8-inch by 7-foot low-flow sluice passing through the weir near the left end of the spillway. The sluice intake invert is at elevation 500.0, and flows are controlled by a hydraulically-operated gate. Capacity of the sluice at the top of the flood control pool is 2,400 cfs.

Hydrologic Data: The maximum peak discharge occurred in May 1990 with a peak of 234,939 cfs. The volume amounted to 2,374,000 acre-feet over a 16-day period, which is equivalent to 5.30 inches of runoff from the lower basin and 0.94 inches from the entire basin above the dam site. The largest total volume of runoff occurred in 1957 and amounted to 4,550,000 acre-feet, which is equivalent to 10.15 inches from the lower basin and 1.80 inches of runoff from the total area above the dam site.

LAKE DATA: Based on 1977 sediment survey.[223]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	612.0	-	-	-
Maximum Pool	604.96	-	-	-
Top of Gates and Flood Control Pool				
Flood Control Storage	585.0-597.0	-	1,510,800	3.27
Top of Power Pool	585.0	105,500	2,314,600	5.20
Power Storage	565.0-585.0	-	1,463,000 (2)	3.27
Bottom of Power Pool and Spillway Crest				

[223] Runoff from the lower drainage area of 8,405 square miles. Total drainage area is 47,522 square miles. Includes 56,000 acre-feet for water supply (50 mgd yield).

FORT GIBSON LAKE OKLAHOMA

Authorization: Flood Control Act approved August 18, 1941; incorporated in the Arkansas River multipurpose plan by the River and Harbor Act of July 24, 1946; Project Document HD 107, 76th Congress, 1st Session; and the Water Resources Development Act of 1986, Public Law 99-662.

Location: On the Grand (Neosho) River at river mile 7.7 in Mayes, Wagoner, and Cherokee counties, about 5 miles north of Fort Gibson, Oklahoma, and about 12 miles northeast of Muskogee, Oklahoma.

Purpose: Flood control and hydroelectric power.

Status: Complete.

History of Construction: Construction began in 1942, was suspended during World War II, and resumed in May 1946. Closure of the embankment was completed in June 1949. The project became fully operational when the last of four generators started producing commercial power in September 1953.

Type of Structure: The dam includes two concrete-gravity non-overflow sections. One section, 285 feet long, extends from the spillway to the earth embankment at the right abutment. The other section, 460 feet long, extends from the intake structure to the earth embankment at the left abutment. The dam also includes two earth embankment sections, one of which extends about 374 feet from the natural ground at the right abutment to the right bank, concrete, non-overflow section. The other embankment, 63 feet long, extends from the left abutment to the left bank, concrete, non-overflow section. The powerhouse intake structure is located adjacent to the spillway on the left and is 318 feet long. The total length of the structures, including the spillway, is 2,990 feet, and the maximum height above the streambed is 110 feet. Oklahoma State Highway 251A extends across the top of the structures. There are seven rolled earth-filled dikes on the west side of the reservoir, which have a total length of 21,678 feet.

Spillway and Outlet Works: The spillway section is a concrete-gravity, ogee weir that extends across the existing river channel and a major portion of the right bank floodplain. Spillway capacity is 986,000 cfs at the top of the flood control pool. The spillway is equipped with thirty 40- by 35-foot tainter gates operated by individual electric-motored hoists. The total length of the spillway is 1,490 feet. Outlet works consist of ten 5-foot 8-inch by 7-foot rectangular sluices located through the spillway weir. Capacity of the outlet works varies from 21,000 cfs at the flood control pool elevation with no spillway discharge to 14,400 cfs at the flood control pool elevation with the spillway discharging at full capacity. Flows through the sluices are controlled by means of hydraulically-operated cast-iron slide gates. Emergency closure of the sluices can be accomplished using a bulkhead lowered by a hoist into frames provided at the sluice entrances. A 48-inch-diameter pipe is located through the right abutment of the dam for municipal water supply for the city of Muskogee. Bank-full capacity on the Grand (Neosho) River below the dam is about 100,000 cfs.

Hydrologic Data: Estimated peak discharge and volume for the flood of May 7 to June 1, 1943 (with Grand Lake O' the Cherokees in operation), were 400,000 cfs and 5,918,000 acre-feet, respectively. Total runoff from the drainage area above the dam site was 8.88 inches.

LAKE DATA:[224]

	Elevation (feet)	Area (acres)	Capacity (acre-feet)	ivalent Runoff* (inches)
Top of Dam	593.0	-	-	-
Maximum Pool	582.0	-	-	-
'op of Spillway Gates and Flood Control Pool				
Flood Control Storage	554-0-582.0	-	919,200	1.38
Top of Power Pool	554.0	19,900	365,200	0.55
Bottom of Power Pool	551.0	16,950	311,300	0.50
Spillway Crest	547.0	14,500	248,400	0.37

Power Data:[225]

Item	Amount*
Average Net Power Heads, feet	
Power Pool, full	60.0
Power Pool, empty	57.0
Critical Hydroperiod	58.5
Initial Dependable Capacity, kW	45,000
Installed Capacity, kW	
Initial (four 11,250-kW units)	45,000
Ultimate (six 11,250-kW units)	67,500
Annual Energy Output (four units), kWh	190,500,000

224 *From a 12,494-square-mile drainage area above the dam site.

225 *Continuous power, load factor, and division of energy output power into primary and secondary depends on the upstream operation of Grand Lake O' the Cherokees and Lake Hudson (Markham Ferry Reservoir).

GRAND LAKE O' THE CHEROKEES (PENSACOLA DAM) OKLAHOMA

Authorization: The Flood Control Act, approved August 18, 1941, Public Law 77-228, Project Document HD 107, 76th Congress, 1st Session. The River and Harbor Act of 1946 incorporated the reservoir into the Arkansas River multiple-purpose plan. ``

Location: On the Grand (Neosho) River at river mile 77.0 in Mayes and Delaware counties near Disney, Oklahoma, and about 13 miles southeast of Vinita, Oklahoma.

Purpose: Hydroelectric power and flood control.

Status: Complete.

History of Construction: The project was constructed by the Grand River Dam Authority (GRDA), an Oklahoma State agency. It was completed in 1940 and became operational in 1941. Operation of the flood control storage in the reservoir is the responsibility of the U.S. Army Corps of Engineers in accordance with the provisions of Section 7 of the Flood Control Act of 1944 (58 Stat 890, 33 USC 709).

Type of Structure: The structure is a concrete, multiple-arch dam with gated spillways. The total length of the dam and spillways is 6,565 feet. The structure rises to a maximum height of 147 feet above the streambed. State Highway 28 extends across the top of the dam.

Spillway and Outlet Works: The main spillway has a total length of 861 feet and is equipped with twenty-one 36- by 25-foot-high tainter gates. The weir crest of the main spillway is at elevation 730.0. The two east spillways have a total length of 860 feet and are equipped with a total of twenty-one 37- by 15-foot-high tainter gates. The weir crests of the east spillways are at elevation 740.0. Total capacity of both the main and east spillways is 525,000 cfs at the top of the flood control pool. Bank-full capacity below the dam is about 100,000 cfs and on the Arkansas River at Muskogee is about 150,000 cfs.

LAKE DATA:[226]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	757.0	-	-	-
Top of Flood Control Pool	755.0	59,200	2,197,000	4.00
Flood Control Storage	745.0-755.0	-	525,000	0.96
Top of Power Pool	744.0	46,500	1,672,000	3.04
Power Storage	705.0-745.0	-	1,192,000	2.17

[226] All elevations are Pensacola datum utilized in HD 107. Add 1.1 feet to convert to USC and GS datum. Based on computations dated April 29, 1938. From a 10-298-square-mile drainage area above the dam.

Top of Inactive Pool	705.0	17,000	480,000	0.87

GRDA now follows a seasonal pool that varies from elevation 741 to 744 according to a license granted by the Federal Energy Regulatory Commission.

POWER DATA:[227]

Item	Amount*
Required Flow for Prime Power, average cfs	2,199
Power Heads, average net feet	
Power Pool, full	121.0
Power Pool, empty	91.0
Continuous Power, kW	16,900
Installed Capacity (six 20,000-kW units)*	120,000
Annual Energy Output, kWh	
Primary	133,100,000
Secondary	207,500,000
Total	340,600,000

[227] Based on a 38-week critical hydroperiod, which occurred in 1939 and 1940. *Capacity increased to six 20,000-kW following rehabs completed in June 2003.

HULAH LAKE OKLAHOMA AND KANSAS

Authorization: Flood Control Act approved June 22, 1936, Project Document HD 308, 74th Congress, 1st Session, Public Law 843, 84th Congress, 2d Session, approved July 30, 1956.

Location: At river mile 96.2 on the Caney River, a tributary of the Verdigris River, about 15 miles northwest of Bartlesville, in Osage County, Oklahoma.

Purpose: Flood control, water supply, low flow regulation, and conservation.

Status: Complete.

History of Construction: Construction started in May 1946 and was completed in February 1951. Embankment closure began in February 1950 and was completed in June 1950. Impoundment of the conservation pool began on September 23, 1951, and was completed on September 24, 1951. The project was placed in full flood control operation in September 1951.

Type of Structure: The dam is a rolled, impervious, earth-filled embankment and concrete spillway 5,200 feet long. The maximum height of the embankment is 94 feet above the streambed. A dike 1,115 feet long with a maximum height of 30 feet is located in a saddle near the right abutment above the dam. Oklahoma Highway 10 extends across the dam.

Spillway and Outlet Works: The spillway is a gate-controlled, concrete-gravity, ogee weir 472 feet wide. The structure is located adjacent to the right abutment. Spillway discharge at maximum pool (elevation 771.4) is 266,200 cfs and at the top of the flood control pool (elevation 765.0) is 183,500 cfs. Spillway discharges are controlled by ten 40- by 25-foot tainter gates. The outlet works consists of nine 5- by 6-foot 6-inch rectangular sluices that pass through the spillway. Capacity of the sluices varies from 12,400 cfs at the top of the flood control pool (elevation 765.0) to 7,950 cfs at the conservation pool (elevation 733.0). The sluices are controlled by hydraulically-operated slide gates. Two gated, 24-inch- diameter, low-flow pipes and one gated, 10-inch-diameter, water supply pipe are provided. Bank-full capacity below the dam is about 6,500 cfs.

Hydrologic Data: The flood of record occurred September 29 to October 19, 1986, and had a volume of 408,000 acre-feet, which is equivalent to 10.46 inches of runoff. Peak inflow to the lake was 133,000 cfs.

LAKE DATA:[228]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	779.5	-	-	-
Top of Flood Control Pool	765.0	13,000	289,000	7.40
Flood Control Storage	733.0 – 765.0	-	257,900	6.61
Spillway Crest	740.0	5,160	61,400	1.57
Top of Conservation Pool	733.0	3,120	22,565	0.80
Conservation Storage	710.0 – 733.0	-	22,553 (2)	0.80
Top of Inactive Pool	710.0	0	14	

[228] Based on 1973 sedimentation survey. From a 732-square-mile drainage area above the dam site. Includes 19,800 acre-feet for water supply (12.4 mgd yield), 7,100 acre-feet for water quality control (4.5 mgd yield), and 4,200 acre-feet for sediment reserve.

KAW LAKE OKLAHOMA

Authorization: Flood Control Act approved October 23, 1962, Project Document SD 143, 87th Congress, 2d Session.

Location: On the Arkansas River at river mile 653.7, about 8 miles east of Ponca City in Kay County, Oklahoma.

Purpose: Flood control, water supply, water quality, hydropower, recreation, and fish and wildlife.

Status: Complete.

History of Construction: Construction began in June 1966 and the project was placed in useful operation in May 1977.

Type of Structure: The dam is a rolled earth-filled embankment 9,466 feet long, including the spillway, and rises about 125 feet above the streambed. The embankment top is 32 feet wide and has a 24-foot- wide, bituminous-surfaced road.

Spillway and Outlet Works: The gate-controlled concrete valley spillway is an ogee weir and includes a stilling basin and outlet works. Total length of the spillway, excluding the non-overflow sections, is 400 feet, with flow over the spillway controlled by eight 50- by 47-foot tainter gates. The spillway structure is located in the right abutment and has a design capacity of 653,000 cfs. Low-flow facilities consist of two 5-foot 8-inch by 10-foot sluices located through two intermediate piers. A 48-inch- diameter water supply pipe is located in the right non-overflow. Operational channel capacity at the dam is about 22,500 cfs.

Power Intake Structure: A powerhouse substructure and a 75-foot-long intake monolith with one 20-foot-diameter penstock were incorporated into the original construction of the spillway. Construction of the generating facilities began in August 1987. Power generation began in August 1989.

Hydrologic Data: The flood of record occurred September 29 to October 4, 1986, and had a volume of 2,377,000 acre-feet, which is equivalent to 6.70 inches of runoff. Peak inflow to the lake was 185,700 cfs.

LAKE DATA:[229] .

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	1056.5	-	-	-
Top of Flood Control Pool	1044.5	39,690	1,327,160	3.74
Flood Control Storage	1010.0 – 1044.5	-	920,610	2.45
Top of Conservation Pool	1010.0	16,750	406,540	1.15
Conservation Storage	978.0 – 1010.0	-	330,180	1.08
Spillway Crest	997.5	11,070	234,167	0.66
Top of Inactive Pool	978.0	5,240	76,360	0.22
With Future Power				
Flood Control Storage	1013.0 – 1044.5	-	867,310	2.45
'op of Power and Water Supply Pool	1013.0	18,775	459,850	1.30
ower and Conservation Storage	978.0 – 1013.0	-	383,480 (3)	1.08

[229] Based on 1986 sedimentation survey. Contributing drainage area above the dam site is 6,652 square miles. The spillway design drainage area is 8,975 square miles. The total drainage area is 46,530 square miles. The Oklahoma Municipal Power Authority installed a 37-megawatt unit which came on line in August 1989. The unit is operated by run of river. Includes 171,200 acre-feet for water supply (167 mgd yield), 31,800 acre-feet for water quality control (39 mgd yield), and 140,500 acre-feet for sediment reserve.

KEYSTONE LAKE OKLAHOMA

Authorization: Flood Control Act approved May 17, 1950, Project Document SD 107, 81st Congress, 1st Session.

Location: On the Arkansas River at river mile 538.8, about 15 miles west of Tulsa in Tulsa County, Oklahoma.

Purpose: Flood control, water supply, hydroelectric power, navigation, and fish and wildlife.

Status: Complete.

History of Construction: Construction began in January 1957 and the project was placed in flood control operation in September 1964. The number 2 generating unit became operational on May 2, 1968, and the number 1 generating unit became operational on May 21, 1968.

Type of Structure: The embankment is constructed of rolled earth-filled material. The total length of the dam, including a 1,600-foot-long concrete section, is 4,600 feet. The maximum height is about 121 feet above the streambed. The concrete section consists of a spillway 856 feet wide, a non-overflow section, and a power intake structure. Highway 151 crosses the dam to connect relocated U.S. Highway 51 on the south with relocated U.S. Highway 64 on the north.

Spillway and Outlet Works: The spillway is a gated, concrete, ogee-weir with a net width of 720 feet, surmounted by eighteen 40- by 35-foot tainter gates. Spillway capacity at the top of maximum pool (elevation 766.0) is 939,000 cfs and at the top of the flood control pool (elevation 754.0) is 565,000 cfs. The spillway is also equipped with nine 5.67- by 10-foot sluices located between alternate intermediate piers. Channel capacity of the Arkansas River below Tulsa, Oklahoma, is about 90,000 cfs.

Power Intake Structure: The powerhouse and power intake structure are located between the spillway and the left non-overflow sections and include two penstocks, each 27 feet in diameter, controlled by two 14- by 30-foot gates.

Hydrologic Data: The flood of record occurred September 29 to October 21, 1986, and had a volume of 4,444,000 acre-feet, which is equivalent to 3.73 inches of runoff. Peak inflow to the lake was 344,000 cfs.

LAKE DATA:[230]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	771.0	-	-	-
Top of Gates and Flood Control Pool	754.0	54,320	1,737,600 (2)	1.46
Flood Control Storage	723.0 – 754.0	-	1,180,000	0.99
Top of Power Pool	723.0	23,610	557,600	0.47
Power Storage	706.0 – 723.0	-	296,700 (3)	0.25
Spillway Crest	719.0	20,100	469,900	0.39
Bottom of Power Pool	706.0	13,380	260,900	0.22

POWER DATA:

Item	Amount
Required Flow for Seasonal (June to September) Continuous Power, average cfs	1,120
Average Net Power Heads, feet	
Power Pool, full	86
Power Pool, empty	66
Average	81.5
Seasonal (June to September) Continuous Power, kW	6,400
Installed Capacity (two 35,000-kW units), kW	70,000
Annual Firm Energy Output, kWh (based on original capacity)	
Primary	43,000,000
Secondary	185,000,000
Total	228,000,000

[230] Based on 1988 sedimentation survey. Runoff from contributing basin area of 23,351 square miles. Total drainage area is 74,506 square miles. Sediment reserve is 508,600 acre-feet. Includes 20,000 acre-feet for water supply (20 mgd yield).

LAKE HUDSON (MARKHAM FERRY DAM) OKLAHOMA

Authorization: Flood Control Act approved August 18, 1941, and River and Harbor Act of July 24, 1946. (The project was incorporated in the multiple-purpose plan for the Arkansas River.) Public Law 476, 83rd Congress, 2d Session, approved July 6, 1954 authorized construction by Grand River Dam Authority; and Public Law 85-500 (Flood Control Act of 1958) authorized revision of flood control storage or pool elevations per approval of Corps of Engineers.

Location: On the Grand (Neosho) River at river mile 47.4, about 2 miles northwest of Locust Grove and about 8 miles southeast of Pryor in Mayes County, Oklahoma.

Purpose: Flood control and hydroelectric power.

Status: Complete.

History of Construction: Construction was started in December 1961 by the Grand River Dam Authority (GRDA), an Oklahoma State agency, and was completed in April 1964. Operation of the project is under their jurisdiction with the exception of the flood control storage, which is the responsibility of the U.S. Army Corps of Engineers in accordance with provisions of Section 7 of the Flood Control Act of 1944 (58 Stat 890, 33 USC 709).

Type of Structure: The structure is a concrete gravity and earth-filled embankment and concrete spillway having a total crest length of about 4,494 feet, including the powerhouse, and rising to a maximum height of about 90 feet above the streambed. A roadway extends across the top of the dam. The rolled earth- filled dike is 5,100 feet long and rises to a maximum height of 50 feet.

Spillway and Outlet Works: The spillway is a concrete-gravity, ogee weir that extends across the river channel and a portion of the floodplain on both banks. Spillway capacity at maximum pool (elevation 640.4) is 736,000 cfs and at the flood control pool (elevation 636.0) is 609,000 cfs. The spillway is equipped with seventeen 40- by 37-foot-high tainter gates operated by two traveling gate hoists. Gross length of the spillway is 824 feet.

Hydrologic Data: Estimated peak flow and volume for the May 1943 flood were 400,000 cfs and 5,535,000 acre-feet, respectively. Total runoff from the drainage area above the dam site during that flood was 9 inches.

LAKE DATA:[231]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	645.0	-	-	-
Top of Gates and Flood Control Pool	636.0	18,8000	444,600	0.72
Flood Control Storage	619.0 – 636.0	-	244,200	0.40
Top of Power Pool	619.0	10,900	200,300 (3)	0.33
Spillway Crest	599.0	4,500	48,700	0.08

POWER DATA:[232]

Item	Amount
Power Heads, average net feet	
Power Pool, full Continuous Power, kW Load Factor, percent Installed Capacity, kW	52.0
Initial	100,000
Ultimate Annual Energy Output, four units, kWh	100,000 190,000,000

[231] From the 11,533 square miles above the dam site. The top of the embankment is at elevation 645.0. The top of the concrete non-overflow portion of the structure is at elevation 642.0. Power production is run of the river.

[232] Continuous power, load factor, and division of power into primary and secondary is dependent upon the method of operation of the Grand Lake O' the Cherokees upstream. Grand River Dam Authority construction plans, as called for in the Federal Power Commission license effective June 1, 1955, and Amendment No. 2 issued April 7, 1961, provide for installation of four 25,000-kW units.

OOLOGAH LAKE OKLAHOMA

Authorization: Flood Control Act approved June 28, 1938, Committee Document 1, 75th Congress, 1st Session. The power portion of the proposed two-stage development was authorized by Public Law 761, Section 4, in the River and Harbor Act approved 24 July 1946 and deauthorized by Public Law 93-251 on March 7, 1974.

Location: On the Verdigris River at river mile 90.2, about 2 miles southeast of Oologah in Rogers County, Oklahoma, and about 27 miles northeast of Tulsa in Tulsa County, Oklahoma.

Purpose: Flood control, water supply, navigation, recreation, and fish and wildlife.

Status: Complete.

History of Construction: Construction began in July 1950. The project was placed in standby status in October 1951 after the right abutment access road was constructed. Construction resumed in December 1955 and was completed in May 1963. Construction of the project for ultimate development was initiated in July 1967. All structures were completed in 1974.

Type of Structure: The dam is a rolled earth-filled embankment about 4,000 feet long and rises to a maximum height of about 137 feet above the streambed. State Highway 88 is located along the crest of the dam.

Spillway and Outlet Works: The controlled spillway is located in a saddle about 2 miles east of the left abutment. It consists of seven 40- by 21-foot-high radial gates mounted upon a modified concrete ogee weir section with the crest at elevation 640.0. The outlet works consist of two 19-foot-diameter conduits, each served by two 9- by 19-foot gates. One conduit could serve as a power penstock in the event power production proved desirable. The capacity of each conduit is 15,000 cfs with the reservoir at elevation 638.0 and 17,500 cfs with the reservoir at elevation 661.0. A 48-inch low-flow pipe is provided for small releases. The estimated channel capacity of the Verdigris River below the dam site is 30,000 cfs.

Hydrologic Data: Peak flow and volume for the May and June 1943 flood were 138,000 cfs and 2,179,000 acre-feet, respectively. Total runoff from the drainage area above the dam site during that flood was 9.42 inches.

LAKE DATA:[233]

Feature	Elevation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	687.0	-	-	-
Maximum Pool	678.25	92,160	2,927,430	23.33
Top of Flood Control Pool	661.0	67,117	1,559,279	12.43
Flood Control Storage	638.0 – 661.0	-	1,007,060	8.02
Spillway Crest	640.0	33,400	616,690	14.91
Top of Conservation Pool	638.0	31,043	552,235	4.40
Navigation, Municipal, and Industrial Water Supply				
Top of Permanent Pool	592.0	880	6,935	0.06

[233] Data based on 1977 sedimentation survey. From a 4,339-square-mile drainage area above the dam; 2,353 square miles are uncontrolled. Includes 342,600 acre-feet for water supply (154 mgd yield), 168,000 acre-feet for navigation, and 34,700 acre-feet for 50 years' sediment.

TENKILLER FERRY LAKE OKLAHOMA

Authorization: Flood Control Act approved June 28, 1938. Installation of power features was authorized by the River and Harbor Act approved July 24, 1946; Project Document Committee No. 1, 75th Congress, 1st Session, HD 758, 79th Congress, 2d Session.

Location: On the Illinois River at river mile 12.8, in Cherokee and Sequoyah Counties, about 7 miles northeast of Gore and about 22 miles southeast of Muskogee, Oklahoma.

Purpose: Flood control and hydroelectric power.

Status: Complete. A dam safety project is underway and is scheduled for completion in FY 06.

History of Construction: Major construction started in June 1947. The spillway, outlet works, and tunnels were completed in 1951, and embankment closure occurred in May 1952. Impoundment of the power pool began in July 1952. The project was completed for full flood control operation in July 1953. Installation of the two hydropower units was completed in December 1953 and power generation was initiated. Work on the repair and extension of the spillway apron was initiated in July 1960 and completed in August 1961.

Type of Structure: The structure is a rolled, impervious and semi-pervious earth-filled dam about 3,000 feet long with a maximum height of 197 feet above the streambed. Oklahoma State Highway 100 extends across the top of the dam. An earth-filled dike about 1,350 feet long is located between the right end of the dam and the spillway.

Spillway and Outlet Works: The concrete-gravity spillway, located in a narrow ridge comprising the right abutment of the dam about 800 feet west of the axis of the dam, has a total width of 590 feet. Spillway capacity is 290,400 cfs at maximum pool (elevation 672.2) with flow controlled by ten 50- by 25-foot tainter gates. A flood control outlet extending through the narrow ridge comprising the right abutment consists of a 19-foot conduit. Capacity of the conduit is 23,300 cfs at the top of the flood control pool. Flow through the conduit is controlled by two 9- by 19-foot tractor-type service gates installed at the upstream end of the conduit and operated by individual electric hoists located on the operating floor of the gate tower structure. A 19-foot-diameter penstock is provided through the narrow ridge comprising the right abutment to the powerhouse. Operational channel capacity below the dam is 10,800 cfs.

Hydrologic Data: Estimated peak discharge and volume of the March and April 1945 floods were 118,000 cfs and 1,184,000 acre-feet, respectively. Total runoff from the drainage area above the site was 13.79 inches for the entire period. The May 1950 flood had a peak discharge of 180,000 cfs with a volume of 720,000 acre-feet, which is equal to 8.39 inches of runoff.

LAKE DATA:[234]

Feature	levation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	677.2	-	-	-
'op of Gates and Flood Control Pool	667.0	20,800	1,230,800	14.33
Flood Control Storage	632.0-667.0	-	576,700	6.72
Spillway Crest	642.0	14,700	791,900	9.22
Top of Conservation Pool	632.0	12,900	654,100 (2)	7.62
Conservation Storage	594.5-632.0	-	371,000	4.32
Top of Inactive Pool	594.5	-	283,100	3.30

POWER DATA:[235]

Item	Amount *
Average Net Power Heads, feet	
Power Pool, full	145.0
Power Pool, empty	107.5
Critical Hydro-period, average	127.2
Average Power Release During Critical Hydroperiod, cfs)	536
Continuous Power, kW	4,980
Dependable Capacity, kW	28,000
Critical Period Plan Factor, percent	14.0
Installed Capacity (two 19,550-kW units), kW	39,100
Annual Energy Output, kWh	
Firm	41,700,000
Secondary	53,400,000
Total	95,100,000

[234] From a 1,610-square-mile drainage area above the dam. Includes 25,400 acre-feet for water supply; 345,600 acre-feet for power drawdown storage, and 283,100 acre-feet of dead storage.

[235] Based on individual operation and a 75-week critical hydro-period that occurred in 1933 and 1934. * Based on 1969 tailwater conditions and flows for 1923 through 1965. The critical period plant factor is based on generation during the 1962 through 1964 critical hydro-period.

WISTER LAKE OKLAHOMA

Authorization: Flood Control Act approved June 28, 1938, Committee Document No. 1, 75th Congress, 1st Session. The conservation pool elevation for December 1 to May 31 was changed by the 98th Congress in Public Law 98-63 dated July 30, 1983. Water Resource Development Act of 1996 permanently raised the lake level by 3.5 feet, making the level 478 feet.

Location: On the Poteau River at river mile 60.9, about 2 miles south of Wister in LeFlore County, Oklahoma.

Purpose: Flood control, water supply, low flow augmentation, water conservation, and sedimentation.

Status: Complete.

History of Construction: Construction started in April 1946 and was completed in May 1949; embankment closure started in June 1948 and was completed in May 1949; and impoundment of the conservation pool started in October 1949 and was completed in December 1949. The project was completed for full flood control operation in October 1949. Major rehabilitation of the embankment was completed in 1990.

Type of Structure: The dam is a rolled, impervious earth-filled embankment with rock-protected slopes. The dam is 5,700 feet long and rises to a maximum height of 99 feet above the streambed. Oklahoma State Highway 270 is located along the top of the dam. A rolled earth-filled dike that extends from the right abutment is 2,400 feet long and rises to a maximum height of 40 feet.

Spillway and Outlet Works: An uncontrolled, concrete, chute-type spillway with modified broad- crested weir is located in a ridge, which extends downstream from the right abutment of the main embankment. The spillway has a total width of 600 feet. Spillway capacity is 170,910 cfs at maximum pool (elevation 523.5). The outlet works consist of two 15.8- by 14.0-foot egg-shaped conduits located in the valley adjacent to the right abutment of the dam. Capacity of the outlet works varies from 14,600 cfs at the top of the flood control pool to 7,900 cfs at the conservation pool elevation. Flows are regulated by six 7- by 12-foot tractor-type, vertical-lift gates located in a concrete gate tower. A 30-inch-diameter gated pipe conduit provides low-flow regulation. Two water supply intakes are located in the gate tower; one for possible future water supply use and the other to supply the project. Controlling bank-full capacity below the dam is 6,600 cfs.

Hydrologic Data: The flood of record occurred on 18 June 1934 with a peak discharge of 81,000 cfs. The largest total volume, 567,000 acre-feet, occurred in April 1927. Total runoff during that period was 10.71 inches.

LAKE DATA:[236]

Feature	levation (feet)	Area (acres)	Capacity (acre-feet)	Equivalent Runoff (inches)
Top of Dam	527.5	-	-	-
Spillway Crest and Top of Flood Control Pool	502.5	23,366	427,481	8.07
Flood Control Storage	474.6-502.5	-	388,399	7.33
Top of Conservation Pool	478.0	7,386	61,423	1.16

[236] Based on 1985 sedimentation survey. From a 993-square-mile drainage area above the dam site. Includes 14,000 acre-feet for water supply.

APPENDIX F: MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM—RECREATION VISITATION AND ECONOMIC IMPA

This appendix contains a summary report entitle, *McClellan-Kerr Arkansas River Navigation System: Recreation Visitation and Economic Impact* by Lowell Caneday and Fatemeh Soltani (Oklahoma State University).

The recreation survey results are available as a hard copy upon written request.

Visit the ODOT website at: http://ok.gov/odot

Looking for a research report or publication? Try the Oklahoma Transportation Library On-Line Catalog: *http://l92018.eos-intl.net/L92018/OPAC/Index.aspx*

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McClellan-Kerr Arkansas River Navigation System

Recreation Visitation and Economic Impact

By

Lowell Caneday, Ph.D.

Fatemeh (Tannaz) Soltani, MBA, M.S.

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ACKNOWLEDGEMENTS

After more than 30 years of working with local, state, and federal agencies in Oklahoma that provide outdoor recreation opportunities, this project permitted me an opportunity to investigate a portion of the public recreation estate that had not been studied. The McClellan Kerr Arkansas River Navigation System is best known for its role in transportation and navigation, but it also provides recreation resources. These resources are primarily managed by the United States Army Corps of Engineers (Tulsa District) or managed under contracts from the USACE.

Valuable assistance to conduct this research was provided by Tannaz Soltani and Catalina Palacios, doctoral candidates at Oklahoma State University. As young scholars interested in tourism and leisure behavior, Tannaz and Catalina provided technical skill in preparing the online surveys and analyzing data. Tannaz also managed the data generated by the surveys and conducted the analysis of that data.

In addition, numerous campground hosts situated at various locations along MKARNS also aided in this study. These hosts provided local knowledge, posted invitations for participation in the study, and aided in communication with visitors to the public access locations.

On behalf of the USACE, Amanda Palmer responded to requests for information on recreation access locations and attendance figures. Her assistance was invaluable!

No survey based research would be possible without respondents. The assistance of each individual who responded is greatly appreciated.

Lowell Caneday, Ph.D., Regents Professor

Leisure Studies

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SECTION 1 – INTRODUCTION

Background and Context

In 2012, Dr. Mike Langston contacted the author of this report, Dr. Lowell Caneday, regarding the possibility of participating in an assessment of recreational demand, use, and economic impact along the McClellan Kerr Arkansas River Navigation System (MKARNS). Caneday had conducted numerous such studies in recreational settings for the National Park Service, the United States Forest Service, the U.S. Army Corps of Engineers, the Oklahoma State Park system through the Oklahoma Tourism and Recreation Department, and cities across the state of Oklahoma. In particular, Langston indicated assistance was needed in preparing and conducting surveys of the public during this research effort.

As a result, the author agreed to participate with primary responsibilities related to conducting the recreational component of this project. That was intended to encompass (1) identification of public use areas for contact with the recreational visitor, (2) design of a research protocol and assessment instrument to gather desired data, (3) analysis of the data following collection, and (4) reporting on the results.

As of December 2013, a contract was finalized between Oklahoma State University and the University of Arkansas-Little Rock (UALR) specifying the details of the responsibilities for Drs. Langston and Caneday at OSU. The scope of work was detailed as:

"The OSU Team (Drs. Langston and Caneday) will conduct surveys to ascertain the economic impact of MKARNS to the local and regional economies as well as the potential impacts of proposed improvements such as increasing the depth to 12 feet. Three groups of respondents will be targeted:

1. Businesses located within the three Oklahoma ports along MKARNS (Catoosa, Muskogee, and Johnson's 33). We will solicit needed information from these businesses through site visits and interviews and/or mailings.
2. Customers of these port businesses (first target group) who use MKARNS for shipping. These will be identified through contact with the port businesses.
3. Recreationists who make use of MKARNS (including fishermen/women, watercraft operators, shoreline visitors, and their associated outfitters). These will be surveyed using an online survey (hosted by OSU's Qualtrics web service). Potential participants will be made aware of the survey through cards and flyers distributed to appropriate locations along the river (such as boat landings, local businesses, and outfitters) and contact with recreational groups who may utilize MKARNS (such as city recreation departments, fishing tournaments or clubs, and Native American Tribal nations.

Survey instruments will be designed and results interpreted in close consultations with UALR (Dr. Robinsons) and the USACE (Mr. Tyler Henry)."

In January 2014, Dr. Langston resigned from his position at Oklahoma State University and transferred his responsibilities related to this project to Dr. Caneday. During spring 2014, two surveys were drafted, amended, and finalized for use in this study. Those surveys are included in the Appendix.

The surveys and the associated research protocol were subject to review and approval by the Oklahoma State University Institutional Review Board for protection of human subjects. Those approvals were granted as of May 27, 2014. The research protocol began Memorial Day weekend 2014.

SECTION 2 – SURVEY OF MKARNS PORTS

Survey Instrument and Process

The survey instrument utilized to gather information from the various ports along MKARNS was prepared by research staff at UALR. This instrument was reviewed by personnel from ODOT, USACE, and OSU, with additional input from persons familiar with language and issues along the navigation corridor.

Once the instrument was finalized, the survey was entered into Qualtrics, an online software package that supports data collection from a variety of devices. Qualtrics was hosted in a secure environment on the Oklahoma State University servers. An invitation to participate in the survey was distributed by email to port contacts provided by ODOT.

Following approval of the survey and research protocol by the IRB, the email invitation was distributed on June 20, 2014. The email included a link to the online survey and a printable Word document with instructions as provided by Dr. Dennis Robinson.

Between June 20 and August 30, three reminder email messages were sent to each of the invited participants. In addition, telephone conversations ensued between representatives from several of the ports and principals in the research process.

Survey Responses

Some difficulty arose among the port representatives in interpreting the language and information requested in the survey. Questions regarding the specifics were referred to Dr. Dennis Robinson at UALR. Dr. Robinson and his staff at UALR also met with individuals at ports to explain the survey and the requested information.

Additional messages of encouragement to participate in the survey were sent by ODOT to the port representatives.

As of September 8, there were seven responses from port representatives although none of these completed the survey entirely. Responding ports included Five Rivers, Harbor Industrial District Pine Bluff, Oakley Port 33, Port of Pine Bluff, Port of Little Rock, Port of Muskogee, and Tulsa Port of Catoosa. These responses were forwarded to UALR.

SECTION 3 – SURVEY OF ASSOCIATED BUSINESSES

Survey Instrument and Process

During preparation of the survey of port representatives, it became apparent that some additional information would be needed from businesses associated with the individual ports. In particular, the research principals agreed that specific information from these associated businesses was needed in three areas:

- Percentage of a company's business that relied upon MKARNS;
- Physical presence and space at one of the MKARNS ports; and
- Ability of the company to conduct current business without services from MKARNS.

As a result, a secondary and short survey (Appendix FA) was prepared. And amended IRB application was submitted for review and approval. The IRB approved this amendment. This survey was also entered into Qualtrics.

This additional survey was sent by email to (1) a list of 43 customers provided by ODOT, and to (2) the port representatives. These port representatives were asked to post the link to the Qualtrics site (a URL) on their respective social media sites or in communication with their associated businesses. As a result, responses were generated through email, Facebook, Twitter, Linked-In, and other social media.

Survey Responses

One-hundred-eighty-one responses were received from businesses associated with MKARNS ports. Clearly these were generated well beyond the direct email invitations and represent a "snowball" sampling of businesses directly or indirectly linked to the navigation system.

The list of businesses provided by ODOT included addresses beyond Oklahoma and Arkansas. Among the listed businesses beyond the two local states were those from Indiana, Minnesota, Missouri, Colorado, Iowa, Illinois, Georgia, North Carolina, New York, Tennessee, Kansas, and Florida. Since the survey design included snowball sampling, it is likely that several of the responding businesses are outside the immediate proximity of Oklahoma and Arkansas.

The survey was short and to the point for these associated businesses. This aided in generating high levels of response.

> Question 1: What percentage of your company's business relies upon navigation on the McClellan Kerr Arkansas River Navigation System (MKARNS)?

Qualtrics includes a variety of response tools. For this item, the principal investigator selected a 'slide tool' that allowed respondents to slide a pointer to a selected percentage along a scale from 0% on the left to 100% on the right. The scale was demarcated at 10 point intervals. As a result, it is likely that respondents gave approximate percentages in their answers and responses were grouped by ten-point interval.

Forty-two responding businesses indicated that 100% of their business relied upon MKARNS. Forty-five additional businesses reported that 90% of their business relied upon MKARNS. The 80% level was the most common response with 49 businesses indicating this level of business relied on MKARNS. Thirty-six businesses reported at the 70% level, while only eight businesses responded at lower levels.

> Question 2: Does your company have a physical presence and space at one of the ports on MKARNS?

Respondents were given the opportunity to reply “Yes” or “No” to question 2. Thirty-nine of the respondents indicated they had a physical presence or space at one of the ports along the navigation corridor. The remaining 142 responding businesses do not have a physical presence at one of the ports, but do rely upon navigation along MKARNS for at least a portion of their business.

> Question 3: Could your company conduct its current business without the navigation and transportation options provided by MKARNS?

The third question in this survey of associated businesses also offered the opportunity for a response of “Yes” or “No.” Almost 90% of the 181 businesses that responded to this survey indicated that they would be unable to conduct their current business without the navigation and transportation options provided by MKARNS.

SECTION 4 – SURVEY OF RECREATION VISITORS

Survey Instrument and Process

There are a number of tools and models available for assessing visitor attitudes, activities, and expenditures. This study was based on the IMPLAN model (http://www.implan.com). With more than 35 years of experience, IMPLAN was originally developed in response to the Rural Development Act of 1972 with an emphasis on economic impact modeling. IMPLAN has been widely used in recreation settings and is particularly applicable in rural settings. As a result, it is a fitting tool and model for use in assessing economic impacts of recreation use in the rural environments surrounding MKARNS.

The principal investigator on this portion of the study had utilized IMPLAN in several applications for the U.S. Forest Service and Oklahoma State Parks. A recent economic impact analysis of lodges in Oklahoma State Parks provided recent evidence of the utility of online survey responses from recreation visitors to public spaces.

As a result, a survey (Appendix FB) was prepared based on the IMPLAN model. This survey segmented expenditure into five major categories common to recreational visitors: (1) lodging, (2) food and beverage, (3) transportation, (4) recreation, and (5) other expenses. In addition, the investigators decided to request responses with a five mile distance of the MKARNS corridor and beyond that distance. These categories directly correlated with IMPLAN economic codes, while the distance from a particular feature or economic generator varies between studies.

Additional questions related to party size and length of stay are common in IMPLAN applications to permit analysis of the data. These questions were added to the economic measures.

Further additions to the survey were unique to this study, addressing purpose of visit to the MKARNS corridor, perceptions of the MKARNS corridor, and place of residence. The actual survey is included in Appendix B.

In addition to the survey, a recruitment methodology that had been utilized in Oklahoma State Parks was implemented for this study. Respondents were recruited using posters placed on-site in recreational facilities along MKARNS. These posters were placed on bulletin boards, signs, restroom doors, and other locations in public access points. In campgrounds with campground hosts, the hosts were provided additional posters as replacements. The posters included a URL and a QR code that could be entered into any electronic device to access the online survey. A copy of the poster is included in Appendix FB

The survey and research methodology were approved by the IRB at Oklahoma State University. Posters were placed over the Memorial Day weekend and replaced as needed on two occasions during the summer. This survey was also posted on Qualtrics and the URL or the QR codes directed respondents to the online site.

Recreation Locations along MKARNS

Multiple public access locations permitting recreational visitors to launch a boat, camp, fish, or otherwise access the water and surrounding environment of MKARNS are distributed along the entire route of the navigation channel. Determining which of these locations remained open to the public and supported current recreational access required on-site visitation. The following discussion presents these locations by segment of the navigation channel beginning at Catoosa and continuing to the Oklahoma/Arkansas state line.

Catoosa to Highway 412

Rogers Point on the southwest quadrant of the intersection of Highway 66 and MKARNS is managed by the City of Catoosa. Rogers Point includes two boat ramps, supporting parking areas, restroom facilities, picnic area and open space. In this location, Rogers Point is easily accessible along a four-lane highway, although Highway 66 was undergoing reconstruction during summer 2014.

Highway 33 Landing offers a boat ramp and parking lot along the east side of the navigation channel just south of Highway 412. This location is directly east of Johnston's Port 33. As with Rogers Point, the four lane highway access provides easy entry and exit for anglers and boaters into Highway 33 Landing.

Highway 412 to Newt Graham Lock and Dam

Several public access locations were at one time operating along the area impounded upstream from Newt Graham Dam. These included Commodore Landing and Rocky Point. However, these locations have been closed. Some local use may continue, but the entry roads are gated and overgrown with vegetation.

Bluff Landing Recreation Area is operated by the USACE on the south bank of an oxbow lake along the western side of MKARNS. Bluff Landing includes two campgrounds offering electricity and water. In addition, Bluff Landing includes picnic shelters, boat ramps, and substantial parking. Bluff Landing Recreation Area is located on 71st Street (Kenosha Avenue), east of Broken Area and is readily accessible to the population base in that part of the Tulsa metropolitan area. Throughout the summer, Bluff Landing was managed by an on-site campground host and sustained continuous recreational visitation.

Newt Graham Lock and Dam to Highway 51

The area immediately adjacent to Newt Graham Lock and Dam is designated as Goodhope Ramp on the east side of the channel and Bluegill Point on the west side. Goodhope Ramp remains an active public access location with a boat ramp and parking area. However, Bluegill Point has become a dumping ground. There may be some local activity including fishing at Bluegill Point, but the area would not attract desirable recreational activity in its present condition.

Further south along MKARNS, the Port of Dunkin is located just north of State Highway 51. To the south of Highway 51, Afton Landing Recreation Area offers a campground, with campground host, electrical service, water, and boat ramps. Afton Landing is easily accessed from Highway 51 and remained busy throughout the summer 2014.

Highway 51 to Highway 69

Along the northwest-to-southeast segment of MKARNS between Highway 51 and Highway 69 there are two public recreation access locations in operation. Coal Creek is located east of Highway 69 along Cannon Road and is most readily accessible from Wagoner. Coal Creek public access is limited to a boat ramp and parking lot, but it does receive fairly consistent, seasonal boating traffic, and heavy use by anglers.

Tullahassee Loop Recreation Area is west of Highway 69 and is accessed by county roads. Tullahassee Loop offers a campground and boat ramp. A campground host was present throughout the summer, but Tullahassee Loop had minimal camper use throughout the summer 2014. However, the boat ramp provided an important, heavily used point of access to the water for many anglers and boaters from the local area.

Highway 69 to Highway 62

The Chouteau Lock and Dam is located immediately east of Highway 69 and serves as a dividing point for the area in this segment of the MKARNS. At one time, Pecan Park, located just south of Chouteau Lock and Dam, served as an important and large public access point. However, Pecan Park has been closed except for a boat ramp presently in use.

Below this location, the Verdigris joins the Arkansas River and immediately is joined by the Neosho (Grand) River. This historic “three rivers” junction is close to Muskogee and serves the substantial population base of the city. Hyde Park is operated by the City of Muskogee and is adjacent to the home location for the USS Batfish in War Memorial Park.

The riverfront is dominated by the Port of Muskogee. However, Three Forks Harbor provides an important public access location just south of Highway 62 on the Arkansas River. In addition to meeting space and offices of the River Center, the Three Forks Harbor includes marina facilities, slips, and river access.

A variety of special events hosted at the River Center attract a wide range of audiences.

Highway 62 to Highway 10 Landing

MKARNS and the Arkansas River wind southward parallel to the Muskogee Turnpike. County roads and state highways provide routes for the public to access the river. However, most of the locations along this segment of MKARNS are poorly marked and require some local knowledge.

The entry drive into Hopewell Park was overgrown and gated. A sign on the entry indicated the area was managed by a rural water district.

Spainard Creek (variously spelled Spaniard Creek on some maps) is the most developed and most heavily used recreation access point along this segment. Spainard Creek offers a large campground with a campground host, electricity, water, and picnic shelters. The area is divided into two sections, each served with a boat ramp. Spainard Creek is separated by a peninsula from the main traffic on MKARNS.

Highway 10 Landing is located south of the community of Braggs and directly across Highway 10 from Greenleaf State Park. Highway 10 Landing includes a boat ramp, courtesy dock, parking lot, and restroom and is frequently used by anglers and boaters. An information kiosk also serves as a point of contact for recreation visitors and provided an excellent location for the poster utilized in this study.

Arrowhead Point is no longer accessible to the general public. Private development in this location south of Braggs has included fencing of the access road. Some trespassing does occur, but almost all use of this area is limited to local residents.

Highway 10 Landing to I-40

The segment of MKARNS between Highway 10 Landing and Interstate 40 includes the Webbers Falls Lock and Dam. Upstream of that facility, Webbers Falls Reservoir widens in areas from the narrower river valley to the north. Brewers Bend Recreation Area is a significant recreation development offering camping, a campground host, electricity, water, picnic shelters, boat ramps, and courtesy docks. Brewers Bend remained an active recreation site throughout summer 2014.

Rock Dike Park is identified on maps and road signs, but the area is not open for traditional recreation use. Rock Dike Park is located just west of Webbers Falls Lock and Dam 16.

Below Webbers Falls Lock and Dam, MKARNS returns to a more riverine environment and continues southeast between the towns of Webbers Falls and Gore. Each of these towns includes public access locations to MKARNS.

The town of Webbers Falls operates a park on the west side of the Arkansas River providing picnic areas, shelters, a gazebo and band stand, boat ramps with courtesy dock, and full service camping. In addition, the park includes a memorial commemorating the tragedy of May 2012.

A port area (C.G.B. Webbers Falls) is just north of the Highway 100/64 bridge across the Arkansas River and linking Gore on the east side to Webbers Falls on the west side.

On the east bank of the Arkansas River just north of the Highway 100/64 bridge is Summers Ferry Park operated by the town of Gore. This park includes a picnic area with shelters, camping, open play space, and a boat ramp.

Gore Landing includes two locations: Gore Landing South adjacent to Highway 64 and Gore Landing North located along a county road and adjacent to the lower Illinois River. Gore Landing South offers few recreation amenities other than access to the river. By contrast, Gore

Landing North includes camping, electrical service, water, picnic facilities, restrooms with showers, and boat ramps. Private concessionaires utilize Gore Landing North as the termination point for canoe and raft trips on the Lower Illinois River.

Robert S. Kerr Reservoir

Gore Landing, Summers Ferry and Webbers Falls Park are situated in the upper reaches of Roberts S. Kerr Reservoir, a 42,000 acre lake along the Arkansas River. This reservoir is impounded west of the dam site located near Highway 59 south of Sallisaw. Robert S. Kerr Reservoir provides the setting for several public access locations of various quality and amenities. The Port of Keota is also located in this segment of MKARNS.

Sequoyah National Wildlife Refuge is a 20,800 acre sanctuary and breeding habitat for migratory waterfowl and other wildlife species. The refuge headquarters are three miles south of Vian. Within the refuge there are numerous amenities such as primitive campgrounds, trails, and boat ramps to support recreational activities.

Also in the Vian vicinity, Vian Creek is a public access location with a parking lot and boat ramp utilized by recreational boaters and anglers. Vian Creek is two miles southeast of Vian and east of Sequoyah National Wildlife Refuge.

Continuing to the east, an area marked on some maps as Sallisaw Creek is now managed as Cherokee Nation Park. This area includes two campgrounds with electricity and water, picnic area with shelters, and boat ramps. The entry into Cherokee Nation Park, five miles south of Highway 64 and I-40, has been significantly improved with a well-marked gate and sign.

Applegate Cove Recreation Area is one of the more developed public access facilities with a full service marina on Robert S. Kerr Reservoir. In addition to the marina, Applegate Cove includes a campground with electricity and water, supported by a campground host, restrooms with showers, picnic and day use area, and boat ramps. Applegate Cove is easily accessed from Highway 59 south of Sallisaw and north of Robert S. Kerr Lock and Dam.

The area around Robert S. Kerry Lock and Dam includes public access facilities as well. On the north side of the dam and navigation channel is an area designated as Dam Site. This location is primarily utilized by anglers and sightseers. The south side of the channel is designated as Fisherman's Landing. While there are rough roadways that parallel the navigation channel, this area is truly a walk-up location utilized by anglers.

Two more developed recreation facilities are situated west of Highway 59 on the south side of Robert S. Kerr Reservoir. These locations are Short Mountain Cove and Cowlington Point.

Both Cowlington Point and Short Mountain Cove offer campgrounds with electricity, water, showers and comfort stations. Each was supported by an on-site campground host. Both areas include boat ramps with courtesy docks. Cowlington Point offers one of the better beaches on Robert S. Kerr Reservoir.

There are two mapped public access locations further west on Robert S. Kerr Reservoir. Keota Landing is two miles north of Highway 9 near Keota and north of the Port of Keota. However, this public access location has received little or no maintenance for several years. The restroom is in poor condition and campgrounds are overgrown. The boat ramp continues to receive some use, although all use of Keota Landing is local. During 2014, the county road leading north from Keota and past Keota Landing was resurfaced. This resurfaced roadway belies the condition of the recreation access point.

The second public access point shown on most maps is Little Sanbois Creek. Finding Little Sanbois Creek requires careful navigation since signs are non-existent. There is a boat ramp at this site, but only local residents are even aware of its existence.

Robert S. Kerr Reservoir to the State Line

To the east of Highway 59, the Arkansas River returns to a more riverine environment, although this stretch of the river is impounded by W. D. Mayo Lock and Dam 14. Public access locations are extremely limited along this section of MKARNS except for local use patterns. At Lock and Dam 14, the south side of MKARNS includes a boat ramp and parking area utilized by anglers. The north side of the channel shows off-road-vehicle activity.

An area marked on most maps as Moffett Landing is located at the Highway 64 bridge over the Arkansas River as the river crosses the border into Arkansas. The east side of the channel is Riverfront Park in Fort Smith, Arkansas. There did not appear to be any recent recreation access at Moffett Landing.

Recreational Use of MKARNS

USACE maintains traffic counters at several access points. In addition, locations with campground hosts and fee collection requirements include fairly accurate visitation counts through fiscal 2012. The following numbers report the most recent visitation for specific MKARNS locations as documented by USACE.

- 32,167 visitors at Afton Landing (Chouteau L&D)
- 21,826 visitors at Tullahassee Recreation Area (Chouteau L&D)
- 205,796 visitors at Three Forks Harbor (Webbers Falls L&D)
- 52,678 visitors at Brewers Bend Recreation Area (Webbers Falls L&D)
- 9,618 visitors at Summers Ferry (Robert S. Kerr L&D)
- 4,249 visitors at Vian Creek (Robert S. Kerr L&D)
- 32,064 visitors at Webbers Falls City Park (Robert S. Kerr L&D)
- 21,263 visitors at Gore Landing (Robert S. Kerr L&D)
- 34,902 visitors at Applegate Cove Recreation Area (Robert S. Kerr L&D)
- 18,061 visitors at Short Mountain Cove Recreation Area (Robert S. Kerr L&D)
- 26,611 visitors at Cowlington Point Recreation Area (Robert S. Kerr L&D)
- **459,235 visitors total at these developed sites**

For context, the Tulsa District of the U.S. Army Corps of Engineers reported over 16 million recreational visits at its various facilities during fiscal 2012. This number has been quite consistent over a five-year span from 2007 through 2012. USACE sites included in their accounting are most numerous on lakes such as Lake Tenkiller, Fort Gibson, Lake Texoma, and Lake Eufaula, but numerous smaller lakes are also included. The MKARNS sites receive fewer visitations than the higher profile sites on some of the larger lakes. As a result, the MKARNS corridor may comprise about 5% of the total recreational visits within the Tulsa District.

Several sites along MKARNS do not have the traffic counters or campground hosts which formalized the reported recreational visits. As a result, a variety of methods were necessary to estimate recreational visitation to these locations. These methods included:

- Conversations with local managers as at Rogers Point, operated by the City of Catoosa, and Sequoyah National Wildlife Refuge, operated by the U.S. Fish and Wildlife Service, and Cherokee Nation representatives for Cherokee Nation Park;
- Conversations with on-site hosts as at Bluff Landing Recreation Area and Spainard Creek Recreation Area and USACE representatives at the various Locks and Dams;
- Observation of use patterns, number of occupants per vehicle, and vehicle counts at locations such as Highway 33 Landing, Highway 10 Landing, and Coal Creek.

The following numbers report the most recent visitation for specific MKARNS locations as documented by these various means at these specific sites.

- 23,800 visitors at Rogers Point Public Use Area (Newt Graham L&D)
- 3,650 visitors at Highway 33 Landing (Newt Graham L&D)
- 54,400 visitors at Bluff Landing Recreation Area (Newt Graham L&D)
- 2,800 visitors at Bluegill Point Public Use Area (Newt Graham L&D)
- 2,800 visitors at Goodhope Ramp Public Use Area (Newt Graham L&D)
- 7,600 visitors at Coal Creek Public Use Area (Chouteau L&D)
- 1,600 visitors at Pecan Park Recreation Area (Chouteau L&D)
- 48,300 visitors at Spainard Creek Recreation Area (Webbers Falls L&D)
- 4,850 visitors at Highway 10 Landing (Webbers Falls L&D)
- 51,700 visitors at Cherokee Nation Park (Robert S. Kerr L&D)
- 10,300 visitors at Dam Site (Robert S. Kerr L&D)
- 14,600 visitors at Fisherman's Landing (Robert S. Kerr L&D)
- 3,100 visitors at Keota Landing (Robert S. Kerr L&D)
- 900 visitors at Little Sanbois Creek (Robert S. Kerr L&D)
- 63,200 visitors at Sequoyah National Wildlife Refuge (Robert S. Kerr L&D)

These estimates of visitation at the dispersed locations along MKARNS show an annual recreation visitation of 293,600 people. Some of these locations such as Sequoyah National Wildlife Refuge draw from a significant distance. Other locations like Bluff Landing Recreation Area rely upon a more localized market from Broken Arrow and Tulsa. Other locations such as Highway 33 Landing and Highway 10 Landing attract recreation visitors because of the intersection of highways with the waters of the navigation channel. Others such as Little Sanbois Creek or Keota Landing draw from a limited, rural population in close proximity to the residence of the respective recreation visitors.

Survey Response from Recreational Visitors

A Survey of Visitor Expenditure along MKARNS (Appendix FB) was developed based upon the expenditure categories and codes utilized in the IMPLAN model. This survey had been used in numerous prior studies by the principal investigator. The survey was hosted on Qualtrics, an interactive software program permitting online responses from individuals utilizing a variety of devices: smart phones, computers, pads, and others. The survey was also printed and provided to campground hosts for delivery to visitors at public access locations who may desire to respond to the survey, but who did not have access to an electronic communication device.

Recruitment and public notice of the online survey was generated through posters (Appendix FB) posted at each public access location along MKARNS in Oklahoma. These posters were laminated for protection against weather conditions and posted on bulletin boards, restroom doors, signs, and other locations that would catch the attention of recreation visitors. Each poster included general information regarding the survey and a URL and QR code linking directly to the online survey.

Additional posters were provided to the campground hosts, where they were present. These hosts were encouraged to replace the posters if they were removed during the summer between Memorial Day and Labor Day 2014. However, these campground hosts did not “buy-in” to the research project and rarely replaced missing posters or encouraged visitors to respond to the survey. Posters were replaced by the principal investigator on two trips to the MKARNS corridor and additional face-to-face surveys were completed by the principal investigator.

An identical research protocol had been utilized during the summer 2012 at campgrounds throughout the USACE – Tulsa District. In the 2012 research effort, rangers and personnel from USACE encouraged campground hosts to directly recruit respondents. As a result, a much greater response rate was achieved during 2012 than was true in 2014. These responses from 2012 were utilized to supplement the 2014 responses. Since the attendance data from the USACE was also from 2012, these responses are considered to be valid and reliable.

The 2012 survey did not include questions 15 through 18 that were included in the 2014 survey. These questions were specific to MKARNS and had not been utilized in the 2012 survey. As a result, the responses to these questions only reflect 2014 respondents.

A grand total of 469 responses were received from the combined 2012 and 2014 efforts. Of these respondents, 61 were generated during the 2014 research effort and 399 were products of the 2012 research effort. Among these total respondents, 91 identified themselves as day visitors to MKARNS, meaning they did not spend a night within the MKARNS corridor. Three-hundred-seventy-eight (378) respondents indicated they spent at least one night in the MKARNS corridor and therefore were considered to be overnight visitors.

Table F1 - Expenditures of Day Visitors per Trip

Expenditure category	**Within five miles of the MKARNS corridor**	**More than five miles from the MKARNS corridor**
Lodging (IMPLAN codes 411 & 412)		
1. Lodge, cabins, hotels, motels, B&B rental homes	$122.51	$18.20
2. Campground fees (including hook-ups)	$11.37	$3.22
Food and Beverage (IMPLAN codes 324 & 413)		
3. Restaurants, bars, take-out food/drinks from restaurants	$15.27	$19.36
4. Groceries, drinks, take-out food/drinks not from restaurants	$4.77	$21.04
Transportation (IMPLAN codes 326 & 338)		
5. Gas and oil for auto, boat, RV, etc.	$6.86	$43.66
6. Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$12.03	$5.60
7. Local transportation (e.g., bus, taxi, cab, etc.)	$0.00	$0.00
Recreation (IMPLAN codes 403, 406 through 410)		
8. Admissions and fees (e.g., golf green fees, stables, etc.)	$5.97	$2.69
9. Sporting goods (e.g., boat equipment, fishing gear, etc.)	$5.05	$7.53
10. Casino gambling	$0.00	$1.32
Other expenses (IMPLAN codes 327 & 328)		
11. Clothing	$2.03	$2.64
12. Souvenirs (e.g., Maps, books, mugs, etc.)	$5.51	$4.39
13. How many people were in your party on this trip?		2.34
14. How many nights did you spend in the MKARNS corridor on this trip?		0

As reported, these day visitors may have been local residents or transients, indicated by the fact that some of the day visitors to MKARNS had spent one or more nights in lodging outside the MKARNS corridor. However, their visit to MKARNS was limited to some portion of one day.

With an average party size of 2.34 persons per group, it is more valuable to examine the expenditures per person per day on a visit to the MKARNS corridor. These expenditures are reported in Table F2.

A typical trip to MKARNS for a day of fishing, boating, hunting, or other recreation leads to an expenditure of $69.09 per person within five miles of the MKARNS corridor for that trip's activities. However, among those who were truly day visitors and not spending a night on their trip, the expenditure was $24.86. In addition, the average day visitor spent $46.81 outside the MKARNS corridor, with the largest expenditures being for lodging and transportation.

Table F2 - Expenditures of Day Visitors per Person per Day

Expenditure category	Within five miles of the MKARNS corridor	More than five miles from the MKARNS corridor
Lodging (IMPLAN codes 411 & 412)		
1. Lodge, cabins, hotels, motels, B&B rental homes	$44.23	$6.57
2. Campground fees (including hook-ups)	$4.11	$1.16
Food and Beverage (IMPLAN codes 324 & 413)		
3. Restaurants, bars, take-out food/drinks from restaurants	$5.51	$6.99
4. Groceries, drinks, take-out food/drinks not from restaurants	$1.72	$7.60
Transportation (IMPLAN codes 326 & 338)		
5. Gas and oil for auto, boat, RV, etc.	$2.48	$15.76
6. Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$4.34	$2.02
7. Local transportation (e.g., bus, taxi, cab, etc.)	$0.00	$0.00
Recreation (IMPLAN codes 403, 406 through 410)		
8. Admissions and fees (e.g., golf green fees, stables, etc.)	$2.15	$0.97
9. Sporting goods (e.g., boat equipment, fishing gear, etc.)	$1.82	$2.72
10. Casino gambling	$0.00	$0.48
Other expenses (IMPLAN codes 327 & 328)		
11. Clothing	$0.73	$0.95
12. Souvenirs (e.g., Maps, books, mugs, etc.)	$1.99	$1.58
13. How many people were in your party on this trip?		2.34
14. How many nights did you spend in the MKARNS corridor on this trip?		0

There are few opportunities for certain types of expenditures within the MKARNS corridor including lack of local public transportation and casinos. In addition, few grocery stores or department stores are available within five miles of the MKARNS corridor.

Based upon the responses from the day visitors in this survey, the average expenditure for a day's recreational visit by one person to MKARNS was $108.41 of which $86.75 was spent at a distance of five miles or more from the corridor while $21.66 was spent within the navigation corridor.

In the same manner, overnight recreation visitors along the MKARNS responded to the survey. These overnight visitors reported having spent at least one night within five miles of the MKARNS corridor and may have spent additional nights on their recreational visit outside of the MKARNS corridor.

Within the MKARNS corridor, lodging options vary by provider and by location. Campgrounds are located directly on the navigation corridor or on adjacent lakes and creeks. A few private lodges, cabins, motels and rental properties are located along the corridor, particularly in the vicinity of Robert S. Kerr Reservoir or near the cities of Muskogee, Webbers Falls, Gore and Vian. Greenleaf State Park is directly across Highway 10 from Highway 10 Landing and offers campgrounds and cabins operated by the state of Oklahoma.

Table F3 - Expenditures of Overnight Visitors per Trip

Expenditure category	**Within five miles of the MKARNS corridor**	**More than five miles from the MKARNS corridor**
Lodging (IMPLAN codes 411 & 412)		
1. Lodge, cabins, hotels, motels, B&B rental homes	$274.81	$30.93
2. Campground fees (including hook-ups)	$3.30	$0.16
Food and Beverage (IMPLAN codes 324 & 413)		
3. Restaurants, bars, take-out food/drinks from restaurants	$51.86	$55.08
4. Groceries, drinks, take-out food/drinks not from restaurants	$15.57	$35.99
Transportation (IMPLAN codes 326 & 338)		
5. Gas and oil for auto, boat, RV, etc.	$31.39	$37.25
6. Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$15.83	$4.46
7. Local transportation (e.g., bus, taxi, cab, etc.)	$0.13	$0.00
Recreation (IMPLAN codes 403, 406 through 410)		
8. Admissions and fees (e.g., golf green fees, stables, etc.)	$17.60	$11.53
9. Sporting goods (e.g., boat equipment, fishing gear, etc.)	$14.79	$4.80
10. Casino gambling	$2.96	$13.57
Other expenses (IMPLAN codes 327 & 328)		
11. Clothing	$4.43	$7.43
12. Souvenirs (e.g., Maps, books, mugs, etc.)	$9.53	$6.88
13. How many people were in your party on this trip?		4.97
14. How many nights did you spend in the MKARNS corridor on this trip?		2.43

As would be expected for an overnight recreational visit, the largest categories of expenditure for these respondents were lodging, food from restaurants, and transportation expenses such as fuel. Average spending for an overnight visit to one of the recreational sites along MKARNS was $650.30 per group. These overnight recreational visitors reported an average party size of 4.97 persons and an average visit length of 2.43 nights. The longest reported visit to a location within the MKARNS corridor was 11 nights, although the principal investigator recognized that some recreational vehicles remained in campsites for the entire summer.

Party size for recreational visitors also varied with the largest responding party being 65 persons. This is likely to have been an organized travel club that is known to have utilized one of the campgrounds on Robert S. Kerr Reservoir. As a result, the average party size was 4.97 persons with a standard deviation of 8.27. It should also be noted that it is quite common to observe a recreational vehicle like a travel trailer on a campsite with two or more vehicles associated with that one site. It is also common to see a recreational vehicle on a campsite with one or more tents also located on the campsite. As a result, the party size reflects the perception of the respondent.

A more accurate reflection of expenditures by overnight guests is reported in Table F4. The data in this table reflect the average expenditure of an overnight visitor per person per day.

Table F4 - Expenditures of Overnight Visitors per Person per Day

Expenditure category	**Within five miles of the MKARNS corridor**	**More than five miles from the MKARNS corridor**
Lodging (IMPLAN codes 411 & 412)		
1. Lodge, cabins, hotels, motels, B&B rental homes	$22.75	$2.56
2. Campground fees (including hook-ups)	$0.27	$0.01
Food and Beverage (IMPLAN codes 324 & 413)		
3. Restaurants, bars, take-out food/drinks from restaurants	$4.29	$4.56
4. Groceries, drinks, take-out food/drinks not from restaurants	$1.29	$2.98
Transportation (IMPLAN codes 326 & 338)		
5. Gas and oil for auto, boat, RV, etc.	$2.60	$3.08
6. Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$1.31	$0.37
7. Local transportation (e.g., bus, taxi, cab, etc.)	$0.01	$0.00
Recreation (IMPLAN codes 403, 406 through 410)		
8. Admissions and fees (e.g., golf green fees, stables, etc.)	$1.46	$0.96
9. Sporting goods (e.g., boat equipment, fishing gear, etc.)	$1.22	$0.40
10. Casino gambling	$0.25	$1.12
Other expenses (IMPLAN codes 327 & 328)		
11. Clothing	$0.37	$0.62
12. Souvenirs (e.g., Maps, books, mugs, etc.)	$0.79	$0.57
13. How many people were in your party on this trip?		4.97
14. How many nights did you spend in the MKARNS corridor on this trip?		2.43

These overnight visitors spent an average of $53.85 per person per day on a recreational visit to MKARNS. Of those expenditures, $36.62 was expended within five miles of the MKARNS corridor with the largest portion of that expenditure ($23.02) being for lodging. Similarly, these recreational visitors who spent at least one night within the MKARNS corridor also spent an average of $17.23 per person outside of the corridor.

Based upon the responses provided by actual visitors to the MKARNS corridor, the following spending patterns have been documented:

- Recreational day trips to MKARNS showed an average party size of 2.34 persons per group;
- A recreational day trip to MKARNS produces an expenditure of $191.37 per group within five miles of the MKARNS corridor;
    - These recreational day trips lead to an expenditure of **$69.09 per person** within five miles of the MKARNS corridor;
- A recreational day trip to MKARNS produces an expenditure of $129.65 per group beyond five miles from the MKARNS corridor;
    - These recreational day trips lead to an expenditure of **$46.80 per person** beyond five miles from the MKARNS corridor;
- A recreational day trip to MKARNS leads to an expenditure of **$115.89 per person**;
- Recreational overnight trips to MKARNS showed an average party size of 4.97 persons per group and an average of 2.43 nights per visit;
- A recreational overnight trip to MKARNS produces an expenditure of $442.20 per group within five miles of the MKARNS corridor;
    - These recreational overnight trips to MKARNS lead to an expenditure of **$36.61 per person per day** within five miles of the MKARNS corridor;
- A recreational overnight trip to MKARNS produces an expenditure of $208.08 per group beyond five miles from the MKARNS corridor;
    - These recreational overnight trips to MKARNS lead to an expenditure of **$17.23 per person per day** beyond five miles from the MKARNS corridor;
- A recreational overnight trip to MKARNS produces an expenditure of **$53.85 per person per day**.

In addition to the economic information requested from survey respondents, visitors were asked four other questions on the Survey of Visitor Expenditure along MKARNS (Appendix B). These questions were unique to the 2014 survey effort and only available to those persons responding online or in person to the survey administered during summer 2014. Responses to these questions were quite limited in number. Sixty-one individuals responded to Question 15 on the survey with fewer responses to the remaining questions.

Question 15 asked: “What was the purpose of this visit to the MKARNS corridor on this trip?” Response options provided in the survey included, “Day visit,” “Overnight visit,” “Weekend visit,” and “Other.” Among the sixty-one respondents, the dominance of overnight visitors responding to the survey is evident. The responses showed:

- 7 day visits
- 22 overnight visits
- 32 weekend visits

- 0 “Other”

Question 16 and 17 were intended to ascertain the perception of the recreation visitors regarding the importance of MKARNS. Response levels were so limited and sporadic that interpretation of the responses is meaningless.

Question 16 asked: “From your perspective, how important is public access the MKARNS corridor for recreation such as boating and fishing?” Response options included, “Important,” “Neutral,” and “Unimportant.” All of the online responses were “Important.” During face-to-face interviews with recreation visitors, respondents would add comment beyond the options identified in the survey. These generally focused on comments such as:

- This is my fishing hole.
- This is where our family has come for years.
- Don’t close this place down.

Question 17 asked: “From your perspective, how important is the MKARNS for the economy of Oklahoma?” Again, the response options included, “Important,” “Neutral,” and “Unimportant.” All of the online responses were “Important.” During face-to-face interviews, respondents expressed other perspectives as well:

- I am sure it is important for barges.
- Oklahoma needs the shipping.
- It puts Oklahoma on the map.
- Sometimes there is too much barge traffic in the channel.

One final question, Question 18 asked, “Are you a resident of Oklahoma?” All of the online respondents indicated “Yes,” they were residents of Oklahoma. During face-to-face interviews visitors from Arkansas and Texas did respond to the survey. For those who were not residents of Oklahoma, the survey asked for home zip code. No home zip codes were provided in response to this question.

Economic Impact of Recreation along MKARNS

As presented in this report, the USACE documents 459,235 recreational visitors at the 11 more developed recreation sites along MKARNS. The principal investigator for this project utilized a variety of sources to estimate recreational visitation at 15 of the lesser developed recreation sites not included on the USACE report. As a result, the estimated visitation at these public access locations is 293,600 persons annually.

Based upon years of prior research, the USACE estimates that 80% of visitation to its sites in the Tulsa District is day use with 20% of recreational visits being overnight use. As a result, these visitation patterns of day visitors and overnight visitors along MKARNS show:

- USACE reports of 367,388 day visitors at the monitored locations
- USACE reports of 91,847 overnight visitors at the monitored locations
- USACE reports of a total of 459,235 total visitors at the monitored locations
- Principal investigator estimates of 234,880 day visitors at the unmonitored locations

- Principal investigator estimates of 58,720 overnight visitors at the unmonitored locations
- Principal investigator estimates of 293,600 total visitors at the unmonitored locations
- A total of 602,268 day visitors at all locations
- A total of 150,567 overnight visitors at all locations
- A grand total of 752,835 visitors at all locations along MKARNS

Using the visitation patterns and the expenditure patterns for these visitors, it is possible to estimate the total expenditure of recreational visitors utilizing public access locations along MKARNS. This is comprised of the recreation expenditures by day and overnight visitors within the immediate MKARNS corridor, beyond five miles from the corridor, and the total direct expenditure. The total estimated direct recreational expenditure generated by visits to public access locations along MKARNS is almost $78 million annually.

- 602,268 day visitors spent a total of $69,796,838. Of this total, $41,610,696 was spent within five miles of the MKARNS corridor and $28,186,142 was spent beyond five miles of the MKARNS corridor.
- The typical day visitor spent $69.09 per day of a visit within five miles of the MKARNS corridor.
- The typical day visitor spent $46.80 per day of a visitor beyond five miles of the MKARNS corridor.
- 150,567 overnight visitors spent a total of $8,106,527. Of this total, $5,512,257 was spent within five miles of the MKARNS corridor and $2,594,269 was spent beyond five miles of the MKARNS corridor.
- The typical overnight visitor spent $36.61 per day of a visit within five miles of the MKARNS corridor.
- The typical day visitor spent $17.23 per day of a visitor beyond five miles of the MKARNS corridor.
- 752,835 recreational visitors to the MKARNS corridor spent $77,903,364 per year to visit the MKARNS corridor. Of this total, $47,122,953 was spent within five miles of the MKARNS corridor and $30,780,411 was spent beyond the five mile corridor.

The authors of this report have utilized the Money Generation Model Version 2 (MGM2) to assess economic impact in recreation settings in Oklahoma. While this project was based on IMPLAN, MGM2 is also developed on IMPLAN. For the purposes of this report, the authors selected two important measures to document the economic impact of recreation visitation and expenditures along MKARNS: total economic impact and number of jobs created.

Oklahoma has a multiplier of 1.27 based upon the MGM2 estimation, which yields an economic impact of $98,937,272 from recreational visitors along the MKARNS. With one job resulting from an expenditure of $46,600 according to the MGM2 estimation, there are 2,123 jobs generated by recreational visitors along the MKARNS.

Although recreation was not – and is not – the primary purpose for the McClellan Kerr Arkansas River Navigation System, recreation is clearly an important economic, social, cultural, and personal component of MKARNS.

REFERENCES

IMPLAN – The leading provider of U.S. economic impact data.

Money Generation Model Version 2.

APPENDIX FA – SURVEY OF ASSOCIATED BUSINESSES

Survey of MKARNS Related Businesses

Oklahoma State University is assisting the Oklahoma Department of Transportation and the Arkansas-Oklahoma Port Operators Association in assessing the economic impact of the McClellan-Kerr Arkansas River Navigation System (MKARNS). As part of that assessment, it is important to determine the transportation and commodity flow on the system. Your participation in this survey is completely voluntary and confidential. If you have questions about your rights as a research volunteer, you may contact (1) the Principal Investigator at Oklahoma State University: Lowell Caneday, Ph.D. at 405-744-5503 or Lowell.Caneday@okstate.edu, or (2) the Oklahoma State University Institutional Review Board (IRB) Chair, Dr. Shelia Kennison, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

1. What percentage of your company's business relies upon navigation on the McClellan Kerr Arkansas River Navigation System (MKARNS)?

2. Does your company have a physical presence and space at one of the ports on MKARNS?

Yes or no response

3. Could your company conduct its current business without the navigation and transportation options provided by MKARNS?

Yes or no response

APPENDIX FB – SURVEY OF RECREATION VISITORS

Oklahoma State University is assisting the Oklahoma Department of Transportation, the U.S. Army Corps of Engineers, and the Arkansas-Oklahoma Port Operators Association in assessing the economic impact of the McClellan-Kerr Arkansas River Navigation System (MKARNS). As part of that assessment, it is important to determine the spending patterns and preferences of recreation visitors and tourists along the waterway. The survey will take about 10 minutes of your time. Your participation in this survey is completely voluntary and anonymous. If you have questions about your rights as a research volunteer, you may contact (1) the Principal Investigator at Oklahoma State University: Lowell Caneday, Ph.D. at 405-744-5503 or Lowell.Caneday@okstate.edu, or (2) the Oklahoma State University Institutional Review Board (IRB) Chair, Dr. Shelia Kennison, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

Survey of Visitor Expenditure along MKARNS

Instructions: Please fill in the blanks below to report spending on your party's recent visit to the MKARNS corridor. Indicate that amount spent within five miles of the river corridor and that spent outside the area.

Expenditure category	**Within five miles of the MKARNS corridor**	**More than five miles from the MKARNS corridor**
Lodging (IMPLAN codes 411 & 412)		
1. Lodge, cabins, hotels, motels, B&B rental homes	$	$
2. Campground fees (including hook-ups)	$	$
Food and Beverage (IMPLAN codes 324 & 413)		
3. Restaurants, bars, take-out food/drinks from restaurants	$	$
4. Groceries drinks, take-out food/drinks not from restaurants	$	$
Transportation (IMPLAN codes 326 & 338)		
5. Gas and oil for auto, boat, RV, etc.	$	$
6. Other auto & boat expenses (e.g., repairs, parking, rental, slips, etc.)	$	$
7. Local transportation (e.g., bus, taxi, cab, etc.)	$	$
Recreation (IMPLAN codes 403, 406 through 410)		
8. Admissions and fees (e.g., golf green fees, stables, etc.)	$	$
9. Sporting goods (e.g., boat equipment, fishing gear, etc.)	$	$
10. Casino gambling	$	$
Other expenses (IMPLAN codes 327 & 328)		
11. Clothing	$	$
12. Souvenirs (e.g., Maps, books, mugs, etc.)	$	$
13. How many people were in your party on this trip?		
14. How many nights did you spend in the MKARNS corridor on this trip?		

Thank you for your assistance in this important study related to the McClellan-Kerr Arkansas River Navigation System. Your participation is greatly appreciated.