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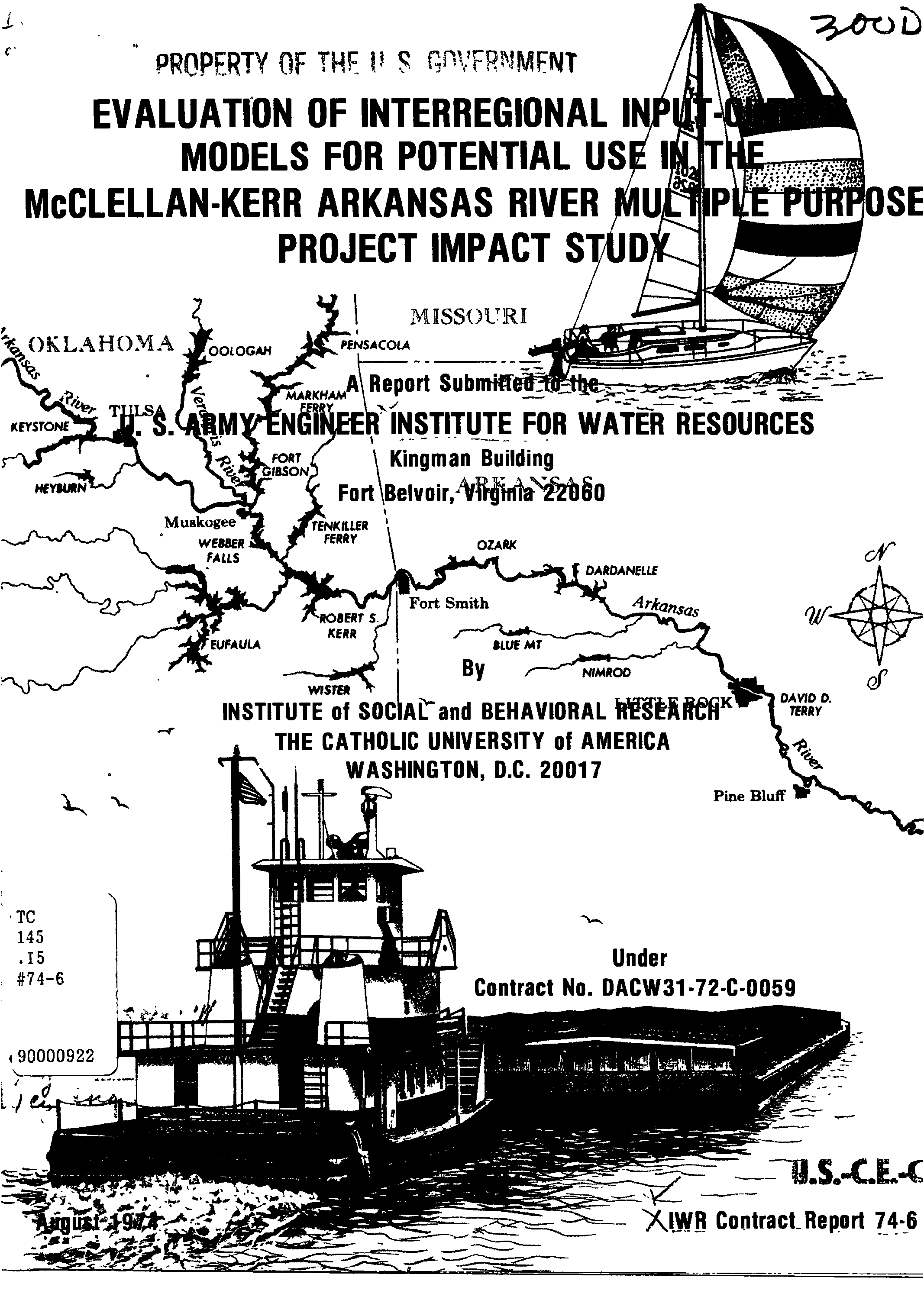
EVALUATION OF INTERREGIONAL INPUT-OUTPUT MODELS FOR POTENTIAL USE IN THE McCLELLAN-KERR ARKANSAS RIVER MULTIPLE PURPOSE PROJECT IMPACT STUDY



A Report Submitted to the

U. S. ARMY ENGINEER INSTITUTE FOR WATER RESOURCES

Kingman Building
Fort Belvoir, Virginia 22060

By

INSTITUTE of SOCIAL and BEHAVIORAL RESEARCH
THE CATHOLIC UNIVERSITY of AMERICA
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Project Impact Study

U.S. Army Engineer
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Chapter 1

INTRODUCTION

Purpose of the Research

The purpose of this research is (1) to critically re-examine and evaluate the current state of input-output models in use and (2) to recommend an empirically feasible inter-regional I/O model for use by the McClelland-Kerr Arkansas River Multiple Purpose Project Impact Study (MKARMPPIS).[1] It is not the intent of this study to actually construct a model, but rather to suggest a theoretically sound and empirically feasible model to analize the impact of the Arkansas River project.

Organization of the Report

Following the introduction some theoretical aspects of I/O analysis will be briefly surveyed in Chapter 2. Chapter 3 contains an investigation of some empirical works of inter-regional I/O studies. In Chapter 4, a proposed interregional I/O model in terms of broad guidelines will be presented. Finally, the summary of this study will be included in Chapter 5.

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[1] The McClellan-Kerr Arkansas River Multiple Purpose Project consists of 17 locks and dams, several canals and 10 power houses along 450 miles of the Arkansas River between the junction of the Arkansas and Mississippi Rivers and Tulsa, Oklahoma. The projects cost 1.2 billion dollars in 1968 prices. The waterway to Tulsa was completed at the end of 1970. The principal benefits of the project are: water transportation, supply of water and electric power, and flood control. See Map 1, Arkansas River Basin.

MAP 1 - ARKANSAS RIVER BASIN

Chapter 2

THEORETICAL ASPECTS OF INPUT-OUTPUT MODELS

National Model

Since its introduction in the 1930's by Professor Wassily Leontief, I/O analysis has been extensively utilized as a means of investigating structural interrelationships among industries and projecting the level of change in the economy under a given condition of autonomous change in final demands. Much has been said about the strengths and weaknesses associated with using this type of analysis. The ability to analize the impact of a public project upon the strucutral relationships of many industrial sectors, under general equilibrium conditions, is a major strength of the model. However, there are major difficulties resulting from the assumptions of constant structural relationships, constant economies of scale, and the large data and resource requirements in the construction of the model.[1]

The core of an I/O model consists of three basic sets of equations: structural, balance, and solutions equations. A national I/O model will be explained through these equations.

Structural equations

Structural equations are the basic formula which represents

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[1] For a complete description of the theoretical foundation of input-output analysis see: Hollis Chenery and Paul G. Clark, Interindustry Economics (New York: John Wiley and Sons, Inc., 1959). Wassily Leontief, Input-Output Economics (New York: Oxford University Press, 1965). William H. Miernyk, The Elements of Input-Output Analysis (New York: Random House, 1965)

interindustry dependencies of an economy. The equation takes the formula $a_{ij} = \frac{x_{ij}}{x_j}$

where a_{ij} is an input coefficient which gives the inputs from various supplying industries required by a producing industry to produce a dollar's worth of its product, x_{ij} equals the total value of commodity i purchased by j^{th} industry, and x_j equals the total outlay of j^{th} industry which equals the total output of that industry.

If A is the representative matrix of technical coefficients, structural relationships with n industrial sectors will be expressed as:

$$A = \begin{bmatrix} a_{11}a_{12}\cdots a_{1n} \\ a_{21}\cdots\cdots a_{2n} \\ \cdots\cdots\cdots\cdots \\ \cdots\cdots\cdots\cdots \\ a_{n1}\cdots\cdots a_{nn} \end{bmatrix}$$

Balance equations

The balance equation in the I/O model states that the total output of each industry is equal to the sum of the interindustry (intermediate) demand and final demand: $x_i = \sum_{j=1}^{n} a_{ij}x_j + y_i$

where x_i is the output of commodity i, $\sum_{j=1}^{n} a_{ij}x_j$ equals the interindustry demand for the commodity i and y_i equals the final demand for the commodity i. Balance equations for the entire economy in matrix form are as follows:

$$(X-AX = Y) = \begin{bmatrix} x_1 - a_{11}x_1 - a_{12}x_2 \ldots a_{1n}x_n = y_1 \\ x_2 - a_{21}x_1 - a_{22}x_2 \ldots a_{2n}x_n = y_2 \\ . \quad . \quad . \quad . \quad . \\ . \quad . \quad . \quad . \quad . \\ . \quad . \quad . \quad . \quad . \\ x_n - a_{n1}x_1 - a_{n2}x_2 \ldots a_{nn}x_n = y_n \end{bmatrix}$$

Solution equations

Total outputs of industries (X) can be estimated by solving the above balance equations if the structural coefficients (A) and the final demands (Y) are given. Mathematically the balance equations can be solved by inverting the difference of the identity matrix and A matrix, $X = (I-A)^{-1}Y$, which is the rearrangement of $(I-A)\ X = Y$ which is again derived by factoring the balance equation $X-AX=Y$.

The mathematical relationships expressed above apply to any type of I/O model: regional and interregional. As shown above if we can estimate structural coefficients and final demand matrices, the rest of the impact study is a mere mathematical computation. In the I/O analysis, therefore, our main concern is how to estimate structural and final demand matrices.

Regional Model

With increasing national concern for regional economic analysis[2] the number of I/O models applied to regional economic studies has rapidly expanded.[3] The I/O model applied to regional analysis has weaknesses in addition to those present in national application. Nevertheless, the I/O model is extensively applied in regional analysis. The predominant use of I/O analysis in regional application has been a single region model which is the direct application of a national I/O model to a single region. This type of model is called a "regional I/O model."

The adequacy of this model for a regional study has been criticized on several accounts. Exports to and imports from other regions are lumped together without identifying their origin and destination. Generally, regional economies are far less self-sufficient. They are very dependent on other regions for supplies and markets. Regions are so closely interrelated that the impact of an investment project on one region cannot be fully understood unless interregional relationships are studied. This is especially true in the case of the MKARMP project, which was designed to not only improve the economic conditions of the project area but also

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[2] For the development of regional economic studies see: John Meyer, "Regional Economics: A Survey," American Economic Review, LII (March, 1965), 19-54.

[3] Phillip Bourque and Millicent Cox, An Inventory of Regional Input-Output Studies in the United States (Seattle: Graduate School of Business Administration, University of Washington, 1970).

to stimulate the economies of neighboring regions.

Another criticism is that the regional I/O model ignores feedback effects and the impact of economic changes in other regions on the study region. Although there is no general index, some empirical studies have shown that by ignoring the feedback effects, regional models have significantly underestimated the regional economic impacts.[4] The I/O model which overcomes these defects is an interregional I/O model closed on the national boundary.

Interregional Model

When more than one region is considered in an I/O model, two sets of structural relationships are apparent: industrial relationships and trade relationships. An I/O model for multiregional study is called an "interregional I/O model."[5] Due to the increased requirements for detailed information, it is more difficult to construct this type of model. Further, such infor-

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[4] In his economic impact study of the Italian economy, divided into two regions, Chenery estimated that the change in level of income upon the change in final demand in the southern half of Italy will be underestimated by 18 percent when the feedback effects from the northern half were ignored. See Chenery, op. cit., Chapter 12.

In his regional impact study of nine U. S. regions, on the other hand, Greytak has estimated that by ignoring feedback effects the impact on each region was understated by an average of 27%. See David Greytak, "Regional Impact of Interregional Trade in Input-Output Analysis," The Regional Science Association Papers, XXV (1970) 203-217.

[5] For a detailed discussion of an interregional model see: Chenery, Leontief, and Miernyk op. cit., and John H. Cumberland "Interregional and Regional Input-Output Techniques," Methods of Regional Analysis by Walter Isard (Cambridge, Massachusetts: The MIT Press, 1960), p. 309-74.

mation is many times not available. The new relationships state the amount of commodity i from region r which is required to produce one dollar's worth of output for industry j located in region s. Using the Isard notation,[6] these new coefficients are denoted by a_{ij}^{rs}.

Moses Model

To distinguish a_{ij}^{rs} from a_{ij} we rewrite the two dimensional structural coefficient into separate components in terms first delineated by Moses, i. e., $a_{ij}^{rs} = a_{ij}^{s} \cdot t_{ij}^{rs}$. The a_{ij}^{s}'s are the technical coefficients in the region s which means the amount of commodity i required by industry j located in region s, regardless of where the sources are located. This differs from the conventional regional table in which the coefficient is computed only for the input requirements from the studied region. The term t_{ij}^{rs} is a trade coefficient and gives the amount of commodity i produced in region r which goes to industry j located in region s. Following the same fashion as in the national or regional model, the total output and industrial and trade relationships will be estimated by solving the matrix equation $X = [1-TA]^{-1}TY$ if trade coefficients T, regional production coefficients A, and regional final demands Y, are known.[7]

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[6] Walter Isard, "Interregional and Regional Input-Output Analysis: A Model of a Space-Economy," Review of Economics and Statistics, XXXIII, No. 4, (November, 1951), 318-28.

[7] Leon N. Moses, "The Stability of Interregional Trading Patterns and Input-Output Analysis," American Economic Review, XLV, No. 5 (December, 1955), 803-32.

The trade information required for such a model involves both industrial and space dimensions, i.e., tracing the trade of commodity i produced in one region to the different industries in different regions. However, the data for this level of disaggreration is not readily available, nor is an extensive survey practical. To apply this model in empirical study, Moses was able to reduce a substantial amount of information required to construct the model by assuming that every industry including the final users using i commodity in the same region would purchase the commodity both from domestic and imported sources in the same proportion. This is expressed by $t_{ij}^{rs} = t_i^{rs}$ for all j.[8] The trade coefficient t_i^{rs} represents the fraction received from r of the total amount of commodity i received by region s from other regions including itself, i.e., $\sum_{r=1}^{n} t_i^{rs} = 1$.[9]

Table 1, Interregional Input-Output Coefficient Matrix, shows an interregional I/O table for a three region model: East, Middle West, and West. Each regional economy is comprised of three industrial sectors: agriculture, manufacturing, and service industries. The forth row block, total input $[a_{ij}^s]$, gives the

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[8] The same trade coefficients are expressed as "Supply Coefficients" by Chenery, op. cit., Chapter 12.

[9] This method of deriving the trade coefficients, i. e., dividing the receipts of a commodity from a particular region by the total receipts of that commodity by the receiving region, is called the "column coefficient model." On the other hand, in the "row coefficient model," the trade coefficients are estimated by dividing the shipments of a commodity to a particular region by the total shipments of that commodity by the shipping region.

TABLE I REGIONAL INPUT-OUTPUT COEFFICIENT MATRIX

Producing Region \ Consuming Region	1. East			11. Middle West			111. West		
	1 Agr.	2 Mfg.	3 Svc.	1 Agr.	2 Mfg.	3 Svc.	1 Agr.	2 Mfg.	3 Svc.
I. East									
1. Agriculture	$a^{1}_{11}(t^{11}_{1})$	$a^{1}_{12}(t^{11}_{1})$	$a^{1}_{13}(t^{11})$	$a^{2}_{11}(t^{12}_{1})$	$a^{2}_{12}(t^{12}_{1})$	$a^{2}_{13}(t^{12}_{1})$	$a^{3}_{11}(t^{13}_{1})$	$a^{3}_{12}(t^{13}_{1})$	$a^{3}_{13}(t^{13}_{1})$
2. Manufacturing	$a^{1}_{21}(t^{11}_{2})$	$a^{1}_{22}(t^{11}_{2})$	$a^{1}_{23}(t^{11}_{2})$	$a^{2}_{21}(t^{12}_{2})$	$a^{2}_{22}(t^{12}_{2})$	$a^{2}_{23}(t^{12}_{2})$	$a^{3}_{21}(t^{13}_{2})$	$a^{3}_{22}(t^{13}_{2})$	$a^{3}_{23}(t^{13}_{2})$
3. Services	$a^{1}_{31}(t^{11}_{3})$	$a^{1}_{32}(t^{11}_{3})$	$a^{1}_{33}(t^{11}_{3})$	$a^{2}_{31}(t^{12}_{3})$	$a^{2}_{32}(t^{12}_{3})$	$a^{2}_{33}(t^{12}_{3})$	$a^{3}_{31}(t^{13}_{3})$	$a^{3}_{32}(t^{13}_{3})$	$a^{3}_{33}(t^{13}_{3})$
II. Middle West									
1. Agriculture	$a^{1}_{11}(t^{21}_{1})$	$a^{1}_{12}(t^{21}_{1})$	$a^{1}_{13}(t^{21}_{1})$	$a^{2}_{11}(t^{22}_{1})$	$a^{2}_{12}(t^{22}_{1})$	$a^{2}_{13}(t^{22}_{1})$	$a^{3}_{11}(t^{23}_{1})$	$a^{3}_{12}(t^{23}_{1})$	$a^{3}_{13}(t^{23}_{1})$
2. Manufacturing	$a^{1}_{21}(t^{21}_{2})$	$a^{1}_{22}(t^{21}_{2})$	$a^{1}_{23}(t^{21}_{2})$	$a^{2}_{21}(t^{22}_{2})$	$a^{2}_{22}(t^{22}_{2})$	$a^{2}_{23}(t^{22}_{2})$	$a^{3}_{21}(t^{23}_{2})$	$a^{3}_{22}(t^{23}_{2})$	$a^{3}_{23}(t^{23}_{2})$
3. Services	$a^{1}_{31}(t^{21}_{3})$	$a^{1}_{32}(t^{21}_{3})$	$a^{1}_{33}(t^{21}_{3})$	$a^{2}_{31}(t^{22}_{3})$	$a^{2}_{32}(t^{22}_{3})$	$a^{2}_{33}(t^{22}_{3})$	$a^{3}_{31}(t^{23}_{3})$	$a^{3}_{32}(t^{23}_{3})$	$a^{3}_{33}(t^{23}_{3})$
III. West									
1. Agriculture	$a^{1}_{11}(t^{31}_{1})$	$a^{1}_{12}(t^{31}_{1})$	$a^{1}_{13}(t^{31}_{1})$	$a^{2}_{11}(t^{32}_{1})$	$a^{2}_{12}(t^{32}_{1})$	$a^{2}_{13}(t^{32}_{1})$	$a^{3}_{11}(t^{33}_{1})$	$a^{3}_{12}(t^{33}_{1})$	$a^{3}_{13}(t^{33}_{1})$
2. Manufacturing	$a^{1}_{21}(t^{31}_{2})$	$a^{1}_{22}(t^{31}_{2})$	$a^{1}_{23}(t^{31}_{2})$	$a^{2}_{21}(t^{32}_{2})$	$a^{2}_{22}(t^{32}_{2})$	$a^{2}_{23}(t^{32}_{2})$	$a^{3}_{21}(t^{33}_{2})$	$a^{3}_{22}(t^{33}_{2})$	$a^{3}_{23}(t^{33}_{2})$
3. Services	$a^{1}_{31}(t^{31}_{3})$	$a^{1}_{32}(t^{31}_{3})$	$a^{1}_{33}(t^{31}_{3})$	$a^{2}_{31}(t^{32}_{3})$	$a^{2}_{32}(t^{32}_{2})$	$a^{2}_{33}(t^{32}_{3})$	$a^{3}_{31}(t^{33}_{3})$	$a^{3}_{32}(t^{33}_{3})$	$a^{3}_{33}(t^{33}_{3})$
Total Inputs									
1. Agriculture	a^{1}_{11}	a^{1}_{12}	a^{1}_{13}	a^{2}_{11}	a^{2}_{12}	a^{2}_{13}	a^{3}_{11}	a^{3}_{12}	a^{3}_{13}
2. Manufacture	a^{1}_{21}	a^{1}_{22}	a^{1}_{23}	a^{2}_{21}	a^{2}_{22}	a^{2}_{23}	a^{3}_{21}	a^{3}_{22}	a^{3}_{23}
3. Service	a^{1}_{31}	a^{1}_{32}	a^{1}_{33}	a^{2}_{31}	a^{2}_{32}	a^{2}_{33}	a^{3}_{31}	a^{3}_{32}	a^{3}_{33}
		a^{1}_{ij}			a^{2}_{ij}			a^{3}_{ij}	

Sources: Leon Moses, "The Stability of Interregional Trading Patterns and Input-Output Analysis" The American Economic Review, XLV (Dec., 1955) p. 809. Original Table is modified by adding column totals.

regional technical coefficients which show the inputs required by various producing industries from various supplying industries in order to produce one dollar's worth of output in region s without identifying the origin of inputs. a^1_{ij} represents the production function of region East and contains $3^2 = 9$ a_{ij}'s. The total information required for the three regional production function will be, therefore, $3^2 \times 3 = 27$.

The sources of origin and amount of inputs required for the production in each region are shown in the first three row blocks. The $a^1_{ij} \cdot t^{11}_{ij}$ in the first row block in the East region represents intraregional input shipments which are the conventional input-output tables in a single region I/O model. The second and third row blocks in the same region $a^1_{ij} \cdot t^{21}_{ij}$ and $a^1_{ij} \cdot t^{31}_{ij}$ represent inputs which are imported from each industry in the Middle West and Western regions, respectively. The total number of pieces of trade information required for this model are $3^2 \times 3^2 = 81$. If we follow Moses assumption of $t^{rs}_{ij} = t^{rs}_i$ the amount of required information will be reduced to $3^2 \times 3 = 27$.

Since surveys of regional input-output relationships in various regions are so expensive, most of the current empirical works using interregional I/O models substitute a national technical coefficient for the regional production function. In our example this substitution will reduce input-output information from three regional sets to one national set which contains 9 pieces of information. Thus, total requirements for technical and trade information for the above model can be reduced from 108 to 36. This is still four times greater than that data necessary for a single region model. In constructing an interregional I/O model, our primary concern is in the estimation of technical and trade coefficients and the validity of their use for a long-run projection.

Leontief's Intranational Model

In order to eliminate the problem of estimating a huge number of trade coefficients, Leontief, in cooperation with Isard, developed the "intranational I/O model."[10] This model classifies commodities into national and regional goods. National goods are the goods traded nationwide and will be produced by regions each with fixed shares of national demand, regardless of the location of the demand; while regional goods will be produced and consumed within each region. With the combination of the technical coefficients and the classification system of goods, the distribution of the national impact of changing national final demand on each region has been estimated. This model, however, does not show interregional relationships. Since the location of any investment project is considered a decisive factor in influencing the level of regional final demands, and we are interested in interregional relationships; this model is disregarded for further

[10] For a detailed discussion of the model see: Wassily W. Leontief, Studies in the Structure of the American Economy, (New York: Oxford University Press, 1953), p. 93-184.

consideration in this study.

Gravity Model

Census does not offer entire required trade information even for one base year. Leontief and Strout have developed a so-called "Gravity Model" to estimate trade flow information for an interregional I/O model.[11] Their model employs the law of gravity and probability theory to express a relationship of an interregional trade flow of a commodity from one region to another. This flow, $(X_{i,gh})$, is a positive function of the total output of the commodity in region g, $(X_{i,go})$; total consumption in region h, $(X_{i,oh})$; and interregional coefficients of the commodity, $(Q_{i,gh})$, (which is composed of many factors among which transportation cost is a vital factor); and inverse function of the total national output of the commodity, $(X_{i,oo})$, (which is assumed to be equal to the total national consumption): i.e., $X_{i,gh} = \frac{X_{i,go} X_{i,oh}}{X_{i,oo}} Q_{i,gh}$. In essence, this model is first used to estimate the trade coefficients utilizing the base year information of national and regional output, input, and trade flows. New trade flows will be estimated by applying base year trade coefficients to the regional input and output data derived through

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11 For a detailed discussion see: Wassily Leontief and Alan Strout, "Multi-regional Input-Output Analysis," Input-Output Economics, ed. by Wassily Leontief (New York: Oxford University Press, 1966), p. 223-57 and Karen R. Polenske, "Empirical Implementation of a Multiregional Input-Output Gravity Trade Model," Contribution to Input-Output Analysis. ed. by A. P. Carter and A. Brody (Amsterdam: North-Holland Publishing Co., 1970), p. 143-163.

the I/O model. The strength of this model is that it can estimate trade coefficients even without having base year trade flow information if regional input and output data are available.

Linear Programming and Dynamic Models

The critics of the I/O model, however, have raised a serious objection to the assumptions underlying the use of fixed proportions in production and trade functions. This criticism is pointed toward the effectiveness of the I/O model as a tool for projection, especially for long term projection. Resource and/or capacity limitations to increased levels of output or changes in comparative cost advantages among production locations, might cause technical and trade coefficients to vary even over short periods of time. The statbility of the structrual coefficients is an empirical question. An empirical test by Moses has exhibited that trade patterns are sufficiently stable for short-run economic analysis under less than full employment conditions.[12]

Linear programming techniques[13] have been applied in an interregional I/O analysis to accomodate possible changes in the existing trade patterns in the process of maximizing some

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[12] Moses, op. cit., p. 806.

[13] For a detailed discussion of a linear programming technique see Robert Dorfman, Paul A. Samuelson, and Robert M. Solow, Linear Programming and Economic Analysis (New York: McGraw-Hill Book Co., 1958).

objective functions, such as profit maximization or least transportation cost, under various resource restrictions including production and transportation capacities. But this type of model requires more information than in conventional I/O studies and still remains a theoretical exposition.[14]

The most current I/O models designed to estimate economic impacts around or after 1970 have used national technical coefficients of 1963 or earlier base years. Some national I/O studies have updated technical coefficients for a long-run projection by extrapolating historical trends and using informed judgment.[15]

In the United States only a partial form of dynamic analysis[16] has been applied to national or regional I/O models.[17] In these

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[14] Some of the studies are: Curtis C. Harris, Jr., "A Multiregional, Multi-industry Forecasting Model," The Regional Science Association Papers, XXV (1970), 169-180, and Leon N. Moses, "A General Equilibrium Model of Production, Interregional Trade, and Location of Industry," Review of Economics and Statistics, XLII, No. 4 (November, 1955), 803-832.

[15] The Department of Labor, for example, has projected industrial relationships and employment projection for 1970 and 1980 through the I/O analysis in which the 1958 input-output coefficients are projected for 1970 and 1980.

[16] For a detailed discussion of a dynamic theory in I/O analysis see: Wassily Leontief, "Dynamic Analysis," Studies in the Structure of the American Economy, ed. by Wassily Leontief and others. (New York: Oxford University Press, 1953) pp. 53-92, and ibid., "The Dynamic Inverse," Contributions to Input-Output Analysis ed. by A. P. Carter and A. Brody (Amsterdam: North-Holland Publishing Co., 1972), p. 17-46.

[17] **Examples: for a national model: Clopper Almon Jr.,** The American Economy to 1975 (New York: Harper and Row, 1966), and for a single region model: Gerald Arthur Doeksen, and Dean F. Sohreiner, A Simulation Model for Oklahoma with Economic Projections from 1963 to 1980. Bulletin B-693, Agricultural Experiment Station, Oklahoma State University (Oklahoma: Oklahoma State University, May, 1971).

models, given an initial change in the base year final demand, successive final demands are projected within the system over a period of time. Econometric submodels were used in projecting the major components of the final demand vectors. The advantage of these dynamic models is that one can estimate the comprehensive, long run economic impacts of an investment. The total impact includes direct, indirect, income and investment multipliers. The investment multiplier effect is the same as the accelerator effect. This author has used the term "a partial dynamic model" because although these models are designed to measure the dynamic impact of the initial final demands, they failed to adjust constant structural coefficients parallel with the change in time.

Two Japanese studies[18] (1968, 1970) have tried a full scale, dynamic interregional analysis in the empirical study which consists of nine internal regions with 10 sector economies in each region. The model was designed to estimate a long run impact of alternative transportation investments on national and regional economies. The model has been constructed to integrate the effect of reduced transportation rates resulting from the investment. These changes in transportation rates cause changes in the production coefficients and trade patterns. Further, the different

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[18] Kozo Amano and Masahisa Fujita, A Study on the Regional Economic Efficiency of Improving Transportation Facilities (Kyoto, Japan: Kyoto University, 1968). and ibid., "A Long Run Economic Effect Analysis of Alternative Transportation Facility Plans - Regional and National," Journal of Regional Science, X No. 8 (1970), 297-323.

investment projects would result in different final demand vectors. Since the final demand vectors were projected within the system, any initial change in final demands would result in different projections for final demands throughout the period considered. Econometric submodels are combined with the Moses interregional I/O model. The model has been found to be successful in that the outputs projected by the model correspond to the base year information. To apply such a model for the U. S. economy would be extremely difficult. Much of the required data does not exist, particularly the data on capital stock, and the production cost differentials by industry in each region.

The examination of the forementioned models suggest that our choice of an interregional model for the MKARMPPIS is a type of Moses model with the trade coefficients estimated either by census reports combined with surveys or by a gravity model, if the base year trade information is not available. This type of model has a fixed production and trade coefficients. Therefore, our investigations of empirical works have been limited to those works which followed Moses model and/or modified the model with gravity techniques.

Chapter 3

INVESTIGATION OF EMPIRICAL MULTIREGIONAL I/O MODELS

The four empirical, fixed column coefficient, interregional I/O models of the Moses type investigated were: the Harvard Study[1] by Karen Polenske, the Appalachian Study[2] by the Research and Development Corporation, the Washington University Study[3] edited by Charles Leven, and the Eleven Western States Study[4] by H. Craig Davis and later modified by Davis & Everard Lofting.[5] The first three models were similar in that the researchers completely constructed the model and had to prepare their own estimates of output, trade coefficients and total demand. In the fourth model the researchers used existing regional input-

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[1] Karen R. Polenske, Multiregional Input-Output Model for the United States Harvard Research Project, Report No. 1. (Cambridge, Massachusetts: Harvard University, 1970).

[2] Research and Development Corporation, Preliminary Analysis: An Analytical System for the Measurement of Economic Impacts in Appalachia Prepared for the Office of Appalachian Studies, U. S. Army Corps of Engineers, October, 1966.

[3] Charles L. Leven, editor, Development Benefits of Water Resource Investments Prepared for the Institute for Water Resources, U. S. Army Corps of Engineers, November, 1969.

[4] Craig H. Davis, Multiregional Input-Output Techniques and Western Water Resources Development, Prepared for the Water Resources Center, U. S. Army Corps of Engineers.

[5] Craig H. Davis, and Everard M. Lofting, Multisectoral Model of Pacific Mountain Interstate Trade Flows to be published by the Institute for Water Resources in 1972.

output models and modified them for interregional analysis. Since the MKARMPPIS model would probably require estimates of output, trade coefficients and total demand for the several regions, the first three studies will be discussed first and in more detail than the other study. The Harvard model was the most detailed and comprehensive model, and the methods used to obtain estimates of the required data were often more clearly explained in this study than in the other studies. Further, the methodologies used for the first three studies were similar and the basic data sources were often the same. For these reasons the Harvard study will be discussed in detail while the methodologies used for the Appalachian and Washington University studies will be briefly sketched and the important differences between them and the Harvard study will be noted.

The Harvard Study

The Harvard study is a multiregional I/O model of the entire United States. The country is divided into 44 regions corresponding to states, or in some cases, groups of states. The model contains eighty-six industries, sixty-one of which are producing industries and the remaining fifteen are service or value added industries. The purpose of the study is two fold; first, to construct a multiregional I/O model of the United States for 1964 and, second, given the 1963 technology and interregional trade data and projected sets of final demands for 1970 and 1980, to estimate 1970 and 1980 regional outputs and shipments of commodities among the regions within the model. To accomplish these purposes "five major sets of multiregional input-output data have been compiled for each state: base year outputs, employment, and payrolls; 1963 interindustry flows; 1963 interregional trade flows; base-year final demands; and 1970 and 1980 projected final demands."[6]

Estimation of Production Coefficients

The Harvard study was the only empirical study of the four mentioned which attempted to obtain regional production coefficients (or regional interindustry flows). The other studies assumed that the national technological coefficients applied to all regions while the Harvard study estimated some regional technological differences. Different regional technologies were estimated for the agriculture and mining sectors and for part of the construction sector which together comprise 13 per cent of the total 1963 gross output and the final purchases from these sectors accounted for 13 per cent of the total 1963 gross national product. "Most of the research effort on regional differences in technology was concentrated on these sectors because locational factors are likely to cause significant state-to-state variations in their input requirements."[7]

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[6] Polenske, op. cit., p. 3

[7] Ibid., p. 57.

The method used to estimate production coefficients for each region was similar for the agriculture and mining sectors. Each sector was divided into a number of component subsector industries. The total inflows for each of the subsector industries for each region were estimated from various sources. For each region the subsectors were then summed to the eighty order level of detail and divided by the total regional output for the industry thus yielding the regional production coefficient. For the construction industry a similar method was followed, however, due to the lack of available data, the estimates had to be supplemented with product-mix estimates derived from national coefficients. Estimates developed in this manner reflect both the regional technology and the regional product mix. The accuracy of the estimates, which is not known, depends upon the accuracy and completeness of the data used. However, these estimates of regional production coefficients appear to be better than estimates of regional coefficients obtained by directly applying the national production coefficients.

For all the manufacturing and some of the service industries the product mix method was used to estimate interindustry flows. For the remaining service industries national coefficients were assumed. The product mix method delineates regional differences in the composition of the output of each of the sectors, however in using it one assumes that the national technological coefficients apply for each of the sub-sector industries. The components of the 80-order SIC industries were classified into 3 and 4-digit SIC levels of detail. The degree to which this was done varied significantly. Then the national direct input coefficients for these manufacturing and service industries were multiplied by the state outputs and the industries within each state were aggregated to the 80-order input-output classification. "In this way, the resulting regional input requirements for a given industry varied from state to state, reflecting regional variations in the composition of goods produced within the different states."[8] The 1963 national input coefficients were obtained from the 370-order input-output table by OBE[9] and the state outputs for the three and four-digit SIC industries were obtained from special material prepared by Jack Faucett Associates.[10] The text of the Harvard study did not explicitly state the method of obtaining state output estimates or the data sources used. State outputs were needed for the estimation of state shipments. Both types of estimates were provided by Jack Faucett Associates.

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[8] Polenske, op. cit., p. 74.

[9] U. S. Department of Commerce, Office of Business Economics, "Input-Output Structure of the U. S. Economy: 1963," Survey of Current Business, Vol. 49, (Washington, D. C.: Government Printing Office, 1969), p. 16-47.

[10] (Jack) Faucett Associates, Inc., <u>State Outputs for Three- and Four-Digit SIC Industries, 1947, 1958, and 1963</u>, (Unpublished data).

Estimation of output and shipments

Output estimates were made in a previous study by Jack Faucett Associates.[11] In brief, county outputs were estimated by multiplying shipment data,by county, by the national ratio of output to shipments. State outputs were the sum of county outputs. Estimates of shipments by county for 1963 were obtained by multiplying 1964 employment by county by the state ratio of shipments to employment. The employment data was obtained from County Business Patterns.[12] This shipment data was supplemented by data estimated by multiplying the plant size in each county by the national average of shipments to plant size. Estimates of the size of plants by industry and by county were obtained from the Census of Manufacturers.[13]

It is interesting to note that since shipment data was estimated for the Harvard Study by Jack Faucett using previous studies, shipments were obtained from estimates of output which in turn were obtained from estimates of shipments. This procedure lead to a confusing tautology stated in the text of the

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[11] (Jack) Faucett Associates, Inc., 1963 Output Measures for Input-Output Sectors by County, Prepared for the Office of Civil Defense, U. S. Department of Defense, (December, 1968).

[12] U. S. Department of Commerce, Bureau of the Census, County Business Patterns, 1964, (Washington, D. C.: Government Printing Office).

[13] U. S. Department of Commerce, Bureau of the Census, Census of Manufactures, 1963, Vol. III Area Statistics (Washington, D. C.: Government Printing Office, 1966).

Harvard study; "...the values of output were converted to measures of the value of shipments by scaling industry outputs using the national ratio of industry shipments to output. This procedure produced a good estimate of the value of shipments since the state output measures were originally prepared by scaling shipment data using the reciprocal of this ratio."[14]

The estimates of shipments of domestically produced commodities were combined with estimates of imports by state of entry thus yielding estimates of total shipments of commodities, both foreign and domestic, by state. These estimates were used to supplement data for estimating state-to-state flows and as a control total for the trade flow estimates. The initial state-to-state trade flow estimates were prepared using data from various sources. In general these estimates excluded imports. For each industry in each state the sum of state-to-state shipments should have equaled the total shipments of that industry in that state. If the two were not equal the state's total shipments for the industry was prorated to the state-to-state shipments to achieve the equality. Thus "imports were implicitly distributed from various states of entry to states of final destination."[15]

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[14] Polenske, op. cit., p. 80

[15] Polenske, op. cit., p. 82

Estimation of Trade Flows

The state-to-state trade flows for the manufacturing industries were estimated from three data sources. The prefered source was a special tabulation of the Census of Transportation.[16] "Although no precise measure of estimate error is available for origin-destination flows, it is believed that an error of plus or minus 30 percent might be representative."[17] The second data source, used for about 15% of the trade flow estimates, was the ICC Waybill Statistics.[18] The error associated with these estimates is more substantial than the error associated with the previous estimates. "An analysis of errors associated with estimates derived from rail data suggests that the overstatement ranges from 50 percent to over 100 percent. Because this analysis was based on extremely limited data, it is cited only to illustrate the problems of estimation--not to present a precise qualification of statistical variability."[19] The final

[16] U. S., Department of Commerce, Bureau of the Census, Transportation Division, Special Tabulations of 1963 State-to-State Flows for Input-Output Industries, Prepared for the Bureau of Labor Statistics (Unpublished data).

[17] Polenske, op. cit., p. 83

[18] Interstate Commerce Commission, Bureau of Economics, Carload Waybill Statistics, 1963, (Washington, D. C.: Government Printing Office, 1965).

[19] Polenske, op. cit., p. 84

and least preferred method of estimating the trade flows was a proration formula which distributed shipments among the states on the basis of consumption with census region-to-census region data used as a control. The formula is as follows:

$$S_{ij}^{k} = P_{i}^{k} \left[\frac{C_{j}^{k}}{\sum_{j=1}^{44} C_{j}^{k}} \right]$$

$$F_{ij}^{k} = S_{ij}^{k} \left[\frac{R^{k}}{\sum_{i=p}^{q} \sum_{j=m}^{n} S_{ij}^{k}} \right]$$

where:

P_{i}^{k} = total shipments of commodity k from state i

C_{j}^{k} = total consumption of commodity k in state j

S_{ij}^{k} = shipments of commodity k from state i initially allocated to state j

R^{k} = flow of commodity k from census region containing state i to census region containing state j

F_{ij}^{k} = final estimate of flow of commodity k from state i to state j

p,q = total set of states contained in census region which also includes state i

m,n = total set of states contained in census region which also includes state j

No estimates of the error associated with the proration formula were made, they were considered rough approximations which "only provide the correct order of magnitude of actual trade flows."[20] It should be noted that the Jack Faucett Associates did not mention any attempt to test the accuracy of this proration or formula. One fairly quick method would be to make estimates of trade flows for which census data existed and then compare the two types of estimates.

State-to-state commodity trade flows were estimated for nine non-manufacturing sectors. The method was generally the same but the data was obtained from different sources. For the two agricultural industries the commodity trade flow data obtained from the Carload Waybill Statistics was combined with truck movement data obtained from a Department of Agriculture Survey.[21] The trade flow data for the seven extractive industries was obtained primarily from the Carload Waybill Statistics or the Minerals Yearbook, 1963.[22] "With the exception

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[20] (Jack) Faucett Associates, 1963 Interregional Commodity Trade Flows, Prepared for the Office of Business Economics, U. S., Department of Commerce (revised) (Washington, D. C.:. Government Printing Office, 1971).

[21] U. S., Department of Agriculture, Marketing Economics Division, Economic Research Service, For-Hire Motor Carriers Hauling Exempt Agricultural Commodities, Report No. 585. (Washington, D. C.: Government Printing Office, 1963).

[22] U. S. Department of the Interior, Minerals Yearbook, 1963, (Washington, D. C.: Government Printing Office, 1964).

of IO-7, coal mining, and IO-8, crude petroleum and natural gas, available interregional trade flow data on commodities produced by nonmanufacturing industries are very inadequate. Although some information is available on origin-to-destination movements of commodities by mode of transport, coverage by type of commodity and geographic area is extremely limited. ...as a result, 1963 nonmanufacturing industry trade estimates must be considered very rough approximations."[23]

Estimation of Final Demands

As mentioned earlier one of the purposes of the Harvard Study was to estimate regional outputs and shipments of commodities among the regions for 1970 and 1980 given estimates of 1970 and 1980 final demands. Thus careful estimates of base year final demands were needed in order to make good estimates of projected final demands. Base year final demands were estimated by the Harvard research group. The six components considered to comprise base year final demands were: personal consumption expenditures, gross private domestic investment, net change in inventories, net exports, state and local government expenditures, and Federal government expenditures. Jack Faucett Associates[24] projected final demands for 1970 and 1980.

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[23] Faucett, Trade Flows, op. cit., p. 68

[24] (Jack) Faucett Associates, Inc., Projection of Final Demand by State for 1970 and 1980, Report to the Harvard Economic Project, (October, 1970).

When doing so they lumped net change in inventories with gross private domestic investment, thus considered final demand in five components. Both research groups considered the first two components, personal consumption expenditures and gross private domestic investment, the most important components and concentrated their research efforts on these two. For this reason the manner in which these components were estimated will be discussed in some detail. The other components were estimated by using various methods and secondary data from diverse sources.

Personal consumption expenditures is the largest component of final demand. It accounts for about 65% of Gross National Product. Estimates of personal consumption expenditures were obtained for each state by multiplying average consumption expenditures for ten income groups by the estimated 1963 state population in that income group. The average consumption expenditures for 1960 were obtained for ten income groups in four geographic regions from the 1960 Consumer Expenditure Survey.[25] 1963 estimates of population by income group were estrapolated from the 1950 and 1960 Census of Population.[26] Jack Faucett

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[25] U. S. Department of Labor, Survey of Consumer Expenditures, 1960-61, (Washington, D. C.: Government Printing Office, 1970).

[26] U. S. Department of Commerce, Bureau of the Census, U. S. Census of Population: 1960, Vol. I, Characteristics of the Population, (Washington, D. C.: Government Printing Office, 1963).

Associates used a similiar procedure in projection personal consumption expenditures for 1970 and 1980.

Gross private domestic investment was estimated for 1963 in two components: new plant construction, which was directly estimated from the new construction sector; and purchases of new equipment. "State capital flow matrices were obtained by multiplying each column of the national capital flow coefficient matrix for a given year by the respective industry figure in the vector of capital equipment purchases for each state in the given year."[27] This matrix would reveal the volume of purchases by each industry in each state but not the location of the producer. "The row sums of these state capital equipment flow matrices were used to allocate the national gross private capital formation to the states. The result was a set of state vectors for each year showing the total amount of private industry purchases on capital account specified by indusry of production."[28] In projecting gross private domestic investment for 1970 and 1980 Jack Faucett Associates considered four basic components and developed different methods for estimating each component. The components were: durable equipment, plant construction, inventory change, and residential construction.

The data collected for the Harvard study was compiled into the framework of the Leontief-Strout Gravity Model as well as

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[27] Polenske, op. cit., p. 44.

[28] Ibid., p. 45.

the Moses fixed column coefficient model. In order to obtain a solution to either model, either the [I - TA] matrix must be inverted or an iterative procedure must be used to solve the [I - TA] TY matrix product. The advantage of the matrix inversion is that the model has to be solved only once, then the inverted matrix can be used with any set of final demands to obtain outputs and trade flows for all regions. On the other hand, if the iterative procedure is used, the model has to be solved each time a different set of final demands is considered. However, the disadvantage of the matrix inversion is the rather staggering amount of computations required to invert a matrix the size of the Harvard model.

An iterative procedure was used and for the Moses fixed column coefficient model it produced satisfactory results. However, this procedure, when applied to the Leontief-Strout Gravity Model, failed to converge and no solution to the model was obtained. The researchers stated that they were unable to discover the reasons why this procedure failed to converge.

Appalachian Study

The Appalachian study was an attempt to determine whether or not a means existed to construct an interregional input-output system, based upon national coefficients, which would measure the impact of an investment project in Appalachia. In the model, Appalachia was divided into three regions and interregional trade flows were estimated among them. The rest of the United States was considered a fourth region and trade flows from this fourth region to each of the other regions were estimated; however, commodity flows from Appalachia to the rest of the United States were not estimated. Thus the important feedback effect, discussed earlier, was not considered. The study included 83 I/O sectors, 51 of them manufacturing sectors.

For any interregional input output study the two critical sets of data are the interindustry commodity flows and the interregional trade flows. In the Appalachia study the interindustry flows were obtained by multiplying the 1958 national production coefficients by estimates of regional output by sector. Output was estimated from employment data in a similar manner as in the Harvard study. In using the 1958 national production coefficients the study made no attempt to develop any differences in regional technologies or in regional product mix.

The study used two methods to estimate trade flows. One method was a direct survey, the other was a gravity technique. Surveys were used to estimate the interregional movements of agricultural and mineral products and the flows of finance, insurance, real estate, and other services. The result of the survey is questionable because only twenty-one percent of the businesses contacted by mail returned usable questionnaires. "It is not known whether the data provided in the mail survey are representative of business establishments in general because ...the sample of firms providing usable information is to a large extent self-selected."[29]

The interregional flows for the 51 manufacturing sectors were estimated by a regression model employing the gravity technique. A number of statistical tests were used to determine the applicability of such a model and to select a model among several alternative ones. The model selected postulated that shipments from one region to another are a function of the output of the shipping region, total use in the receiving region, and the distance between the two regions. By taking the logarithmic transformation, the model was reduced to a linear form. The coefficients of the model were estimated by running regressions on existing census region to census region data. Then the regression equation was applied to estimate trade flows among the regions considered in the study. The method of estimating each of the independent variables for the census regions, was similar to the method used for regions considered in the study. The method of estimating output was stated above. Use was estimated in two components: intermediate use, and final demand. The intermediate use of a commodity for a region was the sum of all interindustry flows for that commodity. Final demand consisted of personal consumption expenditures and gross

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29 Research and Development Corporation, op. cit., p. 51

private domestic investment. Each were estimated in a manner similar to, but not as detailed as, the procedure used in the Harvard study. Distance was the estimated transportation distance between production centers.

The above method of estimating trade flows, estimating regression coefficients on census region data then applying the coefficients on data for much smaller regions, assumes that that which applies to the whole also applies to the parts of the whole. An estimate of the validity of this procedure could have perhaps been obtained by estimating known state-to-state flows in this manner and comparing the estimates with the actual flows.

Washington University Study

The Washington University study was similar to the Appalachian study in that it was based on national coefficients and it was designed to measure the impact of investment projects in Appalachia and the Ozarks. This area was divided into eighteen regions, each within a state, and the remainder of the United States was considered the nineteenth region. Trade relationships among all the regions were estimated, thus the important feedback effect of an investment project is implicitly considered in the model. The model included twenty-three producing sectors and, as in the case of the Appalachian model, the 1958 national technological coefficients were assumed to apply for each of the sectors.

This study employed a potential model to estimate trade flows among the eighteen substate regions. The model postulated that the value of shipments of a given commodity from one substate region to another equals the percentage of shipments of the shipping state accounted for by the substate region, times the percentage of demand of the commodity by the receiving state accounted for by the substate region times the total value of shipments between the two states. Thus, this model required estimates of shipments and demand for both state level and substate region level. State shipments were considered equal to state output less exports. The state shipments were then prorated to the substate regions on the basis of employment. For each of the manufacturing sectors, output was estimated by multiplying the state value added by the national ratio of output to value added. For the other sectors output was estimated by diverse means. Total demand was estimated for both state and substate regions in two components: intermediate demand and final demand. Intermediate demand was estimated in the same manner as in the Appalachian study. The method of estimating final demand was not clearly stated. The data for the final independent variable in the model, the total value of shipments between the two states, was obtained from the _Census of Transportation_ and _ICC Waybill Statistics_.

The potential model used in this study to estimate trade flows was not tested. It is not a gravity model in that it does not explicitly take distance into account. Rather it is a formula which prorated state-to-state shipments to substate regions on the basis of demand and shipments.

Eleven Western States Study

The Eleven Western States study was of particular interest for two reasons: First, an interregional input-output model was constructed from existing regional input-output tables for individual states, second, the Leontief-Strout Gravity Model was applied to estimate the trade flows among the eleven regions which corresponded to the states considered in the model. The exact solution method of the gravity model was used. This method, unlike the point estimation method, does not require knowledge of interregional trade flows; however, it does require knowledge of the total demand of a commodity for each region, total supply of the commodity for each region, total intra-regional shipments of the commodity for each region, and demand for the commodity for the entire area considered. The estimates of supply and the two types of demand were obtained for each commodity from the regional input-output tables. The regional demand for regionally produced goods was estimated using a three step procedure. First, the 1958 national production coefficients were multiplied by the output of the region. This gave the regional demand for a good regardless of origin. Second, the inflows of each commodity to the region was obtained from the regional tables and prorated to each using sector on the basis of that sector's share of total use of the commodity. Then the second estimate was subtracted from the first yielding the amount of a regionally produced commodity which each sector requires.

Summary

The three interregional studies which constructed data estimates were quite similar in methodology and in basic data sources. The national production coefficients were used either directly, or, in the case of the Harvard study, indirectly to estimate production coefficients of the regions. Employment data was obtained from County Business Patterns, and in two cases was used to estimate output while in the third case used to prorate state output estimates to substate regions. Each study obtained shipment and trade flow data from a special tabulation of the Census of Transportation and from ICC Waybill Statistics. In each case a proration formula or gravity technique was used to estimate trade flows among regions smaller than those for which data was available. None of the formulas were tested with the type of data they were used to estimate.

Of the three studies, the Harvard study made the most detailed and comprehensive data estimates. It was the only study which actually estimated regional production coefficients rather than directly applying the national technological coefficients. The trade flow estimates by Jack Faucett Associates for the study were the most complete, both in terms of the regions and the sectors considered. A study[30] by the Bureau of Economic Analysis pointed out that the trade flow estimates by Faucett were not consistent with the Bureau's estimates of regional output and consumption. The data was readjusted to be consistent with these estimates in two ways: trade flow shipments out of a region were made equal to regional production (supply), and trade flow shipments into a region were made equal to regional consumption (demand). This data is the most current trade flow data consistent with output and consumption.

In order to directly use the trade flow data of one interregional study for a second study, the regions of the latter study must correspond to the regions of the former, or the regions of the latter must be larger and totally comprised of the regions of the former. Thus, the adjusted trade flow data of Jack Faucett is more applicable for multiregional studies in various parts of the United States than the trade flow data of the other studies. For these reasons the data estimated for the Harvard model would be the most useful for an interregional study such as MKARMPPIS.

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[30] U. S. Department of Commerce, Bureau of Economic Analysis, Implementation and Evaluation of the MIRO Model. A Report to the Economic Development Administration. (Washington, D. C.: Government Printing Office, 1972) p. 146-165.

Chapter 4

THE PROPOSED INTERREGIONAL I/O MODEL

As discussed earlier, the I/O model is particularly effective in measuring both the direct and indirect impact that a given change in demand would have on the various industrial sectors in a region. The interregional model would measure the impact of this change not only on the region in which it occurs but also on the neighboring regions. To determine the particular characteristics which would be desirable for an interregional I/O model for MKARMPPIS, the following questions must be answered:

1. What is the main impact area?
2. What are the regions?
3. How many industrial sectors?
4. Which year's production coefficients should be used?
5. Should national production coefficients be applied to regions or should regional production coefficients be developed?
6. What would be the base year for trade flow and how would they be estimated?
7. What types of impacts should be measured?
   output, income, employment
   direct, indirect, induced and
   investment multiplier?

8. Should the model be static or dynamic?

9. Should the model be open or closed?[1]

Following a brief economic survey for the Arkansas River Basin area, the proposed model for MKARMPPIS will address the four broad problem areas: (1) the delineation of regions and industrial classifications (2) the structural coefficients (3) types of impacts and the way in which they will be measured, and (4) the adaptability of the proposed model for other project analysis.

Arkansas River Basin Survey: Industrial and Trade Patterns

In order to estimate the interregional impact of a project with an interregional I/O model, one must identify the industrial sectors and internal regions which are critical in the study. Since a project is designed to improve the economic conditions of a particular region, the region must be clearly identified and its economic structure and trade patterns must be examined.

[1] An open I/O model here means that a household sector is excluded from the processing matrix; while a closed model means that the same sector is closed in the processing matrix so that added consumption effects, resulting from the increased income by the household sector, during a production process on the whole economy, can be measured automatically. The impact of the consumption spending on the economy is called an induced or income multiplier effect.

The Arkansas River Basin represented by economic subareas 117, 118, and 119, shown in Map 2, have been temporarily selected as an impact region.[2] This area has been selected because all project sites and metropolitan areas such as Little Rock, Ft. Worth, and Tulsa, along the Arkansas River are included in this area. Thus, this general area is represented both by production and market centers and is expected to receive the heaviest impacts from the project investments.

In order to analyse the interindustrial and interregional impacts of the investments; the current industrial and trade patterns of the impact area must be known. It is difficult to estimate the current trade patterns of those economic subareas because of a lack of readily available data and time limitations. However, 1963 state shipment data by industry sectors is available from the Jack Faucett study. The three economic subareas represent major portions of the states of Arkansas and Oklahoma and include all SMA's in the two states except the city of Oklahoma. Therefore, the industrial structures and the trade patterns of these two states as one region, were assumed to represent those of the impact region. In this study the shipment data for the commodity producing industries was assumed to represent the output data.

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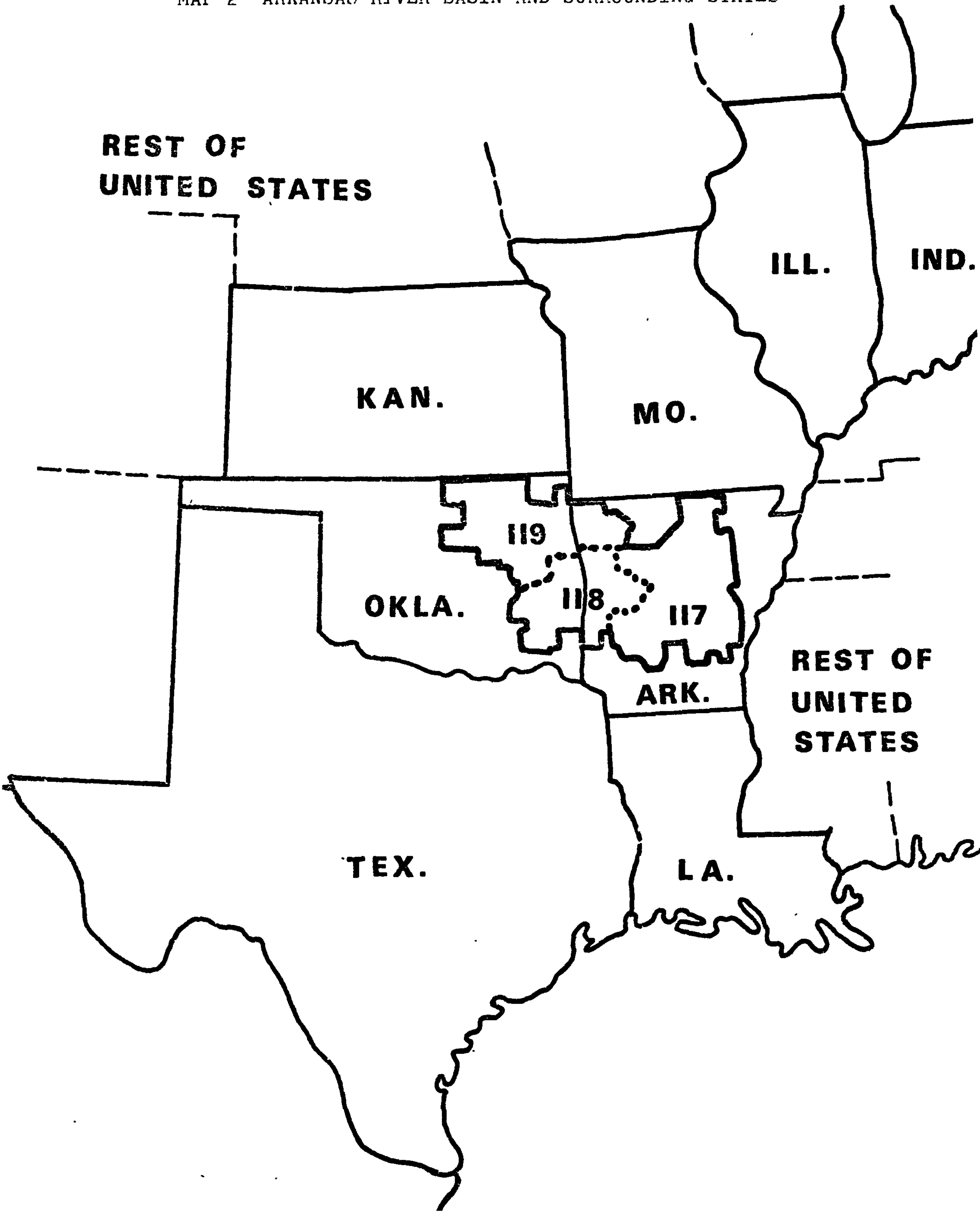
[2] Impact region is defined as the area on which the heaviest impacts of an investment are expected, and the area immediate to the project site is generally considered as an impact region.

MAP 2 ARKANSAS RIVER BASIN AND SURROUNDING STATES



Industrial Structures in Impact Region

Each of the twenty industries listed in Table 2 shares more than one percent of the total shipments of two states. The total shipments of these industrial sectors account for about 90 percent of the total shipments of the two state region. Among these industries, the largest are: food and kindred products; crude petroleum and natural gas; petroleum and related industries; livestock and livestock products; other agricultural products; and aircraft and aircraft parts industries. To compare the relative size of each industrial sector of this region to that of the nation, the location quotient of each industry was calculated. This was done by dividing the ratio of regional production of a particular industry to total regional industrial production by the same ratio for the nation as a whole.[3] Listed in Table 3 are the six regional industries for which value of location quotients is greater than 1.5. The six largest industries previously cited, except the food and kindred product industry, which was replaced by the radio and TV equipment industry, belong to this category.

Trade Patterns in Impact Region

The trade patterns of eight selected industries were assumed to represent the trade patterns of the two state region.

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[3] For the concept, interpretation and various ways to formulate a location quotient see: Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science (Cambridge, Massachusetts: The M. I. T. Press, 1960), p. 232-308.

TABLE 2

PERCENTAGE SHARES OF 1963 MAJOR INDUSTRIAL SHIPMENTS FROM THE STATES OF OKLAHOMA AND ARKANSAS

Industry Number by SIC	Industry Title	Percentage
14	Food and kindred products	.15
8	Crude petroleum, natural gas	.12
31	Petroleum, related industries	.10
1	Livestock and livestock products	.09
2	Other agricultural products	.08
60	Aircraft and aircraft parts	.04
20	Lumber and wood products	.03
56	Radio, T.V. equipment	.03
24	Paper and allied products	.03
40	Fabricated metal products	.02
38	Primary nonferrous manufacturing	.02
27	Chemicals, selected products	.02
26	Printing and publishing	.02
36	Stone and clay products	.02
32	Rubber, miscellaneous plastics	.02
52	Household appliances	.02
45	Construction machinery and equipment	.02
22	Household furniture	.02
18	Apparel	.02
59	Motor vehicles, equipment	.01
		.88

Sources: (Jack) Faucett Associates, Inc., 1963 Interregional Commodity Trade Flow Estimates. Prepared for the Office of Business Economics, U. S. Department of Commerce. Washington, D. C., (revised) March, 1971.

TABLE 3

REGIONAL INDUSTRIES WITH VALUES OF LOCATION QUOTIENT GREATER THAN 1.5

Industry Sector	Location Quotient
Crude petroleum and natural gas	3.5
Livestock and products	2.2
Other agricultural products	2.2
Aircraft and parts	2.2
Petroleum and related products	1.8
Radio and TV equipment	1.5

TABLE 4

MAJOR TRADING PARTNERS OF REGION

Arkansas and Oklahoma (internal)	.38
Texas	.13
Illinois and Indiana	.06
Louisiana	.05
Missouri	.04
Kansas	.03
	.69

The criteria for selection was a high volume of trade. The industries accounted for 60 percent of the total shipments and 55 percent of the receipts.[4] The major trading partners, accounting for approximately seventy percent of the total value of trade considered in the estimate, are the states of Texas, Illinois, Indiana, Louisiana, Missouri and Kansas. They are listed in Table 4 according to their percentage of total trade for the region. Internal shipments were, by far, the greatest component of total trade.

Deliniation of Regions and Industrial Classifications

In theory, the finer the regional classification, the more realistic the survey of regional economies.[5] In practice, however, the further the disaggregation of the region the less reliable the information, simply because of the lack of available empirical data. Usually administrative boundaries do not coincide with economic structures. For example, if a

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[4] The industries selected were: livestock and livestock products; other agricultural products; paper and allied products; chemicals and selected products; petroleum, related industries; crude petroleum, natural gas; food and kindred products; and primary non-ferrous manufacturing.

[5] For the standard classification of a region see John Meyer, op. cit., and Walter Isard, "Regional Science, the Concept of Region and Regional Structure," Papers and Proceedings of the Regional Science Association, II (1956).

state boundary divides a large metropolitan area, the state statistics would hardly explain the true picture of the economy. However, the bulk statistics are compiled and generated by administrative boundaries. After evaluating our objectives, the industrial structure and trade patterns of the project region, and data collection problems, we have weighed the following three alternative plans for the regional delineation of the MKARMPPIS. (See Map 2)

<u>Plan A</u> (Seven Regions)

Three impact regions: The three economic subareas 117, 118 and 119

Three neighboring regions:

a) Texas, Louisiana, Oklahoma and Arkansas minus the three economic subregions above.

b) Kansas and Missouri

c) Illinois and Indiana

One region: The rest of the United States

<u>Plan B</u> (nine regions)

Two impact regions: Oklahoma and Arkansas

Six neighboring regions:

Each state of Texas, Louisiana, Kansas, Missouri, Illinois and Indiana

One region: Rest of the United States

Plan C (five regions)

One impact region: subareas 117, 118 and 119 combined

Three neighboring regions:

a) Texas, Louisiana, remaining states of Oklahoma and Arkansas minus the three economic subareas above.

b) Kansas and Missouri

c) Illinois and Indiana

One region: Rest of the United States

Plan A emphasizes detailed investigation of the three project areas identified as economic subareas 117, 118 and 119. Plan B, on the other hand, primarily emphasizes utilizing the existing information system. The emphasis in Plan C is on the industrial structures within the broad project region and the trade relationships among the project region and its major supply and market areas. The division of the project impact area into economic subareas as done in Plan A is somewhat arbitrary. The merit of the considerable effort which would be required to obtain the local data is questionable when compared to the benefit derived from it. Plan B does not offer a chance of careful observation of the economic impacts of the huge investments in the impact area where the greatest impact is expected to fall. We recommend Plan C because the plan provides both the chance of surveying the impact on the vicinity of the project area and observing the relationships of the impact area with its neighboring regions, yet minimizing the computational work involved.

We did not go into a detailed study of local economy, therefore we are unable to present concrete ideas about how industrial sectors should be identified. The present view is that the number of industrial sectors should be somewhere between 15 to 30 so that the model could be kept within a manageable size yet the industrial sectors could be identified in sufficient detail.

Structural Coefficients

Technical Coefficients

The most current national technical coefficients based on survey are for the year 1963. The next survey of technical coefficients based on 1967 data may not be available before the middle of 1973. As revealed in the investigation of empirical works, most of the interregional I/O studies have substituted the national technical coefficinets for regional production coefficients. In the Harvard study regional coefficients were estimated for the agriculture and mining sectors and partially estimated for the construction industry. The regional production coefficients estimated for the manufacturing sectors reflected the product mix of the region, but assumed the national production function.

There exists projected 1967 and 1970 I/O tables extrapolated from previous national tables. Since the product mix has been considered one of the most dominant factors for differences in regional production coefficients, it is doubtful whether updated national technical coefficients better represent current technical coefficients for each state than those state coefficients estimated by the Harvard study. A survey of several regional technical coefficients is not only expensive and time consuming, but it also has several of its own deficiencies.[6] This author favors the use of 1963 state coefficients estimated by the Harvard study as the best estimate of the 1970 state coefficients over the application of any updated national coefficients uniform for all states.

Since the heaviest impacts of the projects must be expected on the impact region, technical coefficients for this region must be estimated. The production function of this region will be expected to change because of (1) expected economic growth and (2) improved transportation systems resulting either directly or indirectly from project investments.

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[6] The survey does not necessarily afford correct information. One may encounter very low responses to the sample questionnaires; consequently, information through a survey becomes unreliable. For the problems involved in the survey see: Philip J. Bourque and others, The Washington Economy: An Input-Output Study (Seattle: The Graduate School of Business Administration, University of Washington and Department of Commerce and Economic Development, State of Washington, 1967), and William H. Miernyk and others, Simulating Regional Economic Development (Lexington, Massachusetts: D. C. Heath and Co., 1970). For a comparison of state I/O tables based on survey and non-sruvey see: Albert J. Walderhaug, "State Input-Output Tables Derived from National Data," presented at the 131st Annual Meeting of the American Statistical Association, (Ft. Collins, Colorado: August, 1971).

The state coefficients of Arkansas and Oklahoma estimated by the Harvard study, and supplemented by secondary sources and a partial survey can be utilized as estimates of the production coefficients of the impact region.

Trade Coefficients

As previously discussed, the shortage of various types of census data forced the Jack Faucett Associates to develop estimates with large possible errors for significant portions of the 1963 state flow data. This study was reviewed by the Bureau of Economic Analysis. The Bureau has pointed out inconsistencies in the data compulation, and for the benefit of possible users adjusted the data so that it is consistent with regional output data.

The estimation of trade flow data is a major undertaking. The most current transportation census is for 1967, but according to the Department of Transportation, the quality of this census is lower than that of the 1963 census. The 1967 census primarily relied on long distance haul by rail and a significant portion of the transportation statistics are merely an extrapolation of the 1963 data.[7] The next transportation census will be for 1972, which will not be available before the middle of 1974.

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[7] Telephone conversation with Mr. Jack Harmon, U. S. Department of Transportation.

The adjusted Jack Faucett's state flow data could most conveniently be organized to compute trade coefficients for this study. The division of the states of Oklahoma and Arkansas into impact areas and the rest of state areas may require new sets of trade flows between these divided areas and other states. Existing state flows may be adjusted to those new areas prorating the area share and using a gravity technique and a partial survey.

If the studies of IWR and the Southwestern Division of the Army Corps of Engineers[8] generate new data on the change in transportation rates and trade patterns, they can certainly be utilized to adjust the regional technical coefficients and the trade coefficients.

Level of Impacts to be Measured

To what extent should the investment impact be measured? Should only the level of outputs resulting from the direct and indirect impact of given investments be measured? Should the impact include induced effects and/or the capital expansion effects from the investment which is the investment multiplier effect? Should the impact include the effect of transportation

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[8] Both staff members of IWR and Southwestern Division of the Army Corps of Engineers are currently studying the impacts of the Arkansas River Project on transportation rates and trade patterns and compiling annual data systems for economic analysis within the economic subareas 117, 118 and 119.

improvement and agglomeration effects[9] resulting from the initial investment?

This author suggests that the model should be able to estimate the total effect of a given investment on output and income. Total output and income effects include direct, indirect, and income and investment multiplier effects, and exclude agglomeration effects. The income multiplier (induced) effect can be measured either by closing the I/O model or by estimating the consumption function and reiterating added consumption effects. To estimate both income and investment multipliers we suggest that the proposed model would be open, but partially dynamic in that regional final demand vectors would be projected within the system based upon an initial change in the final demand.

Agglomeration effects cannot be measured through this model. Agglomeration effects must be studied separately either by traditional location model or by some linear programming models. However, if the growth pattern of new industrial developments resulting from the original project investments can be estimated by the above methods, the additional impact of the agglomeration effects could be estimated through the recommended

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[9] Agglomeration effects are defined as an economic expansion effect such as entry of new industries based on locational advantage indirectly resulting from the initial project investment. This effect is different from the indirect effect of the project investment which is the result of an increased interindustry demand.

I/O model. If the impact of an improvement of transportation on the regional economy, which seems to be the most predominant impact of the project, can be incorporated in the construction of the regional technical coefficients and trade patterns; the above model can be used for the evaluation of both the effect of project construction as well as the indirect effects of transportation improvement resulting from the project.

Adaptability of the Proposed Model for Other Projects

The model proposed in this study is basically for application to the MKARMPPIS. However, this does not necessarily limit the model's applicability for the evaluation of projects other than the KMARMPPIS. Due to the various degrees of openness of regional economies and the established trading patterns among regions the final demand in any region may vary in both degree and composition according to the size, type, and location of an investment project. The proposed model, if implemented, can evaluate the impact of any type of public or private investment project in the Arkansas River Basin or in any other region, provided the regional boundaries are not changed. If a project impact study requires a reorganization of the regions, the proposed theoretical model can easily be used. Though the required data would be different, the estimates of production coefficients and trade coefficients can be obtained from the studies by Harvard and Jack Faucett Associates, and modified, if necessary, by procedures developed for the MKARMPPIS input-output model.

Chapter 5

SUMMARY

In Summary, the major conclusions of this survey report are as follows:

1) To measure the impact of the McClelland-Kerr Arkansas River Multiple Purpose Project on both industrial and regional interdependencies and to comprehend feedback effects the construction of an interregional I/O model closed on national boundary is suggested.

2) The Moses column coefficient model supplemented by the gravity technique appears to be best suited for the purpose of this study and several empirical works using Moses and Gravity models have been investigated.

3) Except for the Harvard Study, the investigated studies used national technical coefficients of various base years for their regional technical coefficients. However, most of regional (state) technical coefficients estimated for 1963 by Harvard reflect the regional technology and/or the regional produx mix.

4) Except for the Japanese model trade coefficients in existing works are either estimated from the base year flow information directly (column coefficients) or indirectly (gravity model). Due to the massive data requirements of the Japanese model it would be infeasible to apply it for the MKARMPPIS. Although the census data was supplemented by estimates, the state shipment data for 1963 by Jack Faucett Associates and adjusted by the Bureau of Economic Analysis, are the most comprehensive and readily available data for estimating trade coefficients at present time.

5) The Arkansas River Basin Development Projects are exclusively included in the economic subareas 117, 118; and 119. According to the 1963 census, the major commodity trading partners of the state of Arkansas and Oklahoma combined, which was assumed to represent the three economic subareas, were the states of Texas, Louisiana, Kansas, Missouri, Illinois and Indiana. The trade volume within the two states combined plus that of the major partner states accounted for about 70 per cent of the total trade of the two states. The same census reveals the 20 manufacturing industries produced more than one per cent of the total manufacturing outputs.

6) The proposed I/O model consists of five regions: one for the impact region which includes economic subarea 117, 118 and 119, four major trading regions: one for the states of Texas, Louisiana and the remainder of the states of Oklahoma and Arkansas after eliminating economic subareas 117, 118 and 119; one for Kansas and Missouri; one for Illinois and Indiana; and one for the rest of the United States. Industrial sectors will be classified into somewhere between 15 to 30 sectors.

7) State production coefficients of 1963 by Harvard and modified version of Jack Faucett shipment data are recommended in constructing the production and trade coefficients for the proposed model. The same data for the impact region will be supplemented by the data which would be generated by the IWR and Southwestern Division Studies and a local survey.

8) The model will be open; but, partially dynamic. It will be partially dynamic in the sense that, although the production and trade coefficients will be held constant, a changing final demand vector will be projected over the study period.

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PHASE II

INTERREGIONAL INPUT-OUTPUT MODEL:

DATA COLLECTION PLAN

INTRODUCTION

An earlier report submitted to the Army Corps of Engineers recommended a particular type of interregional Input-Output model for the McClellan-Kerr Arkansas River Multipurpose Project Impact Study (MKARMPPIS). The purpose of this report is to outline the types of data required to implement the recommended model, analyze the methods by which the data can be collected, and recommend a procedure for collecting the data required for the model. There are various procedures for obtaining the required data, and each of these procedures may entail using different sources. The accuracy of the data may vary according to the sources and procedures used; the effort, both in terms of time and cost, may also vary according to the sources and procedures used. Thus before recommending a particular procedure one must consider the various sources and methods, and weigh each method according to the probable accuracy of the data which can be obtained and the time and cost involved in obtaining such data.

Another critical point which will be explored in the discussion is the choice of the base year. If the primary purpose of the model is to measure the direct and indirect impact of the actual construction of the MKARMPPIS,then a base year which is early in,or in the middle of, the construction period is preferable.

However, if the primary purpose of the model is to measure the long range impact of the project, particularly how it may have reshaped the economic structure of the impact region, and to estimate the impact of subsequent investment projects in the area, then a base year at, or near, the end of the construction period is preferable.

The types of data required for the implementation of the model will be discussed in the first section of this report, the advantages and disadvantages of a survey to obtain the data will be analyzed in the second section, and in the concluding section a recommended data collection plan and sources of data will be presented. The problems experienced in various empirical I/O studies will be considered throughout this discussion. The recommended data collection plan, it is hoped, will reflect the applicable lessons learned in these studies.

REQUIRED DATA

Transactions Table

The heart of any input-output model is, of course, the transactions table. This table shows the flow of goods and services throughout the economy measured at current prices. The national I/O model has one transactions table which shows the sales of goods and services of each particular industrial sector in the nation to each of the industrial and final demand sectors within the nation. The exports to other nations are lumped together. It also shows the amount which each industrial and final demand sector purchases from every industrial sector in the nation. Imports from other countries are again lumped together. Thus the table only shows those transactions between industries within the nation. Similarly, the regional model has one transactions table which shows the amount which any given industrial sector within that region sells to, or purchases from, every industrial sectors within that region. And it shows the purchases by the final demand sectors from the regional industries. The exports to, and the imports from, every other region within the nation and all foreign countries are lumped together. Thus all transactions between industries are delineated only if they occur between industries located in the same region.

In contrast, the interregional input-output model has a number of transactions tables. Each transactions table shows the amount which each delineated industrial sector located within a given region sells to, or purchases from, every industrial sector located within a particular region. The table also shows the transaction between the final demand sectors in the purchasing region and the industrial sectors in the selling region. The region in which the purchasing industry is located need not be the same as the region in which the selling industry is located. A multiregional input-output model, therefore, requires for each region a transactions table corresponding to every region within the model including itself. Thus the five region model suggested for MKARMPPIS would require twenty-five transactions tables.

As explained in the earlier report, an interregional input-output model of the Moses type is recommended for MKARMPPIS. Each transactions table in such a model is comprised of two parts; the interindustry flows (production functions) and the trade flows. The production function is the amount of goods and services from all industries which are required by an industry in a given region in order to produce its output. The regional origin of the required goods and services is not considered; only the total amount. The trade flow is the volume of trade, according to industrial classification, from one region to another. Technically the production functions and the trade flows for a given region could be estimated together, but since this is very complicated and the data generally does not exist, they are usually estimated independently.

The production function can be obtained either by directly estimating the total inputs required by a given industry or by multiplying previously determined production coefficients of an industry by the output of the industry. The former method usually requires survey, the latter method usually can be accomplished from secondary sources. A discussion of the advantages and disadvantages of each method will be presented in the following section; however, it is now important to discuss the types of production functions which are obtained by using variations of the latter method.

Production Coefficients

Production coefficients are based on survey data and reflect the technology of the year in which the survey was conducted. The most current national coefficients are for 1963. The coefficients have been "updated" to 1970 by using regression analysis. Since they have been extrapolated from previous data, the 1970 coefficients may not reflect the 1970 technology. In some studies the coefficients of the transactions table have been 'updated' by multiplying the production coefficients of a given year, say 1963, by the output of a subsequent year, say 1970. Actually all such a table shows is the 1970 total production considered in terms of the structure of the 1963 economy. Thus, if the production coefficients are required for estimating transactions tables, the choice of the year for the production coefficients is a significant problem.

When production coefficients are used in an interregional input-output model a second problem arises, that is, does the production coefficient reflect the technology of the region. Since regional production coefficients are not readily available; most interregional studies, e.g. the Appalachian Study[1] and the Washington University Study[2], have assumed that the national production coefficients apply for all regions. That is, they assume the production function of an industry is the same in all regions as the national average of production functions for all such industries. This assumption has two parts. First it is assumed that for each industry the product composition of output for the region is in the same proportion as the average composition of output for the entire nation. This assumption of similarity of product mix is tenuous for industries such as agriculture. Second, it is assumed that for each industry the regional technology is the same as the national average of technologies; again a tenuous assumption. For the same industry in two different

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[1] Research and Development Corporation, Preliminary Analysis: An Analytical System for the Measurement of Economic Impacts in Appalachia. Prepared for the Office of Appalachian Studies, U.S. Army Corps of Engineers, October, 1966.

[2] Charles L. Leven, editor, Development Benefits of Water Resource Investments. Prepared for the Institute for Water Resources, U.S. Army Corps of Engineers, November, 1969.

regions may utilize different input patterns. These different input patterns reflect factor cost difference and differences in resource distribution patterns.

In any multiregional model such as the one recommended for MKARMPPIS it is, of course, preferable that the production coefficients reflect the technological and product mix characteristics of the region concurrent with the time of project investment. Such coefficients, if possible, will be developed for the model. The base year for the coefficients of the model would depend upon the primary purpose of the model. If the model will be primarily used to measure the impact of the actual construction of the MKARMPPIS be it the direct, induced, or accelerator impact, a base year of 1963 would be the most obvious choice for the following reasons: 1) This is the latest year for which surveyed national production coefficients are available; 2) the tremendous amount of regional data compiled for 1963 by the Harvard Economic Research Project[3] could be utilized in the model; 3) the major proportion of the construction effort took place in the 1960's. However, if the primary purpose of the model is to measure the changes in the economic structure resulting, in part, from the project, and the impact of subsequent investment projects,

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[3] Karen R. Polenske, Multiregional Input-Output Model for the United States. Harvard Research Project, Report No. 1. (Cambridge, Massachusetts: Harvard University, 1970).

then it would be preferable if the base year was one after the termination of the constructions. A base year of 1970 would suit this purpose for the following reasons: 1) the project was finished in that year; 2) it was a census year and a large amount of data would be available for that year which is not normally available; 3) national production coefficients have been estimated for that year. If the model will be used for the projection of long-term regional economic trends including the project impact, a dynamic model with changing production coefficients and a final demand vector can be constructed.

If 1963 coefficients are used, output data could be developed for 1963 through 1970, thus giving an indication of the economic growth of the impact region, part of which would be due to the construction project. Of course such a procedure would not give the annual structural changes in the economy. But to estimate annual changes in the economic structure would unnecessarily complicate the model.

Trade Coefficients

The trade coefficients of an interregional model reflect the patterns of trade among the various regions of the model. If the coefficients are developed in the construction of the model they are either based on surveyed data of trade flows or estimates of trade flows. This trade flow data gives the volume of shipments, and receipts, by each industry in each region to, and from, each region. Obviously the data requirement is large and often the data has to be estimated by a gravity or proration technique. In any relatively large interregional Input-Output model a considerable effort would be required to estimate all the trade flows. Thus it would be desirable to adapt, if possible, trade coefficients estimated in other empirical studies.

Since the reason for updating production coefficients would be to obtain a better understanding of the current economic structure, and since trade patterns change as readily as production patterns, it would be preferable to update the trade coefficients while updating the production coefficients. However, due to lack of data regional trade patterns are more difficult to update than production coefficients. Thus one may be forced to construct a model which has current production patterns and assumes previous trade patterns.

Final Demands

The components of final demand which would have to be considered would be personal consumption expenditures, state and local government expenditures, federal government expenditures, exports and investment. The base year of each of these components would have to correspond to the base year of the output data considered in constructing the transactions tables. The investment component can be split into two parts, the investment in plant (construction) and investment in equipment. Inventory changes would not be considered because "most input-output studies have had unsatisfactory experiences in attempting to account for inventory change."[4]

> This experience gained primarily with national input-output tables, reflects the facts 1) that records on inventories have not been particularly good, 2) that these records have been kept in different ways by different establishments; 3) that there exist different notions of how to count and value inventories; and 4) that questions regarding inventories have seldom been precisely worded as they might have been.[5]

If the inventory component is disregarded, in effect, it would be the same as assuming that net inventory is zero.

Value Added

The value added row of the transactions table approximately states the payments of each industry to the factors of production. In many empirical studies, e.g. the Harvard Model, value added is estimated as a residual by subtracting the total inputs of an industry from its total output. By estimating value added in this manner the payments to the respective factors of production cannot be delineated. Since the payments to the factors of production actually constitutes income for both individuals and firms, it is the source of consumption and investment expenditures. Thus an increase in value added resulting from an increase in output would be the source of an increase in income which, in turn, would increase consumption and capital expenditures.

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[4] Walter Isard and Thomas Langford. Regional Input Output Study. (Cambridge: MIT Press, 1971) p. 11.

[5] Ibid. p. 103.

Since a dynamic model projects the changes in consumption and in investment resulting from changes in output, in such a model it is important to delineate the amount and the distribution of value added by each industry. For an increase in the output of any industry would increase factor earnings and it is this increase in factor earnings which leads to the increase in consumption and in investment.

SURVEY VERSUS NON-SURVEY PROCEDURES

The preceding section was devoted to outlining the types of data required for the implementation of the model recommended for the MKARMPPIS. In this section the procedures by which such data can be obtained will be introduced. During this discussion it will be brought out that the procedures by which the most accurate data can be obtained might not be feasible due to time and cost limitations. If this occurs, other types of data and procedures for estimation would have to be explored.

The first and most critical question which must be faced is whether or not to survey, and if survey is desirable, to what extent? Also if survey is undesirable, what are the other possible sources of the necessary data, and what are the limitations of such data?

It is quite obvious that it would be far too costly to survey all the transaction tables for all the regions delineated in the recommended model. However, it may be possible to conduct a survey which could be used to estimate the production functions of the impact region and it is certainly worthwhile to explore this possibility.

A particular type of survey which could be conducted would be a stratified random sample. The stratification could be set along the economic subarea boundaries of the impact region. Thus a random sample for each industrial classification could be taken from each of the economic subareas. A strong reason for stratifying the sample along economic subareas is the expected significant variation in the industries in these areas. The sample could be further stratified so that the high output industries would have a disproportionately large representation. Though this would certainly bias the sample as to complete randomness, it would insure that the industries sampled would account for a fairly high percentage of the total output of the region. If the number of sectors of the model would be thirty, and if a sample of five industries for each sector would be taken from each economic subarea, then the total number of industries included in the sample would be 450.

Of the two ways of conducting the survey, mailed questionnaire and personal interview, the interview method would probably produce the most complete results, while the mailed questionnaire method would probably require less time and cost.

In order to determine which method, if either, would be feasible for MKARMPPIS, various empirical studies were consulted. Of the studies in which an interview survey was conducted, the survey used in the West Virginia study[6] more closely corresponded to

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[6] William H. Miernyk, et. al., Simulating Regional Economic Development (Lexington, Massachusetts: D. C. Heath & Co., 1970).

the suggested survey for MKARMPPIS. The surveys are similar in three ways: first, in the West Virginia study 409 firms were interviewed, while 450 firms are projected to be surveyed; second, the geographical area covered in the survey of West Virginia, though not as large, is approximately the same size as the impact region; third, the industrial integration of West Virginia is similar to, though perhaps not as complex as, the interindustry relations of the impact region. Thus, the experiences of the West Virginia study could roughly correspond to the expected experiences of an interviewed survey for MKARMPPIS. It required seven interviewers and the entire summer to complete the survey.[7] The required twenty-one man-months does not include the time spent in identifying the firms, in designing and pretesting the questionnaire, and in compiling the data into a usable form; which takes as much if not more time than the actual conducting of the interviews. Since the geographic area is larger, the number of firms more, and the degree of economic interdependence is expected to be greater, the time and cost required for conducting an interview survey for MKARMPPIS would probably be greater than that required for the West Virginia study. It is doubtful if the increased accuracy

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[7] Miernyk, p. 16.

of the data obtained would justify the time and cost involved.

There are a number of studies which conducted mailed surveys and the experiences seem to be uniformly bad. The Washington University tried to survey, by mail, the trade and service sectors for its multiregional input-output study. In the report it was stated that the responses were inadequate, and those sectors had to be estimated by other means.[8] The mailed questionnaire used for the Appalachian study elicited a twenty-one percent response rate.[9] Perhaps a more relevant experience was that occurred by Schreiner and Muncrief. They used a mailed questionnaire in their study of businesses in South-central Oklahoma. The authors stated that "Representatives of civic organizations, local government officials, chambers of commerce, and extension personnel provided advice and assistance in conducting the survey and increasing the response rate. At the suggestion of local cooperators, newspaper articles, radio broadcasts, regional television and personal contact were used to encourage the response of local businessmen. ...the gross rate of return for the entire eight county area was about 20 percent."[10]

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[8] Leven, p. 187.

[9] Research and Development Corporation, p. 92.

[10] Dean Schreiner and George Muncrief, "Estimating Regional Information Systems with Application to Community Service Planning," Oklahoma Agriculture Experiment Station Journal Article 2313, 1971, p. 26.

If such a concentrated effort in a neighboring geographic region produces only a twenty percent rate of return, one cannot expect that a mailed questionnaire for MKARMPPIS would produce a higher rate of return. A twenty percent rate of return would result in two significant problems. First, if 450 firms were contacted and 20 percent responded, there would not be enough information to construct a transactions table. The sample size would have to be significantly increased, perhaps quadrupled. Second, and more importantly, with a low response rate (twenty percent) random sampling theory no longer applies. Large biases can exist within the data obtained from the returned questionnaires. The size, the nature, and the significance of these biases cannot be determined. Thus production coefficients estimated from this data may significantly differ from the actual production coefficients of the region and the nature of this difference cannot be estimated. For this reason it is not recommended that a transactions table be compiled from data obtained from a mailed questionnaire.

Even though it is not recommended to obtain the data required for all the production coefficients by survey, it may be desirable to conduct an interview survey for a few particular sectors. The transportation sector is certainly one such sector. Since the completion of the project the transportation rates have fallen in the impact region. This would alter the transportation coefficients. If transactions table for 1970 are developed, it would be desirable that the tables refect the change in transportation coefficients. Since it is doubtful such changes can be estimated from secondary source information, the survey of transportation being conducted by the Army Corps of Engineers could be useful in developing the new transportation coefficients.

The large amount, and the type of investment in the impact region probably has significantly changed the production functions of two other sectors as well as the transportation sector. They are the wholesale and retail trade sector, and the recreational industries sector. It would be desirable that the coefficients developed for these sectors reflect the changes which have occurred in them. The coefficients for these two secotrs could be changed in two ways. The first would be for the Corps of Engineers to conduct a survey of these two sectors similiar to that conducted for the transportation sector. The second method would be to estimate the change from secondary sources then contact local authorities, particularly trade associations, to confirm or suggest alterations to these adjusted coefficients.

DATA COLLECTION PLAN AND SOURCES OF DATA

Transactions Table for 1963

The transaction tables for 1963 can be estimated from data prepared for the Economic Development Administration by the Harvard Economic Research Project. This data was assembled into a multiregional input-output model for the United States with 44 regions and 86 sectors. In order to estimate the production patterns and the trade flows for the models recommended for MKARMPPIS (with 5 regions and 30 sectors) certain modifications have to be made on the data. Since most of the sectors of the MKARMPPIS model would be comprised of more than one sector of the Harvard model, the commodity flows for these sectors would have to be appropriately summed. This would present no significant difficulty.

It would more complicated to estimate the production patterns and the trade flows for the regions. For the regions of the MKARMPPIS model which are entirely comprised of one or more complete regions of the Harvard model, the regional commodity flows would be the sum of appropriate commodity flow of the Harvard model. However, in estimating the commodity flows for the impact region and the region which includes the rest of the states of

Arkansas and Oklahoma, some difficulties are encountered. The methods which would be used to estimate the interindustry commodity flows and trade flows would be similar. The interindustry commodity flow matrix for Arkansas, and for Oklahoma, would have to be split into two matrices. One of the new matrices would give the interindustry commodity flows within the portion of the impact region which is in that state, and the other matrix would give the interindustry commodity flows for the rest of the state. Then the interindustry commodity flow matrix for part of the impact region which is in Arkansas will be combined with the corresponding matrix for Oklahoma, and thus the interindustry commodity flow matrix for the impact region will be obtained. A similar procedure will be followed for obtaining the interindustry commodity flow matrix for the region which includes the remaining part of the states of Arkansas and Oklahoma.

The original interindustry commodity flow matrix for each state can be split by first estimating the output by industry for each part of the state, then allocating the interindustry commodity flows according to output. The output estimates can be obtained from the Jack Faucett data which was used to estimate the interindustry commodity flow matrices, or can be obtained by using employment data from County Business Patterns.

Trade flows to and from the impact region could be estimated in a similar manner. The trade flow matrix for each state could be split by a simple proration formula, or a gravity model. It would be desirable to test several models with the type of data which would be used by the model to estimate. Such data is available for some commodities from the Census of Manufactures. The estimates of final demands for 1963, and the estimates of value added by industry for 1963 by the Harvard Economic Research Project can also be used after being treated in a manner similar to procedures followed in estimating trade flows and production coefficients.

Data Sources Used for Interindustry Flow Estimates

Since it is recommended that the Harvard Model be used as the data source for the MKARMPPIS, a detailed breakdown of the sources used for the required data closely follows the Harvard Study.

(a) Agriculture

The two agricultural sectors were divided into ten subsectors. Estimates of Farm production expenses, by category, in 1963 were obtained from the Farm Income branch of the U.S. Department of Agriculture. The categories of farm expenses were subdivided into inputs. These inputs were distributed among the purchasing agricultural subindustries and then assigned to the appropriate producing industry. These estimates of interindustry flows were supplemented by data from the Survey of Farmers' Expenditures in 1955[11] and estimates of imputed expenditures.

(b) Mining

A detailed product mix procedure was also used for the mining industries. The production coefficients were again obtained from the 370-order national table and were supplemented by data from The Interindustry Structure of the U.S. Mineral Industries, 1958. State output estimates were obtained from the latter source and from the Census of Mineral Industries, 1963.

(c) New Construction

A detailed product mix method was also used for the new construction industry. The 1963 national input coefficients were supplemented for four general regions by data from bulletins by the Bureau of Labor Statistics which give labor and material requirements for nine different types of construction. Output estimates were obtained from 1963 Output Measures for Input-Output Sectors by County by Jack Faucett Associates.

(d) Manufacturing and Service Sectors

A far less detailed product mix method was used for the manufacturing and service sectors. Again, the 1963 national production coefficients were applied. The output estimates came from State Outputs for Three-and Four Digit SIC Industries, 1947, 1958, and 1963.

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[11] Complete bibliographical entries of the sources cited in this section are found in the appendix of this paper.

These output estimates were made from employment data from County Business Patterns and from Location of Manufacturing Plants.

Data Sources Used for Trade Flow Estimates

The trade flows for the Harvard study were estimated by Jack Faucett Associates. The principle data source was the Census of Transportation, a special tabulation of the census, Carload Waybill Statistics, and Minerals Yearbook.

With the exception of Coal Mining and Petroleum, the data available for the estimation of trade flows for the nonmanufacturing industries was incomplete. For the manufacturing industries the data was far more complete; however, due to the various methods which had to be used the accuracy of the final estimates varies considerably. A breakdown of the sources used by sector types is given below.

(a) Agriculture

Estimates for shipments for the two agriculture sectors were obtained by combining estimates of rail shipments from Carload Waybill Statistics, 1963 with estimates of truck shipments from For-Hire Motor Carriers Hauling Exempt Agricultural Commodities. These estimates were supplemented with data from The Traffic Pattern of American Raw Cotton Shipments, Grain Transportation Statistics for the North Central Region, and Fresh Fruit and Vegetable Unloads.

(b) Forestry and Fishery Products

There are few commodity shipments from the forestry sector; thus, they were ignored. Since all products of the fishery industry go to other industries, such as the food and kindred products sector, the catches by state reported in Fishery Statistics of the United States were treated as interstate flows.

(c) Extractive Industries

The data for the Coal and Petroleum industries was the most complete among the extractive industries. Coal flows were estimated from Minerals Yearbook, 1963 and Bitumious Coal and Lignite: Changing Patterns in Distribution and Markets: 1962-1964. The petroleum and natural gas flow estimates came from Minerals Yearbook, 1963. For tne remaining three extractive industries state-to-state flows were estimated primarily from Carload Waybill Statistics, 1963 and supplemented where possible by such publications as Iron Ore, 1963, Census of Mineral Industries, 1963, and Minerals Yearbook, 1963.

(d) Manufacturing Industries

Estimates of trade flows of manufacturing industries were obtained in three ways. The first, and prefered method, and most commonly used method, was the data from a special tabulation of the Census of Transportation. This data had two flaws; first, it systematically excluded all shipments less than twenty-five miles; and second, it was not sufficiently complete to estimate all trade flows. The second choice was to expand data available from the Carload Waybill Statistics. Remaining trade flows were estimated by preparing census region to census region trade flows to states.

Data Sources Used for Final Demand Estimates

Final demand was estimated in six components for 1963. The components were: personal consumption expenditures, gross private domestic investment, net change in inventories, net exports, state and local government expenditures, and Federal government expenditures. Personal consumption expenditures were estimated by multiplying estimates of average consumption expenditures from the 1960 Consumer Expenditure Survey by estimates of 1963 population by income group which were extrapolations from the 1950 and 1960 Census of Population. Gross private domestic investment consisted of new plant construction, which was directly estimated from the new construction sector, and purchases of new equipment. Estimates of interindustry flow of new equipment were obtained for each industry in each state by multiplying the national Capital Flow Matrix by estimates of capital equipment expenditures by the respective industry for each state. The study did not cite the source of the latter estimates.

Net change in inventories were estimated for the states by prorating the national total to each of the states on the basis of output. Net exports were estimated by prorating the industrial exports by customs region obtained from Highlights of U.S. Exports and Imports to the customs districts on the basis of total exports by the districts. Purchases by state and local governments were estimated by multiplying the amount spent in each state by function, estimated from the Census of Governments, 1962, by national average of the industrial composition of government purchases by function obtained from the 370-order input-output table published by OBE. Estimates of federal non-defense expenditures by state were generally obtained by prorating the national figure of federal government expenditures from each industry to the states on the basis of federal, civilian employment in the state.

State estimates of defense expenditures, by industry, were largely obtained from three sources. The sources were: Shipments of Defense-Oriented Industries, 1965, Military Prime Contract Awards by Region and State, Fiscal Years 1962-1966, and Unclassified Defense and Space Contracts: Awards by County, State, and Metropolitan Area, United States, Fiscal Year, 1964.

1970 Transactions Table

Interindustry Flows

Transactions tables for 1970 would be more difficult to estimate than ones for 1963. The first problem would be to estimate the interindustry commodity flows for each region. Since a survey method is not recommended, the 1970 interindustry commodity flows must be estimated from the patterns occuring in the existing commodity flow data. There are several ways of accomplishing this. All of which would involve multiplying existing or modified production coefficients by 1970 estimates of output.

Various types of production coefficients can be developed by following different procedures. These production coefficients will reflect the current regional technologies in varying degrees. The first and easiest type to estimate would be to simply assume that the 1970 national production coefficients (which are not surveyed) apply to the regions. As previously discussed, this would be the same as assuming that there are no regional differences in technology and in product mix. A second method would be to simply apply the 1963 regional production coefficients estimated by the Harvard Economic Research Project. Using this procedure some of the differences in regional product mix and technology would be delineated. However, one would have to assume that the structure of the economy had not changed from 1963 to 1970.

The third and prefered method would be to 'update' the 1963 regional coefficients by multiplying them by the ratio of the 1970 national coefficients to the 1963 national coefficients. The assumption implicit in this procedure is that the same trend of change occuring in the national coefficients for this period occurs in the regional coefficients, though the regional coefficients and the national coefficients for 1970 may still significantly differ. There is some empirical justification for this assumption. In the West Virginia study, Miernyk used the "best practice" approach to project changes in the regional coefficients (this approach requires surveyed data). He found that "the changes in West Virginia are consistent with national trends in technical coefficients,"[12] after taking into account the added influence of changing trade patterns on a regional economy.

The estimates of output by state for 1970 can be obtained from the Annual Survey of Manufactures, 1970. These output estimates can be prorated to substate areas on the basis of employment. The employment data can be obtained from the Census of Population, 1970. For the non-manufacturing industries, output can be estimated by multiplying employment of these industries by national ratios of employment to output.

Interregional Flows

The 1970 trade flow matrices will be far more difficult to develop than the 1970 interindustry flow matrices.[13] The easiest method would be to assume that the 1963 trade coefficients still apply and multiply them by the 1970 output estimates. This would imply that though the volume of trade may have changed from 1963

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[12] Miernyk, p. 34.

[13] The last transportation census was for 1967 and the data developed by this census is of a poorer quality than the 1963 census. Further, it would be very time consuming and costly to assemble the 1967 data to a useable form for the model. Unlike production coefficients, trends in national trade coefficients within the country are not estimated, however ; even if they were, it is doubtful that they could be applied. Thus, there is no practical way of estimating changes in regional trade patterns without regional data.

to 1970, the actual trade patterns did not. Due to the lack of available trade flow data, the changes in the transportation patterns which occured after the project completion could only be estimated through survey. The survey of the transportation sector, conducted by the Corps of Engineers, may produce sufficient data to estimate changes in the transportation margins for all industrial sectors. These changes could then be used to alter the commodity flow matrices, thus, the transportation and trade coefficients.

Value Added

Estimates of value added for 1970 by state can be obtained for most sectors from the Bureau of the Census publication. The Census of Agriculture, 1969, the 1970 Survey of Mineral Industries, and the Survey of Manufacturing Industries, 1970, give a breakdown of value added by state. The state figures for value added can be prorated to the sub-state regions on the basis of employment by industry. Value added by the trade and service sectors can be estimated by prorating the national totals to the respective regions on the basis of employment by sector.

Final Demands

Estimates of the final demands for 1970 would have to be derived from various sources. An estimate of personal consumption expenditures can be obtained by using the 1970 Census of Population and the 1960 Consumer Expenditure Survey.[14] The Census of Population gives the number of people in each income group by county and by state. The Consumer Expenditure Survey gives the average expenditures for income groups by geographical regions. By multiplying together the appropriate categories of data from the two sources, estimates of the total purchases from each industry by region can be obtained. Of course some modifications of the data would be required to make them compatible with each other and to make them compatible with the thirty sector model.

Estimates of expenditures for new plant and equipment can be obtained from the 1970 Survey of Manufactures. The data can be broken down to state estimates by using ratios developed from the 1967 Census of Manufactures. This, of course, would imply the assumption that the geographic patterns of investment had not changed from 1967 to 1970. State estimates can then be prorated to sub-state estimates on the basis of employment. By multiplying

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[14] The 1970 Consumer Expenditure Survey will not be published until 1974, thus, could not be used in this study. The assumption implicitly made by using the 1960 Consumer Expenditure Survey, is that the consumption patterns have not changed.

the estimates of expenditures by the capital flow coefficients, the expenditures can be allocated to respective input-output sectors. Unfortunately, the most recent publication of the Capital Flow Matrix is for 1963.

Estimates of state and local government expenditures can be obtained by combining data obtained from four sources: 1) Governmental Finances in 1970-71; 2) Local Government Finances in Selected Metropolitan Areas and Large Counties in 1970-71; 3) State Government Finances in 1970; and 4) Census of Governments, 1967. Since state and local government expenditures can be estimated only by function from this data, additional modification of the data is necessary. First, transfer payments, interest, etc. would have to be netted out in order to obtain expenditures on goods and services. Then, the expenditure on goods and services by function can be allocated among various industries by using the same pattern of allocation developed by the Harvard Economic Research Project. This procedure would imply two things, first, although the degree of expenditures for each function may vary from region to region, the pattern in which the expenditures for a given function are allocated among industries is the same for all regions. Second, this pattern did not change from 1963 to 1970.

Federal government expenditures on goods and services can be estimated in two parts. The amount of federal non-defense expenditures can be estimated for each region by prorating the national figure to the regions on the basis of the amount of federal civilian employment in the region. Federal defense expenditures can be estimated from Shipments of Defense-Oriented Industries and from publications giving the expenditures on military installations. The expenditures estimated from the shipment data and other sources can be allocated to the regions following the same pattern the expenditures were allocated in the Harvard study.

Foreign Trade

Due to the lack of available state data, the exports and imports have to be estimated by customs districts and customs regions. Data giving the exports and imports by industry is compiled for the six customs regions. The customs districts data only gives exports and imports as an aggregate. Thus, as in the Harvard study, estimates of exports and imports by industry can be obtained for the customs districts, when needed, by prorating the customs region's exports and imports to the district on the basis of the district's share of total exports and total imports.

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This report critiques a number of operational multi regional and single region input-output models for application to the impact analysis of the completed McClellan-Kerr Arkansas River Multiple Purpose Project. The use of a modified revision of the Harvard Univ. Multi-region Input-Output Model completed for the Economic Development Administration is recommended.

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