AN EVALUATION OF THE EFFECTS OF WATER SHORTAGES UPON REGIONAL ECONOMIC TRANSACTIONS

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INTRODUCTION

In many regions in the country and especially in Mississippi, most of the water for residential, commercial, industrial, and municipal purposes is supplied from ground water sources. Adequate water is necessary for economic growth and development.

At times, water shortages occur. This could hinder future development or even curtail current production. Hence, it becomes necessary for planners to quantify the consequences on the economy.

The purpose of this paper is to present a theoretical model whereby a systematic analysis of information upon which decisions in regard to expansion of water services may be made. More specifically, assume that production of certain types of industries of given sizes and developments is curtailed in an area due to a moratorium for insufficient water. The loss of economic activity foregone may be assessed. A hypothetical example will be provided.

METHODOLOGY

An economic input-output approach is suggested. Such a model describes the economic activities of a region in an accounting form. It has three main features:

(1) Transactions Table: The table displays the interindustry flow in the sense that goods are transferred from sectors as output to be used by others as input. An exogenous sector defined as Final Demand which includes households, government, and exports absorbs the remainder of output. Algebraically, this may be expressed by

$$Y_i = \sum_j Y_{ij} + D_i , \qquad (1)$$

where:

Y_i = gross output or total sales of sector i,

Y_{ij} = total sales of sector i to sector j, and,

D_i = total sales of sector i to final demand.

A tabular form of a hypothetical transactions table is given in Table 1. The rows represent the sales of each sector to the others, while the columns represent the purchases. The final row denoted by Final Purchases is the amount of purchases from the other sectors in the economy such as household.

(2) Technical Coefficients Table: Entries in the Transactions Table are transformed into technical coefficients which indicate the input requirements per dollar of output and are expressed as:

$$a_{ij} = \frac{Y_{ij}}{Y_j}, \qquad (2)$$

usually displayed in the form shown in Table 2.

(3) Interdependence Coefficients Table: The coefficients measure the direct and secondary effects of a change in output in each sector. By substituting for Y_{ij} in Equation 1 from Equation 2, the result is

$$Y_i = \sum_j a_{ij} Y_j + D_i , \qquad (3)$$

In compact matrix algebra form, Equation 3 may be written as

$$Y - AY = D,$$

hence:

$$Y = [I\text{-}A]^{-1} D.$$

Aside from the three basic tables, an input-output model provides other tools for analytical or predictive purposes. Among the most prominent are output, employment, and income multipliers. These multipliers measure the total change in output, employment, and income in the entire economy of the region due to a change in output, employment, and income in any one of the producing sectors.

Exogenous changes that are caused by new investments or adjustments in the levels of economic activities such as the construction of public or private facilities can be readily analyzed through the apparatus of input-output.

Assume that an I-0 model of a region is comprised of four major producing sectors as follows:

Y_1 = Construction,
Y_2 = Manufacturing,
Y_3 = Services, and,
Y_4 = State and Local Government.

Table 1 is the Transaction Table and Table 2 is the Direct Requirements Table for this hypothetical example.

Assume further that production operations due to lack of water resources have to be curtailed by sectors Y_1 and Y_2 by the amounts of $100 million and $500 million respectively. Then by modifying the current Transactions Table, the impact of loss of trade on all sectors may be estimated. The proposed modification is based in part on procedures adopted from intraregional input-output methodology described by Cartwright (1).

Let: r: study region,
u: unaffected economic sectors,
v: affected economic sectors,

then from Equation 1, economic transactions between the two sectors are:

$$Y_i^r = \sum_j Y_{ij}^r + D_i^r,$$

$$Y_i^u = \sum_j Y_{ij}^{uu} + \sum_j Y_{ij}^{uv} + D_i^u,$$

$$Y_i^v = \sum_j Y_{ij}^{vu} + \sum_j Y_{ij}^{vv} + D_i^v.$$

In matrix notation,

$$\begin{bmatrix} Y^r \end{bmatrix} = \begin{bmatrix} Y_i^u \\ \\ Y_i^v \end{bmatrix} = \begin{bmatrix} Y_{ij}^{uu} + Y_{ij}^{uv} + D_i^u \\ \\ Y_{ij}^{vu} + Y_{ij}^{vv} + D_i^v \end{bmatrix} \qquad (4)$$

and

$$D_i^r = D_i^u + D_i^v$$

The original Transaction Table given in Table 1 may be modified to the form of Equation 4 by adjusting the direct requirements a_{ij} given in Table 2 by the coefficients of location quotients defined as follows:

$$LQ_i^u = \frac{\dfrac{Y_i^u}{\sum_i Y_i^u}}{\dfrac{Y_i^r}{\sum_i Y_i^r}}, \quad \text{and} \quad LO_i^v = \frac{\dfrac{Y_i^v}{\sum_i Y_i^v}}{\dfrac{Y_i^r}{\sum_i Y_i^r}}$$

where

$$LQ_i = \begin{bmatrix} 1 & LQ_i > 1 \\ \\ LQ_i & LQ_i < 1 \end{bmatrix}$$

The sequence for obtaining the values in (4) is as follows:

$$(1) \quad Y_{ij}^{uu} = a_{ij}^{uu} Y_j^u,$$

$$a_{ij}^{uu} = (LQ_i^u)(a_{ij}^r).$$

$$(2) \quad Y_{ij}^{uv} = a_{ij}^{uv} Y_j^v,$$

$$a_{ij}^{uv} = a_{ij}^r - a_{ij}^{vv},$$

$$a_{ij}^{vv} = (LQ_i^v)(a_{ij}^r).$$

$$(3) \quad Y_{ij}^{vu} = a_{ij}^{vu} Y_j^u,$$

$$a_{ij}^{vu} = a_{ij}^r - a_{ij}^{vu},$$

$$a_{ij}^{uu} = (LQ_i^u)(a_{ij}^r).$$

$$(4) \quad Y_{ij}^{vv} = a_{ij}^{vv} Y_j^v,$$

$$a_{ij}^{vv} = (LQ_i^v)(a_{ij}^r).$$

The new final demands D_i^u and D_i^v and final purchases V_j^u and V_j^v can be found from the following relations:

$$D_i^u = Y_i^u - \sum_j Y_{ij}^{uu} - \sum_j Y_{ij}^{uv},$$

$$D_i^v = Y_i^v - \sum_j Y^{vv} - \sum_j Y_{ij}^{vu},$$

$$V_j^u = Y_j^u - \sum_i Y_{ij}^{uu} - \sum_i Y_{ij}^{vu},$$

$$V_j^v = Y_j^v - \sum_i Y_{ij}^{vv} - \sum_i Y_{ij}^{uv}.$$

Results of calculation by section for these equations are given in Tables 3 and 4.

Table 3 shows current total output, the hypothetical unaffected area's total output, the affected area's total output, and the appropriate location quotients by sector. The values of LQ_i^u for the unaffected sectors are greater than 1, while those for the affected sectors are less than 1.

Table 4 is the modified transactions matrix. The four parts of the table may be explained as follows:

(1) Y^{uu} : The elements in this portion represent the sales and purchases of the unaffected industries. In a sense, these entries comprise the new transactions matrix of the region.

(2) Y^{uv} : The elements in this section represent the decreased sales of the unaffected industries to the affected sectors. For instance, the loss to sector Y_3 is \$10.3 million from Y_1 and \$40.1 million from sector Y_2 . That is, the total decrease in the demand for the products of sector Y_3 is approximately \$50.4 million.

(3) Y^{vu} : The elements in this matrix represent the loss in supply of the affected sectors. For instance, sector Y_3 has its supplies decreased by \$1.9 million from sector Y_1 and \$5.8 million from sector Y_2.

(4) Y^{vv} : The elements in this matrix represent the direct losses within the affected sectors. For instance, the loss of sales of sector Y_1 to sector Y_2 in the affected industries is approximately \$26.5 million.

BIBLIOGRAPHY

(1) J. V. Cartwright, R. M. Beemiller, E. A. Trott, Jr., and J. M. Younger. "Regional Impacts with Demand-Driven and Supply Constrained I/O Inverses." SRSA Annual Meeting, Knoxville, Tennessee, May 1982.

TABLE 1
TRANSACTION MATRIX
VALUES IN \$ THOUSANDS

	Y_1	Y_2	Y_3	Y_4	Intermediate Demand	Final Demand	Total Output
Y_1	17,393	113,804	26,638	124,424	282,250	285,975	568,225
Y_2	94,929	659,388	39,485	56,600	850,402	1,298,200	2,148,602
Y_3	58,395	172,531	116,763	115,207	462,896	755,073	1,217,969
Y_4	37,894	113,986	135,227	154,526	441,633	956,351	1,397,984
Endogenous Totals	208,611	1,059,709	318,113	450,748			
Final Purchases	359,614	1,088,893	899,856	947,236			
Total	568,225	2,148,602	1,217,969	1,397,984			5,332,780

TABLE 2
DIRECT REQUIREMENTS MATRIX

	Y_1	Y_2	Y_3	Y_4
Y_1	.03060	.05297	.02187	.08902
Y_2	.16707	.30689	.03242	.04048
Y_3	.10277	.08029	.09586	.08240
Y_4	.06668	.05306	.11103	.11053
Endogenous Totals	.36712	.49321	.26118	.32243
Final Purchases	.63288	.50679	.73882	.67757
Total	1.0000	1.0000	1.0000	1.0000

TABLE 3
LOCATION QUOTIENTS
(Thousands of dollars)

Sector	Current Total Output	Unaffected Total Output u_i	LQ_i^u	Affected Total Output v_i	LQ_i^v
Y_1	568,225	468,225	$\frac{.0989}{.1065} = .9286$	100,000	$\frac{.1666}{.1065} = 1.5643$
Y_2	2,148,602	1,648,602	$\frac{.3483}{.4029} = .8644$	500,000	$\frac{.8333}{.4029} = 2.0682$
Y_3	1,217,969	1,217,969	$\frac{.2573}{.2283} = 1.1270$	0	
Y_4	1,397,984	1,397,984	$\frac{.2953}{.2621} = 1.1266$	0	
Total	5,332,780	4,732,780		600,000	

TABLE 4
MODIFIED TRANSACTIONS MATRIX
(Thousands of dollars)

		U				V					
		Y_1	Y_2	Y_3	Y_4	Y_1	Y_2	Y_3	Y_4	Final Demand	Total
U	Y_1	13,305	81,091	24,735	115,563	0	0	0	0	233,531	468,225
	Y_2	67,619	437,334	34,132	48,917	0	0	0	0	1,060,600	1,648,602
	Y_3	48,119	132,366	116,763	115,207	10,276	40,165	0	0	755,073	1,217,969
	Y_4	31,221	87,474	135,227	154,526	6,673	26,512	0	0	956,351	1,397,984
V	Y_1	1,028	6,228	1,903	8,861	3,060	26,485	0	0	52,444	100,000
	Y_2	10,603	68,555	5,353	7,683	16,707	153,499	0	0	237,600	500,000
	Y_3	0	0	0	0	0	0	0	0	0	0
	Y_4	0	0	0	0	0	0	0	0	0	0
	Final Purchases	296,330	835,554	899,856	947,227	63,284	253,339	0	0		
	Total	468,225	1,648,602	1,217,969	1,397,984	100,000	500,000	0	0		5,332,780