10-1-1966

Preliminary Analysis: An Analytical System for the Measurement of Economic Impacts in Appalachia - Report 1

Research and Development Corporation

0110

REPORT I

PRELIMINARY ANALYSIS:
AN ANALYTICAL SYSTEM FOR THE MEASUREMENT OF ECONOMIC IMPACTS IN APPALACHIA

(Contract No. DA-33017-CIVENG-66-21)

Prepared for the

OFFICE OF APPALACHIAN STUDIES
U. S. Army Corps of Engineers
P. O. Box 1159
Cincinnati, Ohio 45201

Research and Development Corporation

Washington, D. C.

October 1966

NOTE TO THE READER:

This report (the first of four) explains in detail the preliminary analysis made to determine whether or not a means existed to construct a regional input-output system based upon national coefficients. The scope of the system derived is explained.

Report II is the technical notes from the completed study. Utilizing both the preliminary analysis and the technical notes, the reader will be able to survey the utility and limitations of the research. Both reports are published to facilitate that understanding by others concerned with regional or area analysis.

TABLE OF CONTENTS

I. Introduction

This study has as its objectives: (1) to appraise the possibility of constructing an internally consistent statistical description of the economic structure of Appalachia; (2) outline a practical plan for constructing an analytical model for evaluating economic impacts following public investments and from increasing final demands for goods and services produced in the Region; and (3) perform a field investigation to test procedures for obtaining new information, not otherwise available, required for the model.

There are a number of economic effects which might result from public investments. First, public investment increases the demand for goods and services used directly in the project. Second, on-site demands for products and services may generate local demands in industrial sectors which are not employed directly in the project. This effect may also increase demands on sectors which are employed directly in the project. Local residents employed directly in the project and those local people who are supporting them may realize increases in wages, salaries, rents, profits, and interest. Some of the money received by individuals from these sources will be spent in the local area. This spending will again increase the demand for local factors of production and give rise to additional income in the local area, again in the form of wages, salaries, rents, profit and interest. The successive respending within the local area by both individuals and firms gives rise to a multiplier effect.

A third type of impact resulting from public investments is a change in the comparative advantage of the region. Reduced power costs, the availability of clean and adequate supplies of water, and the location of a navigable waterway are factors which might alter the locational advantages of an area. Public investments of this type alter the production functions of some prospective establishments from what these functions would have been without the investment. Public investments in these fields, therefore, affect costs of production and the probability of an establishment locating in the area.

A fourth impact of public investment concerns the economic decisions of residents of the region, and of others. The public investment may provide residents with a more optimistic outlook concerning their economic future, or may reduce the hopelessness of their situation from their point of view. They may become more aggressive in the pursuit of economic gains, which may lead to innovations and investments. The public investment may also trigger investments by outside firms which have already been considering investments in the region. The list of impacts described above is not exhaustive. It is used simply to indicate the focus of the work done under this contract and its relationship to other important economic effects.

The economic impacts to which this study relates result from the first and second effects described above. We are interested in the first type of impact from the standpoint of providing an account of geographic origins of the inputs used directly in water resource development projects. The study of indirect economic effects of development projects requires a study of the economy of the region and its trading relationships with other regions. The major effort was to provide a framework within which the economic effects of water resource development projects and other changes in final demand could be predicted.

These effects are limited, however, to the impact on the existing economic community resulting from specified changes. This work is not directed toward predicting what changes in industrial structure are likely to occur because of water resource development.

The methodology with which we are concerned is related to the estimation of both "U. S. benefits" and "Appalachian benefits" as discussed by Professor Maass in his letter of May 19, 1966 to Colonel John C. H. Lee, Jr. The model which is described would estimate "multiplier" incomes which would result from construction and operation of projects. Additionally, "multiplier" incomes resulting from other changes in final demand could be estimated by the model, once the changes in final demand are specified.

There are a number of ways of attacking the problem of estimating regional economic impacts. The National input-output model has been used as the basis of some analytical techniques which have been employed. In other studies, data from economic units within the region were used to develop the relationships needed. In Section II the National interindustry model is discussed. The relationship between the interindustry accounts and the input-output model is described. The assumptions and structure of the model are sketched and the way in which the model is used for projections is outlined.

Section III contains a discussion of some of the analytical techniques which have been used to estimate regional economic effects which result from external causes. The survey method of constructing regional interindustry accounts is outlined. A method of estimating regional interindustry accounts from the National input-output model and other data is given and the "balanced regional model" is described.

An interregional model is developed in Section IV for three regions of Appalachia. The remaining sections of the report relate to particular aspects of this model. In Section V a number of models are considered for estimating interregional flows of manufactured products. Section VI presents a method of estimating the extent to which products other than manufactured goods needed within a region are supplied from within the region. Procedures are described by which information can be obtained about shipments of products from agriculture, forestry and mines. Procedures are also outlined for obtaining data required by the model for the following industries: services, transportation, utilities, and construction.

A number of elements of the system are considered in Sections VII and VIII. Interindustry sales and purchases of plant and equipment are not shown in the interindustry accounts; a method of considering investment expendituresis outlined. A subdivision of "value added" is presented which enables estimates of payments to residents of Appalachia to be considered. The breakdown of value added enables the consideration of the relationship between income in the Appalachian Region and Personal consumption expenditures. The relationship of local income and State and local government expenditures is also discussed.

Questionnaires were prepared and a survey was conducted to test suggested procedures for obtaining information required by the model. Business firms and households were surveyed in an effort to determine from which areas of Appalachia and the rest of the United States their purchases were made. The results of the surveys are evaluated in Section VIII.

II. National Input-Output Study

The National interindustry study for 1958 provides valuable data for economic analysis. This study specifies the structural interdependence that existed in the National economy in 1958. It is based on a set of interindustry accounts which are consistent with the National income and product accounts. In addition to presenting the output of the Nation in terms of final product flows and incomes generated, the interindustry study showed the flows of intermediate products among industries.

Interindustry Accounts

The National interindustry study for 1958 provided both a set of interindustry accounts for that year and an economic model. The accounts record for each sector, the sales to and purchases from every other sector as well as transactions within the sector itself. A total of 87 sectors were included in the original table.

The interindustry accounts contain a row and a column for each sector. A row corresponding to a sector shows the distribution of a sector's output to itself, to other industries and to final markets. A column shows the purchases by a sector, from producing sectors, imports and "value added."

The final markets, or "final demand," include: (1) Personal consumption expenditures, (2) Gross private fixed capital formation, (3) Net inventory change, (4) Gross exports of goods and services, (5) Federal government purchases, and (6) State and local government purchases. The above can be thought of as the prime movers of the economic system or as exogenous factors in an input-output study. The output of a particular industry, on the other hand, can be thought of as dependent on the levels of final demand.

The value of a sector's output less its purchases of goods and services is defined as value added. It includes payments for primary factors of production. This category shows the combined total payments for the following: (1) Compensation of employees, (2) Proprietor's income, (3) Rental income of persons, (4) Corporate profits, (5) Net interest, (6) Capital consumption allowances, (7) Indirect business taxes, (8) Business transfer payments, and (9) Current surplus of government enterprises less subsidies. Although value added in the interindustry model is equal to payments for these factors of production in the Nation, no detail is given for the components listed above.

Input-Output Model

The input-output model, which was originally developed by Leontief, has been empirically estimated by utilizing data of the interindustry accounts. In order to construct this model, however, certain assumptions regarding the "nature of production" are necessary. Chenery and Clark[1] have specified three basic assumptions of Leontief models as:

1. Each commodity (or group of commodities) is supplied by a single industry or sector of production.

2. The inputs purchased by each sector are a function only of

[1]For a detailed discussion of the assumptions of input-output analysis, see H. B. Chenery and P. G. Clark, Interindustry Economics (New York: John Wiley, 1959), pp. 33-43.

the level of output of that sector, and

3. The total effect of carrying on several types of production is the sum of the separate effects.

A National interindustry model was constructed along with the interindustry accounts. The development of the model from the accounts will be discussed. We begin with the basic accounting relationship for an industry or sector:

(1) $X_i - \sum_j x_{ij} = Y_i$

where X_i means the output of the i th sector

x_{ij} means sales by the i th sector to the j th sector, where j varies over all sectors including the i th.

and Y_i means final demand for products of the i th sector.

However, in the Leontief model it is assumed that inputs are required in a fixed proportion to output. Thus, given this assumption, an input coefficient can be computed from the interindustry accounts. Therefore, we have:

(2) $x_{ij} = a_{ij}X_j$

Substituting the corresponding numbers from the set of accounts for x_{ij} and for X_j, we compute a_{ij}.

Equation (1) can be rewritten as:

(3) $X_i - \sum_j a_{ij}X_j = Y_i$

In the case of an economy with three sectors, (3) could be replaced by:

$$(4)\quad X_1 - a_{11}X_1 - a_{12}X_2 - a_{13}X_3 = Y_1$$

$$-a_{21}X_1 + X_2 - a_{22}X_2 - a_{23}X3 = Y_2$$

$$-a_{31}X_1 - a_{32}X_2 + X_3 - a_{23}X_3 = Y_3$$

By factoring and detaching the coefficients (4) can be written as matrices:

$$(5)\quad \begin{bmatrix} 1-a_{11} & -a_{12} & -a_{13} \\ -a_{21} & 1-a_{zz} & -a_{23} \\ -a_{31} & -a_{32} & 1-a_{33} \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

Equation (5) can be written in matrix form as:

$$(6)\quad (I-A)X = Y$$

The form used to estimate the set of industrial outputs X resulting from a given final demand Y is:

$$(7)\quad (I-A)^{-1}Y = X$$

The final formulation (7) shows that the vector of industrial outputs is a function of the specified and fixed structural interrelationships (the a i j ' s) and of Y, the vector of final demand. which must be determined outside the model. Thus, if we are willing to accept, for the purpose of projections, the assumption that input coefficients are fixed, it is possible to estimate production of each sector for a given final demand. Thus, given the National model, it is possible to estimate National economic impacts of changes in inventories, investment, exports, government expenditures, etc.

The inverse matrix, which is called the matrix of interdependence coefficients, corresponding to $(I-A)^{-1}$ in (7), was provided in the National interindustry study. An interdependence coefficient shows the direct and indirect production in a sector required per dollar of final output in a given sector. Interindustry multipliers can be computed by adding the coefficients in a column of this table. The multiplier for a sector specifies the total production (direct and indirect) required from all industries to produce a dollar's worth of final output in that sector.

Thus the National interindustry study can be summarized in three tables: (1) interindustry transactions, including final demand sectors, (2) direct requirements per dollar of gross output, and (3) total requirements (direct and indirect) per dollar of delivery to final demand. These tables, which were taken from the <u>Survey of Current Business</u> are provided in Appendix (Tables 1 - 3).

III. Regional Input-Output Methods

Most of the regional interindustry studies which have been published have used direct surveys to obtain data used for the construction of interindustry account. The first stage is generally to divide all economic activities into a number of sectors, which may vary according to the scope and purpose of the study. Rao and Allee[1] used six sectors in their study of San Benito County, California. Lund[2] used eleven sectors in a study of Southwest Wyoming. Thirty-seven sectors were used in an interindustry study of California[3] and fifty-eight sectors were used by Gamble and Raphael[4] in their study of Clinton County, Pennsylvania.

Once the sectors have been defined, business establishments are asked to give information on payments for primary factors of production and on the value of purchases from establishments in the region and the value of these purchases accounted for by establishments of each sector, including their own. Similarly, they may be asked about sales to customers within the region, again broken down by sectors. Information is also sought on purchases from outside the region ("imports")

---

[1]Ananda S. Rao and David J. Allee, An Application of Interindustry Analysis to San Benito County, California, University of California, Giannini Foundation Research Report No 278, September, 1964.

[2]Richard E. Lund, A Study of the Resources, People and Economy of Southwestern Wyoming, University of Wyoming, January, 1962.

[3]William E. Martin and Harold O. Carter, A California Interindustry Analysis Emphasizing Agriculture, University of California, Giannini Foundation Research Report No. 250, February, 1962.

[4]Hays B. Gamble and David L. Raphael, A Microregional Analysis of Clinton County Pennsylvania, Pennsylvania Regional Analysis Group, Pennsylvania State University, February, 1965.

and sales outside the region ("exports"). This information, however, is generally not broken down by sectors; instead "imports" are treated as a single supplying sector, and "exports" as a sector of final demand.

On the basis of these data an interindustry flows table, or rather two interindustry flows tables, can be constructed for the region. A table can be constructed by just considering purchases by each sector; this can be described as building the flows table "by columns." Alternatively, a table can be constructed by only considering sales by each sector, which can be described as building the table "by rows." In principle, if all the data were accurate and if establishments questioned were perfectly representative, the two tables would be identical. In practice, this does not happen, and the two tables must be reconciled.

Once the interindustry flows table has been obtained, a matrix of coefficients (corresponding to the a_{ij}'s of the National input-output table) can be constructed. These coefficients show the direct use by a sector within the region of the outputs of sectors in the region per dollar of output of the purchasing sector. The use of such a table for a regional impact study implies the assumption that the proportion of expenditures by any sector on the products of each sector remains constant. Its use also implies that a constant proportion of a sector's requirements of the products of any sector is supplied from within the region.

A number of methods have been devised in an attempt to make use of national interindustry studies in regional analysis. One of these methods considers one region in detail and the "Rest of the World."[1] This model assumes that the production function for a given sector within the region being studied is the same as for that sector in the nation as a whole. Thus, the total requirement of inputs for each sector can be estimated by considering the outputs produced by that sector in the region being studied. Statistics are often available giving outputs by industry for the region being studied. Consider as an illustration the problem of estimating the input requirements of the steel industry in the region being studied. Since we have the national coefficient matrix and an estimate of the output of the steel industry in the region, we can determine the direct input requirements:

$$(8) \quad \begin{bmatrix} a_{is} \\ a_{2s} \\ \vdots \\ a_{is} \\ \vdots \\ a_{ns} \end{bmatrix} X_s = \begin{bmatrix} x_{is} \\ x_{2s} \\ \vdots \\ x_{is} \\ \vdots \\ x_{ns} \end{bmatrix}$$

---

[1] See, for example, Bureau of Business and Economic Research, University of Maryland, "A Regional Interindustry Study of Maryland," <u>Studies in Business and Economics</u>, Vol. 8, No. 2., September, 1954.

Where a_{is} 's are the national coefficients for the steel industry, which specify the cents' worth of each sector's output required in the steel industry.

X_s means the output (in dollars) of the steel industry in the region being studied.

x_{is} means the resulting estimate of value of goods produced in industry i and shipped to industry j.

Since column vectors of a_{ij} 's are available for all sectors from the table of national input-output coefficients, interindustry flows can be estimated by this method, provided that outputs by industry are available for the region being studied.

An estimate of the total industrial demand within the region for the products of a sector can be obtained by summing the estimated interindustry flows from that sector to all purchasing sectors. The total requirements within the region for the products of the ith industry can be expressed as R_i:

(9) $R_i = \sum_j x_{ij} + Y_i$

where Y_i means final demand within the region for product i.

Estimates of regional economic impacts require that regional input-output coeffients be estimated which distinguish between locally produced and imported imputs. These coefficients could be estimated from a table of interindustry transactions between firms within the region being studied. However, data showing these interindustry transactions are seldom available. Therefore, it is necessary to develop a different procedure for allocating the needed inputs between the region being studied and the "Rest of the World."

One method which has been used to make this allocation is to assume that there will be no imports unless local requirements exceed local production. Where local requirements exceed local production it is assumed that imports will just make up the difference. Thus, imports of the products of a sector, say sector i, can be estimated by m_i:

$$(10) \qquad m_i = R_i - X_i$$

A negative m_i would occur in cases where the production of section i within the region being studied exceeded the use of the products within the region. In this case exports of good i would result, with no imports of the product. This method can be used to allocate inputs to (1) those originating within the region, and (2) those imported from the "Rest of the World." Thus, it can be used to develop a table of estimated regional interindustry transactions, given the above assumptions. A table of regional input-output coefficients can be computed from the regional interindustry transactions table by dividing each cell of a column by total output of the sector. This coefficient table can be used to develop models aimed at estimating regional economic impacts.

However, the use of this model in regions of the United States would result in substantial bias. In this country, and especially in the area east of the Mississippi River, the economies of metropolitan areas and larger regions are highly interrelated. Regional "cross-hauling" of the same products is commonplace due to factors such as product differentiation, advertising, and imperfect knowledge on the part of both buyers and sellers. Additionally, the definition of input-output sectors affects the allocation of inputs between the region being studied and imports. As industries are combined into fewer sectors, the amount of net trade in all sectors combined will tend to decrease.

This model overestimates the proportion of locally produced goods and services utilized in local production processes, and underestimates leakages of money from the region, resulting in multipliers which are biased upward. Therefore, it is not an adequate model of the relationships between a region and the rest of the United States. Thus, other techniques for estimating the trading relationships between regions must be sought.

Another method of utilizing the National input-output model for regional studies is due to Isard and Leontief and is known as the balanced regional model. This model divides all commodities into a number of types by considering the extent to which they move in interregional trade. Isard proposed dividing commodities into "national" commodities, which move over great distances in interregional trade, "regional" commodities, which are more restricted in trade, and "local" commodities, which move only a short distance from where they are produced. Corresponding to each type of commodity, "national," "regional," and "local" are sets of geographic areas. The nation is divided into a number of regions and each region, in turn, into a number of localities. Production and consumption of "national" goods are assumed to be in balance within the nation. Further, it is assumed that regional goods are consumed in the region in which they are produced and that local goods are consumed in the locality in which they are produced.

In order to apply this model, a set of constant "allocation coefficients" must be established. These state what proportion of the nation's output of "national" commodities is produced in each locality and what proportion of each region's output of "regional" commodities is produced in each locality. Given these, and a matrix of national technical coefficients, it is possible to compute the level of output resulting in each locality of any given vector of final demands, and thus the effects of changes in final demands upon each region and locality.

Reasonably accurate allocation coefficients are difficult to determine from data available for the United States. One method of estimating allocation coefficients is to assume that increases in final demand would be met in proportion to the existing output in each locality, which can be estimated using published statistics. Therefore, allocation coefficients for national commodities could be estimated by determining the proportion of national output originating in each locality. Allocation coefficients for regional commodities are proportional to the quantity of the commodity produced in each locality within the region.

Consider the estimate of changes in industrial outputs resulting from an increase in final demand for "national" commodities. First, the increase in outputs from "national" industries would occur in all localities in proportion to their former output. Increases in outputs in some "regional" industries would result from increased demands by the "national" industries. These demands would be met by the increased outputs of "regional" industries within the region where they are to be used, because "regional" goods cannot by definition cross regional boundaries. The outputs of "local" commodities would also be increased to support the production of both "national" and "regional" commodities within the locality. Increases in outputs of "regional" and "local" commodities would result in still further output increases in "national" as well as "regional" and "local" industries. These increases in "national" and "regional" outputs would be distributed among localities using the original allocation coefficients. In this way the impact of a given final demand is traced to regions and localities.

It is important to note that this model virtually ignores transportation costs, although regional comparative advantage may receive consideration in estimating the allocation coefficients. Final demands for "national" goods are not regionally specific. Therefore, the model does not adequately represent the economic interrelationships among regions, when the area experiencing the increase in final demand is known. The Census of Transportation indicates that the probability of obtaining a needed "national" good from nearby areas is much higher than from a remote region, even though there is considerable cross hauling.

The balanced regional model using allocation coefficients computed using the technique described underestimates the extent to which "national" commodities close at hand are used in production in preference to those produced far away. The model overestimates imports of "national" commodities, so that from this standpoint it tends to underestimate regional interindustry multipliers. The model underestimates imports of "regional" commodities by considering them to equal zero. The interindustry multipliers based upon the balanced regional model would be biased downward for industries mainly using national commodities and biased upward for industries mainly using regional and local commodities.

We have concluded from our review of existing techniques that the biases which would result from an application of either the regional model based upon secondary data or the balanced regional model are so great that these techniques should not be employed in a study to measure the economic expansion following public investments in Appalachia. Therefore, we developed the interregional model which we believe is superior to existing techniques utilizing secondary data for the purpose of measuring economic impacts in Appalachia. Section IV describes how the National input-output study and information concerning interregional trade are utilized in constructing a three-region input-output model for Appalachia and also presents the additional detail which is available from the National input-output study. The remaining sections of the report describe how information concerning interregional trade can be obtained fromthe three regions of Appalachia and how these and other data can be utilized in the construction of the three-region input-output model.

IV. AN INTERREGIONAL MODEL

Each column of the direct requirements table of the National input-output study (Appendix Table 2) can be thought of as a National production function for that particular sector. For example, we see from the 1958 National input-output Table 1 that Household furniture (Sector 22) used directly 12.4 cents' worth of output from Lumber and wood products except containers (Sector 20) for each dollar's worth of furniture produced. If National output of the Household furniture sector were expanded by a million dollars, approximately $124,000 additional output of lumber and wood products would be required. This estimate is based upon the assumption that the demand for inputs is directly proportional to the level of output of the purchasing sector.

The interregional model is developed from the National model by considering the respective columns as production functions for the individual sectors. It is assumed that the production function for a particular sector is the same in the region being considered as in the Nation as a whole. Referring to the earlier example, this assumption means that the Household furniture sector in the region being studied would utilize directly 12.4 cents' worth of the output of the Lumber and wood products sector for each dollar's worth of output. In other words, technology is assumed to be the same in all regions. Also, it is assumed that the regional industry mix within a sector is equal to that mix for the Nation in cases where there are several industries with different production functions included in a sector. For the

[1]See Appendix Table 2.

purpose of the interregional model the above assumptions are accepted and we concentrate on providing geographic detail concerning inputs.

On the basis of the assumptions described in the preceding paragraph, a set of production functions for the region under study is provided in the coefficient matrix, or the table of direct requirements.

The production function can be looked upon as a demand function for inputs needed by a sector to produce a given output. This function can be written for any industry, say industry j, as:

(11)
$$\begin{bmatrix} a_{1j} \\ a_{2j} \\ \vdots \\ a_{ij} \\ \vdots \\ a_{87j} \end{bmatrix} X_j = \begin{bmatrix} x_{1j} \\ x_{2j} \\ \vdots \\ x_{ij} \\ \vdots \\ x_{87j} \end{bmatrix}$$

However, a study of the Appalachian Region designed to measure economic impacts upon that region requires estimates of trade flows. We are interested in estimating to what extent demands for outputs from economic units within the region will be met by production within the region. That is, we must determine for each sector that proportion of the individual a_{ij}'s which is applicable to the region and that proportion which is applicable to other areas. Returning once again to our example, an estimate is needed of the proportion of all Lumber and wood products delivered to the Household furniture sector, which originates in the Appalachian Region.

In the section which follows, interregional trade will be discussed in terms of three regions of Appalachia. Consider all firms in the northern region which utilize in their production processes Lumber and wood products. Assume that the pattern of interregional trade in these products is the same for all industries. That is, the household furniture industry, the paper industry and all other industries would buy the same proportion of their lumber andwood products from within the region. They would also have similar import patterns from other regions of Appalachia and the "Rest of the World."

If this assumption is accepted, a table describing interregional trade for each sector can be prepared from interregional trade statistics in general. A hypothetical table is shown for Lumber and wood products. On the basis of the entries in this table the input-output coefficients can be distributed according to the region supplying these products. Each dollar's output of the Household furniture sector in Region 1 requires 12.4 cents' worth of Lumber and wood products. The Lumber and wood products must originate in Regions 1, 2 or 3 or in the "Rest of the World." Therefore, on the basis of Table 1, the input-output coefficients can be allocated to regions, thus achieving an integration of information about interregional trade and technological relationship. Table 2 shows hypothetical interregional input-output coefficients for the Lumber and wood products sector supplying the Household furniture sector for the three regions.

Table 1. Interregional shipments of Lumber and wood products.

Region of Origin	Region of Destination (in per cent)		
	Region 1	Region 2	Region 3
Region 1	60	5	--
Region 2	10	35	20
Region 3	--	10	50
Rest of the World	30	50	30

Table 2. Interregional input-output coefficients for Lumber and wood products purchased by Household furniture sector, by regions.

Region Supplying Input	Region of Production		
	Region 1	Region 2	Region 3
Region 1	.075	.006	
Region 2	.012	.044	.025
Region 3		.012	.037

The preceding discussion has outlined the basic elements of an interregional input-output system. However, there are a number of elements of the complete system which have not yet been considered. The problem of estimating interregional trade will now be examined because of its importance in the model. We will discuss problems of the capital account, value added, and other elements of the complete system after presenting methods for estimating interregional trade.

This methodological study is presented in terms of a three-region interregional input-output system. It is thought that there are advantages to describing the economic interrelationships between regions of Appalachia which would not be provided from analyses of single subregions. It is possible that an investment in one region of Appalachia could yield secondary benefits in another region. Therefore, it was believed desirable to describe the interrelationships which would enable the quantification of such effects.

However, the construction of a model of this type is not without costs in terms of foregone capabilities. For example, in this model the interrelationships between the regions in Appalachia and the other parts of the United States are not detailed. Therefore, the economic impact upon the Appalachian Region resulting from investments or changes in final demand in other geographical areas of the country cannot be measured. Furthermore, with this model there is no feedback from the National economy to Appalachia.

The effect of this lack of feedback is shown in the following example. Suppose there is a change in the output of an industry in the Appalachian Region, which increases the demand for raw materials produced in the Appalachian Region and in areas outside Appalachia. An industry outside Appalachia could increase its output in response to the change in demand, resulting in changes in demand for inputs used in its production process. Increased use of products and services needed in production outside Appalachia could result, in turn, in further increases in demand for outputs originating in the Appalachian Region. However, in the model, no feedback of this type will result because of the model's design. Although interregional feedback will not be provided by the model in Appalachia - "Rest of the World" relationships, the model will estimate feedback among the regions of Appalachia.

A major consideration in the design of the model was the estimation of Redevelopment benefits within the Appalachian Region. These benefits can arise directly in a region within Appalachia other than the one in which the investment is made. However, any such benefits arising from trading relationships with other areas must be the result of feedback. Interregional feedback is slight compared to impacts that result because of direct trading relationships.

The three regions were formed by combining economic sub-regions delineated by the Office of Business Economics. However, the regions of this study include only counties within Appalachia, whereas the economic sub-regions of OBE include some counties outside. This difference was necessitated by the objective of this study which was to estimate economic impacts within Appalachia. The techniques developed were not detailed enough to include the entire area of the OBE economic sub-regions and to separate the economic effects upon Appalachia from the effects upon other areas.

The regions which are used in this study should be considered tentative. Economic subregions along the boundaries of each region could have been placed in either of the adjoining regions. The delineation which was made was for the purpose of testing survey schedules, which required precise, if tentative, regional divisions.

Data are available to expand the existing input-output matrix for 1958. Interindustry flows have recently been published which disaggregate the Food and kindred products, Primary nonferrous metals manufacturing, and Electric, gas, water and sanitary services sectors of the original table.[1] Also, sales and purchases by agricultural firms have been estimated for 18 agricultural industries, including agricultural services, by the Economic Research Service, U. S. Department of Agriculture.[2] The sectors for which additional detail is available, along with their input-output identification numbers and related SIC's are shown in Table 3. Additional detail concerning interindustry transactions is provided in Appendix Table 4.

An expanded table of input-output coefficients can be developed from these data by dividing the interindustry transactions in each column by the column total. The resulting matrix would contain 114 sectors: the 87 of the original matrix plus the additional 27. This matrix would provide the basic input relationships on the National level. Various methods would be employed to provide geographic detail which would be used to allocate the input coefficients among regions.

---

[1] U.S. Department of Commerce, Survey of Current Business Vol. 46 No. 4 (April 1966) pp. 14-17.

[2] U.S. Department of Agriculture, Economic Research Service, Interindustry Sales and Purchases Study, mimeo, n.d.

The additional detail will decrease the computational burden of preparing an interregional matrix. It will be easier, for example, to make reliable estimates of trade flows from agricultural sectors to Food and kindred products sectors. In most cases virtually all the output of an agricultural sector would be shipped to a single food processing industry. The same holds for the disaggregated utilities sectors. Whereas, prior to the disaggregation, the utilities sector was shown to purchase both natural gas and coal, it is now shown that electric utilities purchase coal but little natural gas.

Table 3. Additional detail for the 1958 Input-Output Study

Input-output No. and Industry Title		Related SIC Codes (1957 Edition)
14.	Food and Kindred Products	20
14.1	Meat Products	201
14.2	Dairy Products	202
14.3	Canning, Preserving Fruits, Vegetables and Seafoods	203
14.4	Grain Mill Products	204
14.5	Bakery Products	205
14.6	Sugar	206
14.7	Confectionery and Related Products	207
14.8	Beverage Industries	208
14.9	Miscellaneous Food and Kindred Products	209
38.	Primary Nonferrous Metals Manufacturing	2819 (alumina only) 333, 334, 335 336, 3392
38.1	Copper Manufacturing	3331, 3351, 3362
38.2	Aluminum Manufacturing	Pt. 2819, 3334, 3352, 3361
38.3	Other Nonferrous Metals Manufacturing	3332, 3333, 3339, 3341, 3356, 3357, 3369, 3392

Table 3. (Continued)

Input-output No. and Industry Title		Related SIC Codes (1957 Edition)
68.	Electric, Gas, Water and Sanitary Services	49
68.1	Electric Utilities	4911
68.2	Gas Utilities	492
68.3	Water and Sanitary Services	494-497
1	Livestock and Livestock Products	A1 - A4*
	Meat Animals	A1
	Poultry and Eggs	A2
	Farm Dairy Products	A3
	Other Livestock Products	A4
2	Other Agricultural Products	A5 - A16
	Food Grains	A5
	Feed Crops	A6
	Cotton	A7
	Tobacco	A8
	Oil-bearing Crops	A9
	Vegetables	A10
	Fruits	A11
	Tree Nuts	A12
	Legume and Grass seeds	A13
	Sugar and Sirup Crops	A14
	Miscellaneous Crops	A15
	Greenhouse and Nursery Products	A16
Pt. 4	Agricultural Services	A17

*Agricultural industry No. from Interindustry Sales and Purchases Study.

Sources: U. S. Department of Commerce, <u>Survey of Current Business</u>, Vol. 46, No. 4 (April, 1966), p. 14. U. S. Department of Agriculture, Economic Research Service, <u>Interindustry Sales and Purchase Study</u>, mimeo, n.d.

V. Interregional Trade-Manufactured Products

Manufactured products are generally high in value relative to weight when compared to primary products. For this reason, manufactured products tend to move over wide areas in interregional trade. Product differentiation is another factor contributing to the large market areas for manufactured products. Advertising and company sales forces are employed to convince customers that there are real differences between products.

When one observes a flow table showing interregional shipments of manufactured goods, it is evident that market areas are extensive. Even in regions where the production of a sector is equal to the needs for that sector's output, interregional trade occurs. Where distances between regions are short interregional trade will be considerable. Where an area is remote from markets and sources of supply in other regions, such as the Pacific region in the United States, it will tend to be more self-sufficient. Table 4 shows use and production of Fabricated metal products for Census regions of the United States. It can be observed that each region supplies itself with a much smaller proportion of its requirements than it would seem to be able to. Similar relationships can be shown for other "Shipper Groups" of the 1963 Census of Transportation. From this table it can be seen that all regions are both exporters and importers of this commodity.

From the standpoint of an impact model, it is necessary to consider gross rather than net interregional trade. Interregional shipments fall off as transportation cost, or distance, increases even though some manufactured products move from the Atlantic coast to the Pacific coast and vice-versa. It is not unusual for each of the Census Regions to be both exporting a particular commodity to and importing it from each of the other Census Regions.

Table 4. Use, production and shipments of Fabricated metal products, except metal cans and miscellaneous fabricated metal products, by regions, 1963[1] (given in thousands of tons).

Region	Use	Production	Intraregional Shipments	Exports from Region
North East	583	356	91	265
Middle Atlantic	2536	2445	1313	1132
East North Central	3657	5611	2541	3070
West North Central	912	880	197	683
South Atlantic	2675	2359	1697	662
East South Central	1076	943	408	535
West South Central	1301	1197	758	439
Mountain & Pacific	3556	2505	2379	126

[1]Computed from data appearing in U. S. Bureau of Census, 1963 Census of Transportation, Commodity Transportation Survey, Shipper Series (Group 16), p. 9.

Multiregional Input-Output

Wassily Leotief and Alan Strout suggested a multiregional input-output framework to show the economic interdependence between regions and industries.[1] The multiregional or interregional

[1]Wassily Leontief and Alan Strout, "Multiregional Input-Output Analysis," Proceedings of International Conference on Input-Output Techniques (Geneva, September, 1961), pp. 119-150.

input-output system which they suggested was not intended to provide a theoretical description of factors and relationships which determine the pattern of trade among a system of regions. Rather, their objective was to provide a methodology which would be "a rough and ready working tool capable of making effective use of the limited amount of factual information with which, even in the statistically advanced countries, economists have to work."[1]

Leontief's objective was to determine a method for linking information concerning interregional trade with an input-output system. To do this it was necessary to develop a procedure for estimating trade flows where data on shipments did not exist. Leontief suggested a number of models of the "gravity" type, some of which do not require data on shipments between specific pairs of regions, only total exports from, and imports to, a region having to be known.

The formulations developed by Leontief offer promise for the construction of an interregional input-output system. However, it is necessary to test alternative models against estimates of interregional trade flows developed by other means.[2] There are a number of models which can be considered for estimating the geographic patterns of trade. A group of related models will now be considered.

Probability Orientation

Isard has made a strong case for a probability orientation in

---

[1] *Ibid.*, p. 119.

[2] Reference is made here to the 1963 Census of Transportation, in which interregional shipments are actually estimates based upon a probability sample.

the development of models of economic and social interaction.[1] The models developed by Leontief are closely related to models of spatial interaction discussed by Isard. Isard has discussed "the probability point of view" in terms of trip patterns within metropolitan areas.[2] Our discussion will examine similar relationships as they relate to interregional shipments of manufactured products.

Consider the pattern of interregional trade which would be likely to occur if transportation costs and other costs of overcoming physical separation did not exist. In a world of costless transportation a manufacturer might think of the market for his product as consisting of a number of regions, each taking a quantity of his product. The probability that a shipment, drawn at random from the set of all his shipments, will terminate in a given region (say region g) will depend upon the use of the product in region g relative to its use in all regions. The probability of a single shipment terminating in region g can therefore be written as:

$$\frac{U_g}{U_o}$$

where U_g means the use of the particular manufactured product in region g, and

U_o means the total use of that manufactured product in all regions.

We have established the probability of a single shipment terminating in region g, according to our model, and interregional shipments

---

[1] Walter Isard, Methods of Regional Analysis (New York: John Wiley, 1960), pp. 493-568.

[2] Ibid., p. 494.

will now be examined. Assume that the probability of a shipment terminating in region g is the same for all shipments originating in region h. Following this assumption, shipments from region h to region g will be directly related to production in region h and can be written:

$$(12) \qquad T_{hg} = \frac{k\, P_h\, U_g}{U_o}$$

Where, in addition to variables previously defined,
T_{hg} means shipments of a particular manufactured product from region h to region g, and
P_h means production of this product in region h.

Equation (12) can be used to generate a theoretical pattern of shipments based upon the assumption that transportation is costless. These predicted shipments can be compared to the actual shipments of the particular commodity which will be represented by S_{hg}. Ratios of actual to expected shipments can then be computed. In transportation studies these ratios, $\frac{S_{hg}}{T_{hg}}$, have been plotted against the distance between regions h and g, on graphs where both axes have logarithmic scales. A number of these studies showed that the effect of distance upon social and economic phenomena was approximately described by an equation which was linear in logarithmus.

A straight line is fitted to the plot of the ratios $\frac{S_{hg}}{T_{hg}}$ against the distance from h to g, both expressed in logarithms. This would yield an expression:

(13)
$$\log \frac{S_{hg}}{T_{hg}} = a + b \log D_{hg}$$

Where D_{hg} means the distance between region h and region g. The parameters a and b are the intercept of the Y axis (the ratio $\frac{S_{hg}}{T_{hg}}$ at distance equals 1) and the slope of the regression line, respectively.

Eliminating logarithms from both sides of the equation, and letting c be the antilog of a, results in the following expression:

(14)
$$\frac{S_{hg}}{T_{hg}} = \frac{c}{D_{hg}^{b}}$$

Rewriting (14) and substituting for T_{hg} from (12), we obtain:

(15)
$$S_{hg} = \frac{G P_h}{U_o} \frac{U_g}{D_{hg}^{b}}$$

Where G is equal to c · k, the two constants previously defined.

In the above expression the actual quantity shipped from region h to region g is a function of production in region h, use in region g, distance from region h to region g and total use of the product in all regions.

Graphical Model

The 1963 Census of Transportation has recently provided estimates of interregional trade in the United States. A number of formulations can be developed, and tested with these data. The similarity of the model developed by Leontief and the so-called gravity model discussed by Isard suggested that preliminary testing of this type of model could be carried out using graphical techniques.

For the preliminary analytical work, which was carried out to determine a methodology, we selected seven of the "shipper groups" used in the 1963 Census of Transportation. These groups were selected so as to provide commodities with a wide range of value-to-weight ratios. For each shipper group, the necessary calculations were made to construct the graphical model discussed above. These shipper groups were also used to test alternative formulations of mathematical models. These models will be discussed in the following section.

The "Shipper Groups" considered were:

Group 4, Textile Mill and Leather Products

Group 6, Paper and Allied Products

Group 13, Stone, Clay and Glass Products

Group 15, Primary Nonferrous Metal Products

Group 16, Fabricated Metal Products, Except Metal Cans and Miscellaneous Fabricated Metal Products

Group 21, Electric Products and Supplies

Group 23, Transportation Equipment, Except Motor Vehicles

Figure 1 shows for Textile Mill and Leather Products the effect of distance on the ratio $\frac{S_{hg}}{T_{hg}}$, the computation of which is described in the preceding section. In this particular case it appears that the relationship between the variables is approximately linear when both are transformed into logarithms. However, substantial despersion is apparent in Figure 1 around the line which in this case was fitted by eye.

It is possible to use a function of this type in the estimation of interregional trade. Further, this methodology, when combined with input-output analysis, may provide reasonable estimates of economic impacts. The following figures present graphical models for other groups of manufactured products. These graphs indicate that the relationship between the variables can be described quite well by a function which is linear in logarithms.

Dispersion around the line showing the relationship between the ratio $\frac{S_{hg}}{T_{hg}}$ varied from one graph to another and no attempt was made to measure this dispersion. However, we concluded from this graphical analysis that the models developed by Leontief and other related formulations provided a basis for more detailed analysis. The analytical procedures employed will be described in the following section.

However, before moving on, there is one additional point which should be brought out. Separate graphical models were prepared for the areas roughly east and west of the Mississippi River. Models showing shipments originating in the West showed less dispersion about the regression line than did models for the East.

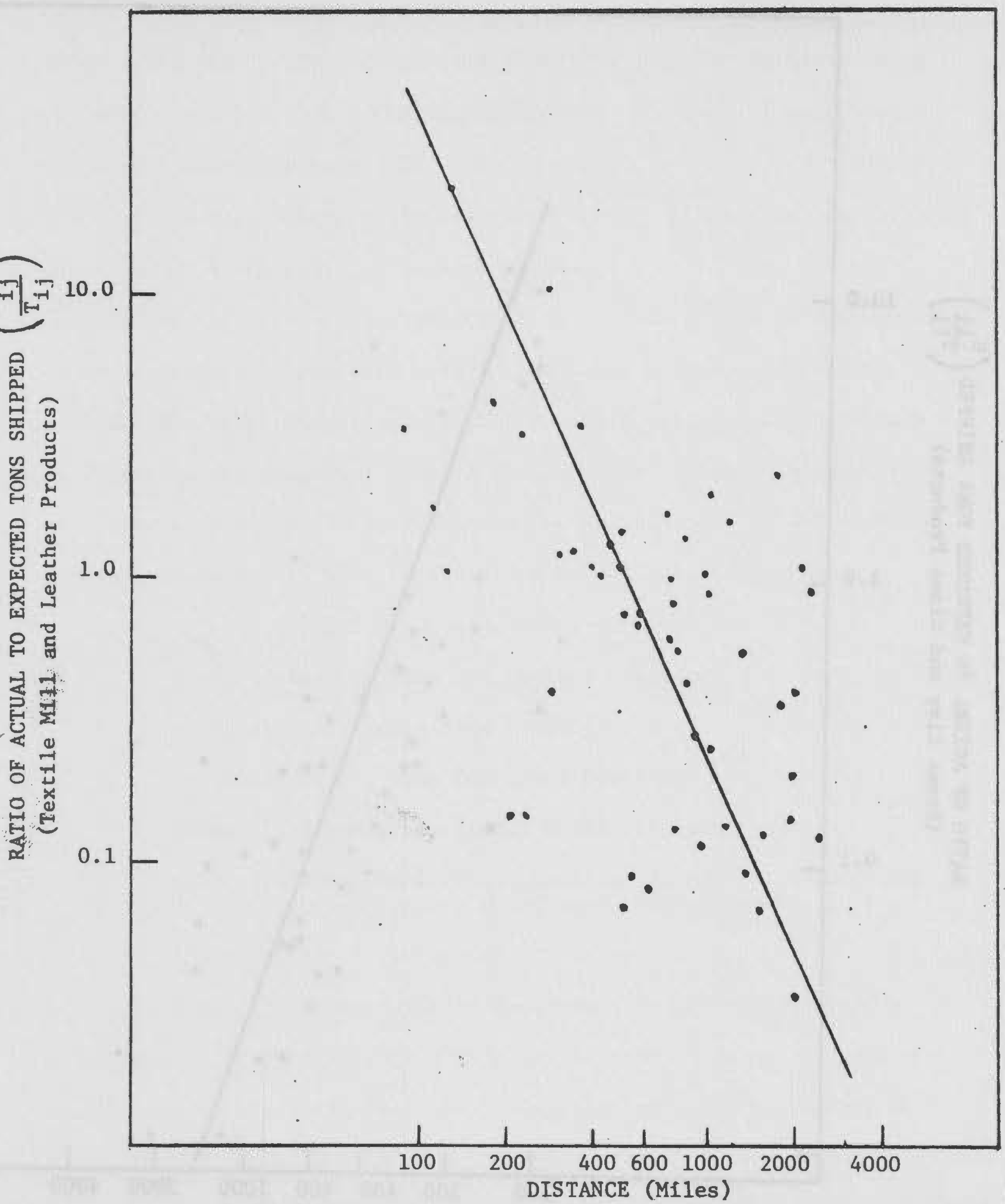

Figure 1. Approximate relationship between the ratio of actual to expected tons shipped and distance, Textile Mill and Leather Products

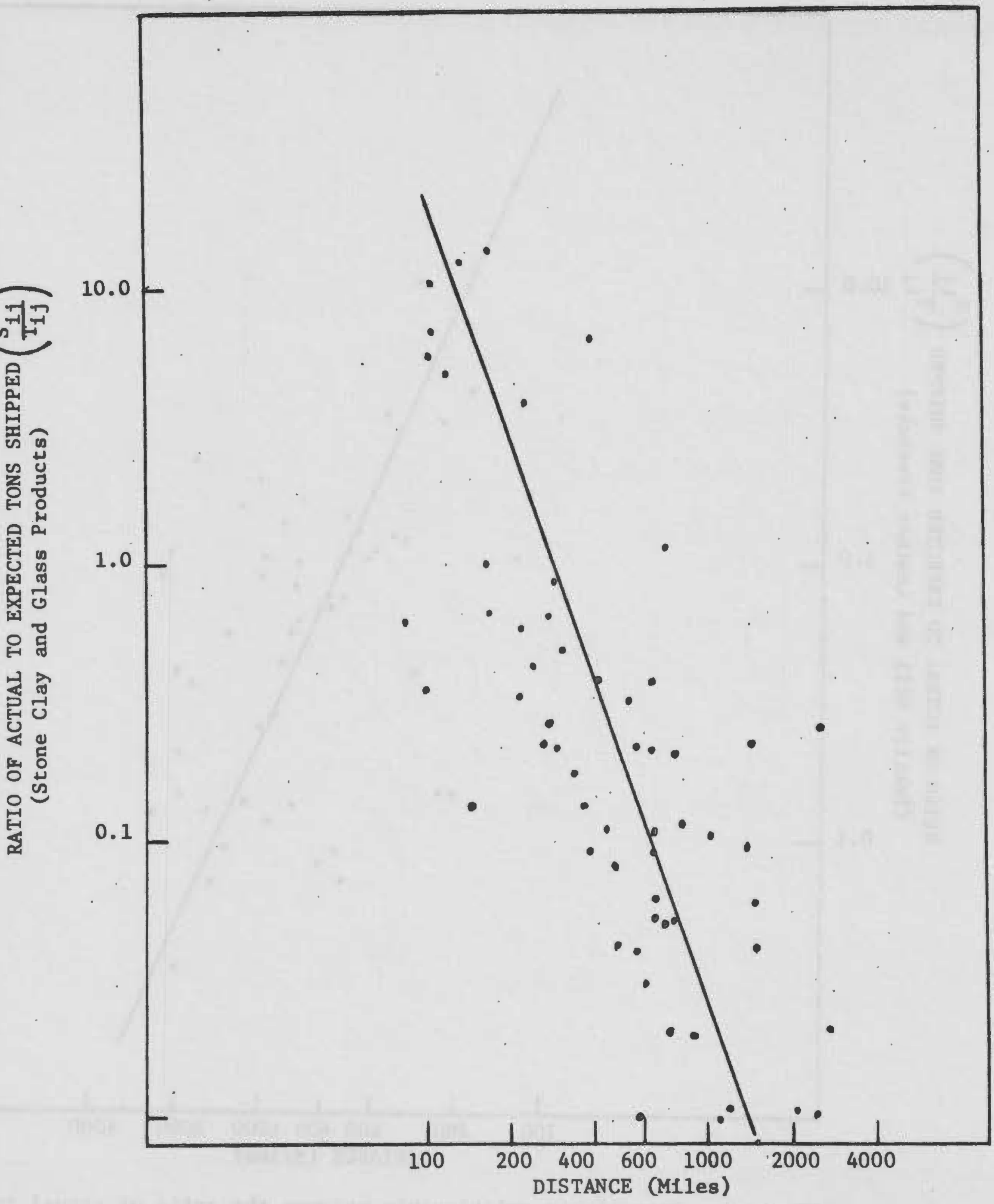

Figure 2. Approximate relationship between the ratio of actual to expected tons shipped and distance, Stone, Clay and Glass Products

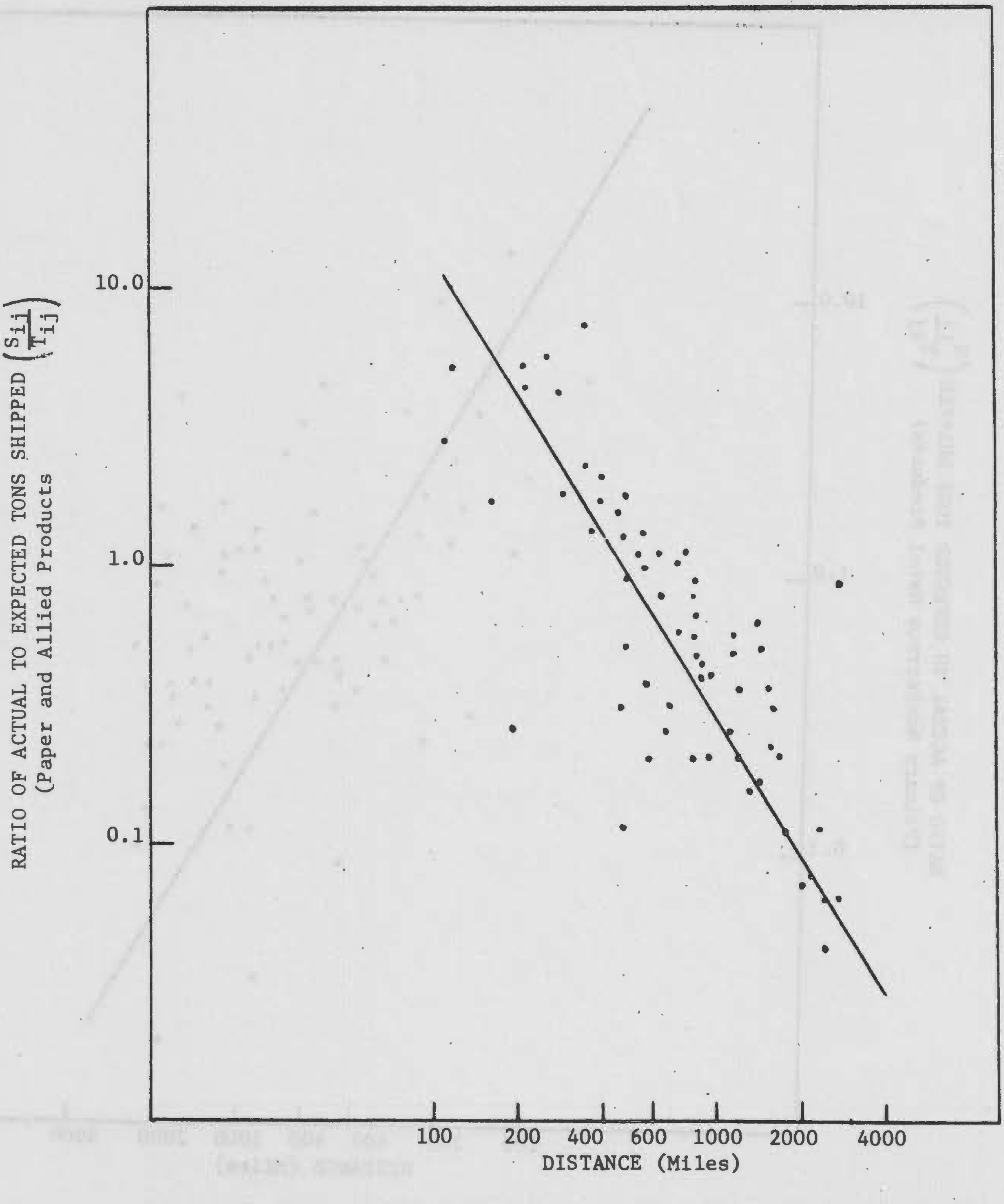

Figure 3. Approximate relationship between the ratio of actual to expected tons shipped and distance, Paper and Allied Products

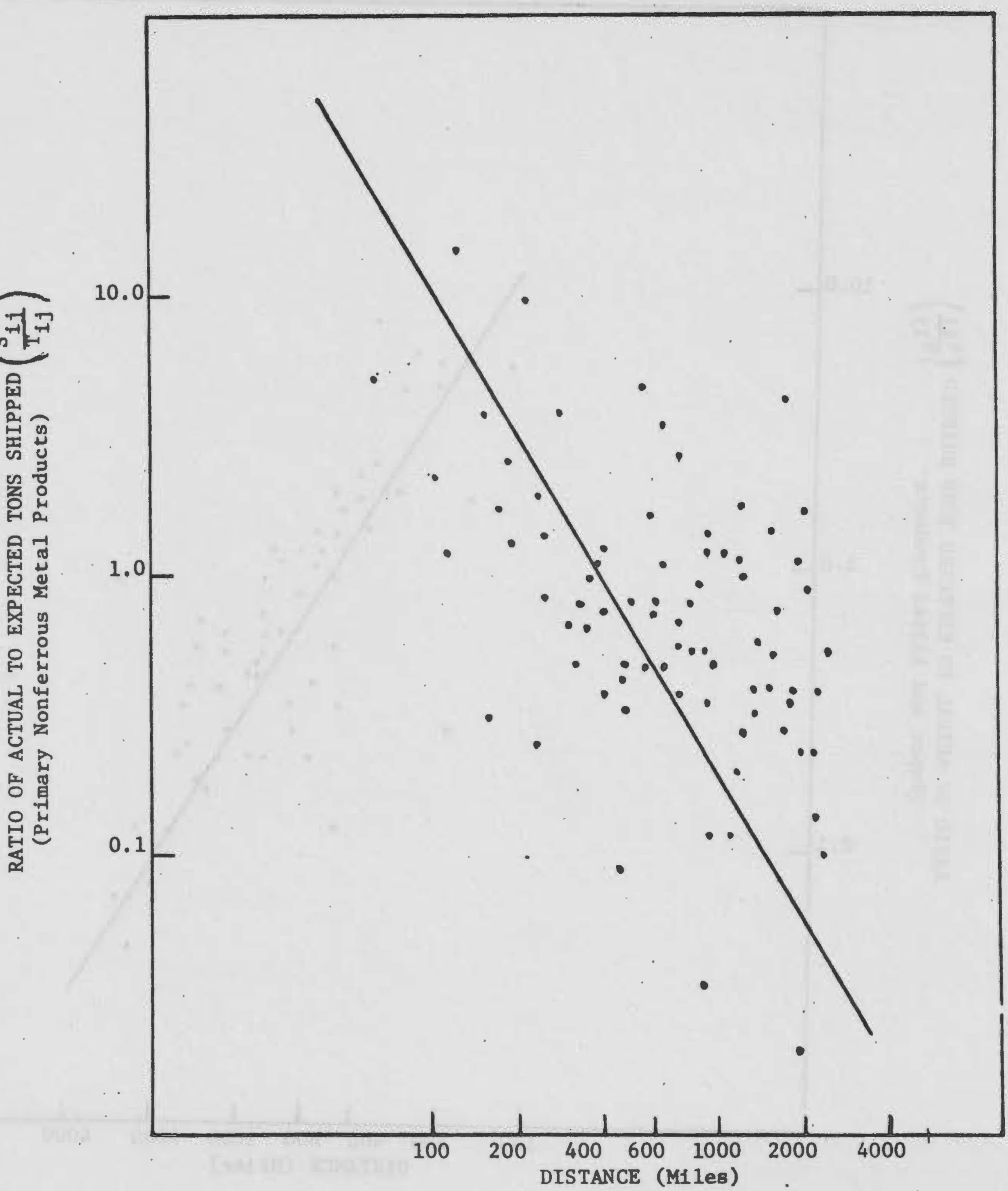

Figure 4. Approximate relationship between the ratio of actual to expected tons shipped and distance, Primary Nonferrous Metal Products

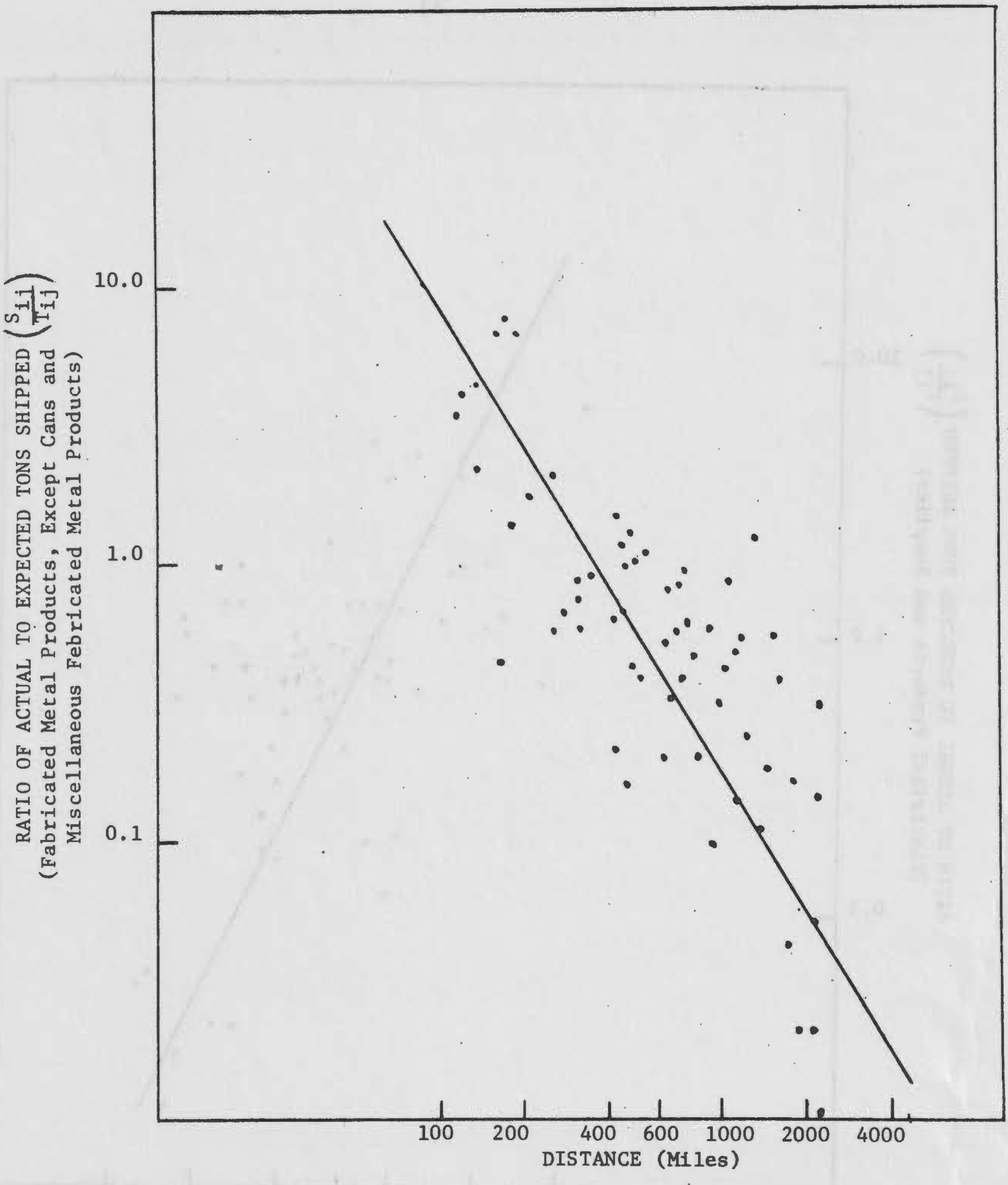

Figure 5. Approximate relationship between the ratio of actual to expected tons shipped and distance, Fabricated Metal Products, Except Cans and Miscellaneous Febricated Metal Products

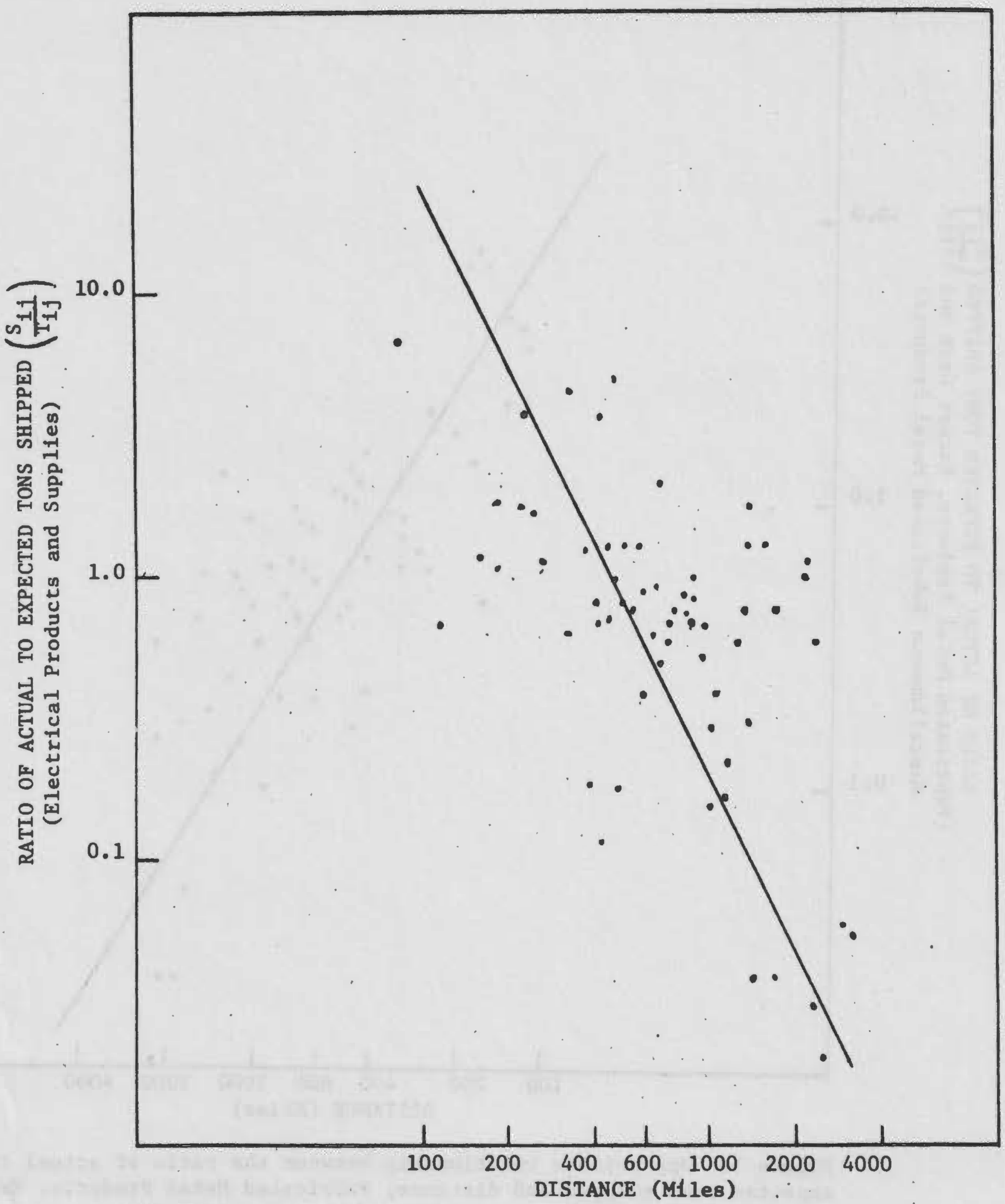

Figure 6. Approximate relationship between the ratio of actual to expected tons shipped and distance, Electrical Products and Supplies

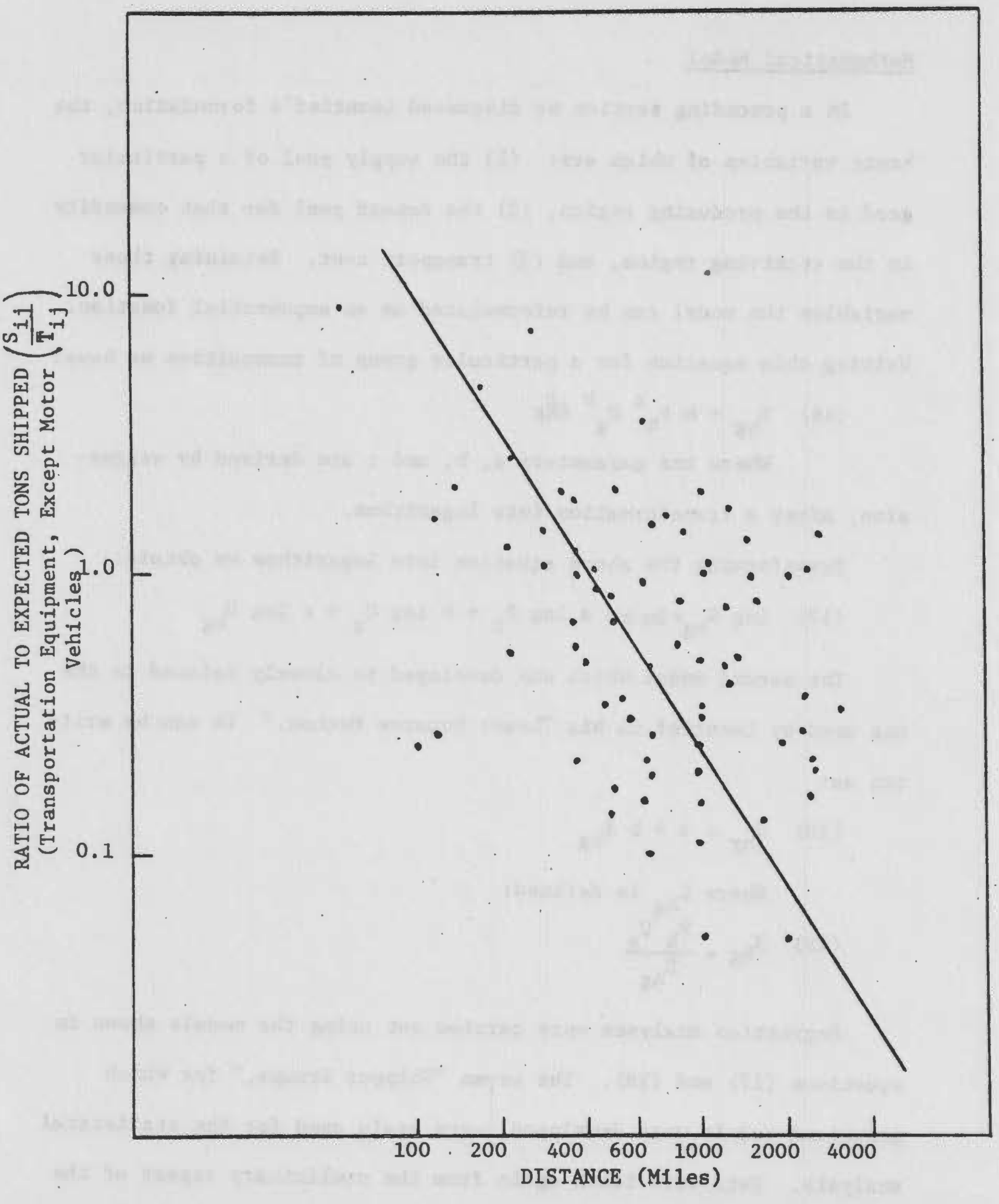

Figure 7. Approximate relationship between the ratio of actual to expected tons shipped and distance, Transportation Equipment, Except Motor Vehicles

Mathematical Model

In a preceding section we discussed Leontief's formulation, the basic variables of which are: (1) the supply pool of a particular good in the producing region, (2) the demand pool for that commodity in the receiving region, and (3) transport cost. Retaining these variables the model can be reformulated as an exponential function. Writing this equation for a particular group of commodities we have:

(16) $S_{hg} = k \, P_h^{a} \, U_g^{b} \, D_{hg}^{c}$

Where the parameters a, b, and c are derived by regression, after a transformation into logarithms.

Transforming the above equation into logarithms we obtain:

(17) $\log S_{hg} = \log k + a \log P_h + b \log U_g + c \log D_{hg}$

The second model which was developed is closely related to the one used by Leontief in his "Least Squares Method." It can be written as:

(18) $S_{hg} = a + b \, X_{hg}$

Where X_{hg} is defined:

(19) $X_{hg} = \frac{P_h \, U_g}{D_{hg}}$

Regression analyses were carried out using the models shown in equations (17) and (18). The seven "Shipper Groups," for which graphical models were developed, were again used for the statistical analysis. Data were taken again from the preliminary report of the 1963 Census of Transportation. The results of the regression analyses are shown below; model 1 refers to equation (17) and model 2 refers to equation (18). The variables are defined again to help the reader understand the following presentation of statistical results.

S_{hg} means predicted shipments of a particular good from region h to region g (thousands of tons).

P_h means the supply pool (production) of that good in Region h (thousands of tons).

U_g means the demand pool (use of that good in Region g) (thousands of tons).

D_{hg} means the distance from Region h to Region g, in straight-line miles.

X_{hg} is defined in equation (19).

Group 4, Textile Mill and Leather Products

Model 1

$$\log S_{hg} = -1.466 + 0.915 \log P_h + 0.585 \log U_g - 0.725\, D_{hg}$$

$$(0.098) \qquad (0.101) \qquad (0.134)$$

$$R^2 = 0.78 \qquad N = 53$$

Model 2

$$S_{hg} = 96.3295 + .0156\, X_{hg}$$

$$(.0010)$$

$$R^2 = 0.80 \qquad N = 53$$

Group 6, Paper and Allied Products

Model 1

$$S_{hg} = 4.128 + 0.552 \log P_h + 0.712 \log U_g - 1.413 \log D_{hg}$$

$$(0.112) \qquad (0.072) \qquad (0.079)$$

$$R^2 \mp 0.89 \qquad N = 69$$

Model 2

$$S_{hg} = 228.570 + 0.0050\, X_{hg}$$
$$(0.0003)$$
$$R^2 = 0.77 \qquad N = 69$$

Group 13, Stone, Clay and Glass Products

Model 1

$$\log S_{hg} = 5.995 + 0.600 \log P_h + 0.506 \log U_g - 1.785 \log D_{hg}$$
$$(0.084) \qquad (0.151) \qquad (0.131)$$
$$R^2 = 0.83 \qquad N = 62$$

Model 2

$$S_{hg} = -850.464 + 0.0016\, X_{hg}$$
$$(.0001)$$
$$R^2 = 0.79 \qquad N = 62$$

Group 15, Primary Non-Ferrous Metal Products

Model 1

$$\log S_{hg} = -4.062 + 0.781 \log P_h + 1.007 \log U_g - 0.685 \log D_{hg}$$
$$(.123) \qquad (0.111) \qquad (0.088)$$
$$R^2 = 0.74 \qquad N = 80$$

Model 2

$$S_{hg} = 83.275 + 0.0138\, X_{hg}$$
$$(.007)$$
$$R^2 = 0.83 \qquad N = 80$$

Group 16, Fabricated Metal Products, Except Metal Cans and Miscellaneous Fabricated Metal Products

Model 1

$$\log S_{hg} = 1.408 + 0.775 \log P_h + 0.664 \log U_g - 1.178 \log D_{hg}$$
$$(0.110) \qquad (0.155) \qquad (0.105)$$
$$R^2 = 0.75 \qquad N = 68$$

Model 2

$$S_{hg} = 37.8593 + 0.0203 X_{hg}$$
$$(0.0013)$$
$$R^2 = 0.78 \qquad N = 68$$

Group 21, Electricl Products and Supplies

Model 1

$$\log S_{hg} = -3.092 + 0.958 \log P_h + 0.620 \log U_g - 0.508 \log D_{hg}$$
$$(0.062) \qquad (0.109) \qquad (0.090)$$
$$R^2 = 0.84 \qquad N = 65$$

Model 2

$$S_{hg} = 62.8979 + 0.0216 X_{hg}$$
$$(0.0008)$$
$$R^2 = 0.91 \qquad N = 65$$

Group 23, Transportation Equipment Except Motor Vehicles

Model 1

$$\text{Log } S_{hg} = 1.046 + 0.719 \log P_h + 0.442 \log U_g - 0.691 \log D_{hg}$$
$$(0.119) \qquad (0.121) \qquad (0.102)$$
$$R^2 = 0.66 \qquad N = 58$$

Model 2

$$S_{hg} = 19.4916 + 0.0673\ X_{hg}$$
$$(0.0028)$$
$$R^2 = 0.91 \qquad N = 58$$

The variables used in the regression analysis explained between 66 and 91 per cent the total variance in shipments. The model which was most like Leontief's explained an average of 83 per cent of the variance in shipments, while the logarithmic function explained an average of 78 per cent of the variance. On the basis of the seven cases studied it is not possible to select the one best model for estimating interregional shipments. The independent variables were found to be highly significant in all regressions. The distance coefficients in Model 1 appeared reasonable, being high for commodities which have high transport costs in relation to their value and low for products having low transport costs in relation to their value. The distance coefficients are:

Stone, Clay and Glass Products	1.78
Paper and Allied Products	1.41
Fabricated Metal Products, Except Metal Cans and Miscellaneous Fabricated Metal Products	1.18
Textile Mill and Leather Products	0.73
Primary Non-Ferrous Metal Products	0.69
Transportation Equipment, Except Motor Vehicles	0.69
Electric Products and Supplies	0.51

The coefficient of the distance variable in the logarithmic function is equal to the exponent of distance in an exponential function. Consider the effect of distance on shipments of the various commodity groups. In the case of stone, clay and glass products, shipments decrease rapidly as distance increases, distance in the denominator being raised to the 1.78th power. At the other extreme is electric products and supplies. The movement of these products is not influenced as greatly by distance. The effect of distance on shipments of electric products was less than proportional to the actual distance and equal to approximately the square root of distance.

Census of Transportation

Data from the Commodity Transportation Survey of the 1963 Census of Transportation were used to estimate the parameters of the mathematical models. Specifically, data showing interregional shipments of a "shipper group" by all means of transport were used. These data are given for 24 "shipper groups" of manufacturing industries.[1]

Estimates of interregional shipments in the Census of Transportation are based upon shipping records from about 400 establishments in each shipper group. An average of about 140 bills of lading, sales

---

[1]The following manufacturing industries were excluded:

SIC 19-Ordnance and accessories
2026-Fluid milk
2051-Bread and bakery products

SIC 2097-Manufactured ice
2411-Primary forest products
27-Printing, publishing and allied products

invoices, summary records and other shipping papers were obtained per plant. Estimates of the total weight of shipments were made by expanding the weight shown on an individual shipping record according to the sampling fraction for that record and aggregating the expanded weight.

The statistics of the Census of Transportation relate to the outputs of manufactured products which are shipped beyond the local area of a plant. These statistics do not reflect shipments of firms that do not ship a "substantial" part of their output beyond the local area. Shipments of firms which had substantial non-local shipments were not recorded if the place where the shipment terminated was less than 10 miles from the place where the firm was located.

The technological relationships given for <u>sectors</u> in the National input-output model must be matched with interregional trade relationship estimated for <u>shipper groups</u>. There are 51 manufacturing sectors in the National input-output model and 24 shipper groups in the Census of Transportation. A shipper group is usually made up of one or more <u>complete</u> input-output sectors. Therefore, in most cases, interregional trade for a particular input-output sector could be estimated by using the mathematical model for the shipper group in which that sector is found. Tables 5 and 6 show the relationships between input-output sectors and shipper groups.

Statistics of the Census of Transportation underestimate the volume of intraregional shipments because of the way short-distance shipments are treated and also because of the treatment of establishments which transport their output mainly within the local area.

This underestimate of intraregional commodity shipments would tend to result in interindustry multipliers for a region of Appalachia which are biased downward.

The statistics of the Census of Transportation used for the construction of the graphical and mathematical models were in units of weight, whereas the desired statistics for the input-output model are dollar values of shipments. Within a shipper group, shipments of the more valuable commodities per unit weight will tend to move longer distances to markets than commodities which are less valuable per unit weight. The graphical and mathematical models, which were based upon weight, therefore tend to overestimate the value of commodities in intraregional trade.[1] Thus, this influence will tend to result in interindustry multipliers which are biased upward. The method of estimating interregional trade which is suggested, and which has these counteracting biases, would result in reasonable estimates of interindustry multipliers.

[1]This will also result in an overestimate of the value of shipments from nearby regions.

Table 5. Shipper Groups in the 1963 Census of Transportation and corresponding sectors in the 1958 National input-output study.

Census of Transportation shipper groups	1958 input-output study sector numbers
1. Meat and Dairy Products	14
2. Canned and Frozen Foods and Other Food Products, Except Meat and Dairy Products	14
3. Candy, Beverages, and Tobacco Products	14, 15
4. Textile Mill and Leather Products	16, 17, 18, 34
5. Apparel and Related Products	18, 19
6. Paper and Allied Products	24, 25
7. Basic Chemicals, Plastics Materials, Synthetic Rubber and Fibers	27, 28
8. Drugs, Paints, and Other Chemical Products	27, 29, 30
9. Petroleum and Coal Products	31
10. Rubber and Plastics Products	32
11. Lumber and Wood Products, except Furniture	20, 21
12. Furniture, Fixtures, and Miscellaneous Manufactured Products	18, 22, 23, 64
13. Stone, Clay and Glass Products	35, 36
14. Primary Iron and Steel Products	37, 38
15. Primary Nonferrous Metal Products	38
16. Fabricated Metal Products, Except Metal Cans and Miscellaneous Fabricated Metal Products	40, 42
17. Metal Cans and Miscellaneous Fabricated Metal Products	39, 41, 42
18. Industrial Machinery, Except Electrical	47, 48, 49, 52
19. Machinery, Except Electrical and Industrial	43, 44, 45, 46, 50, 51, 52
20. Communication Products and Parts	56, 57

Table 5 Continued

Census of Transportation shipper groups	1958 input-output study sector numbers
21. Electrical Products and Supplies	53, 54, 55, 58
22. Motor Vehicles and Equipment	59
23. Transportation Equipment, Except Motor Vehicles	60, 61
24. Instruments, Photographic Equipment, Watches and Clocks	62, 63

Table 6. Sectors in 1958 National input-output study and corresponding shipper groups from the 1963 Census of Transportation.

1958 input-output study sectors	Census of Transportation shipper group numbers
13.[a] Ordnance and accessories	
14. Food and kindred products	1, 2, 3
15. Tobacco manufactures	3
16. Broad and narrow fabrics, yard and thread mills	4
17. Miscellaneous textile goods and floor coverings	4
18. Apparel	4[b], 5 12[b]
19. Miscellaneous fabricated textile products	5
20. Lumber and wood products, except containers	11
21. Wooden containers	11
22. Household furniture	12
23. Other furniture and fixtures	12
24. Paper and allied products, except containers and boxes	6
25. Paperboard containers and boxes	6

Table 6, Continued

1958 input-output study sectors	Census of Transportation shipper group numbers
26.[a] Printing and publishing	
27. Chemicals and selected chemical products	7, 8
28. Plastics and synthetic materials	7
29. Drugs, cleaning, and toilet preparations	8
30. Paints and allied products	8
31. Petroleum refining and related industries	9
32. Rubber and miscellaneous plastics products	10
33. Leather tanning and industrial leather products	4
34. Footwear and other leather products	4
35. Glass and glass products	13
36. Stone and clay products	13
37. Primary iron and steel manufacturing	14
38. Primary nonferrous metals manufacturing	14[b], 15
39. Metal containers	17
40. Heating, plumbing and fabricated structural metal products	16
41. Screw machine products, bolts, nuts, etc., and metal stampings	17
42. Other fabricated metal products	16, 17
43. Engines and turbines	19
44. Farm machinery and equipment	19

Table 6, Continued

1958 input-output study sectors	Census of Transportation shipper group numbers
45. Construction, mining, oil field machinery equipment	19
46. Materials handling machinery and equipment	19
47. Metalworking machinery & equipment	18
48. Special industry machinery and equipment	18
49. General industrial machinery and equipment	18
50. Machine shop products	19
51. Office, computing, and accounting machines	19
52. Service industry machines	18[b], 19
53. Electric transmission and distribution equipment, and electrical industrial apparatus	21
54. Household appliances	21
55. Electric lighting and wiring equipment	21
56. Radio, television and communication equipment	20
57. Electronic components and accessories	20
58. Miscellaneous electrical machinery, equipment, and supplies	21
59. Motor vehicles and equipment	22
60. Aircraft and parts	23
61. Professional, scientific, and controlling instruments & supplies	24

Table 6, Continued

1958 Input-output study sectors	Census of Transportation shipper group numbers
62. Other transportation equipment	23
63. Optical, ophthalmic, and photographic equipment and supplies	24
64. Miscellaneous manufacturing	12

[a]Not estimated in 1963 Census of Transportation

[b]Includes only one 4-digit SIC industry

The objective of the work which was done on both the graphical and mathematical models was to determine if their use was feasible in an interindustry study of Appalachia. The models which have been tested in this section can be used to estimate movements of manufactured products into and out of the Appalachian Region. These models can provide the necessary description of interregional trade in manufacturing sectors to enable an interregional input-output analysis to be based upon the National interindustry study.

The preliminary analysis has indicated that relationships can be developed so that interregional trade in Appalachia can be estimated from available data. However, this does not mean that the models as formulated provide the necessary precision. There are changes which could be made in the above models to improve their accuracy.

The type of model which is suggested would enable unbiased interindustry multipliers to be made, whereas the two models which have been employed and which utilize available data, the balanced regional model and the regional model, lead to biased estimates of interindustry multipliers. The actual measurement of trade flows during a time interval would provide measures of regional input-output coefficients. However, we are most interested in predicting trade flows at a point in the future--after an investment is undertaken or when a change in output capacity is in place. The type of model which has been discussed may provide trade coefficients which approximate the expected value of such flows. It may be that the actual annual trade flows between two regions are dispersed around a central tendency which is measured adequately by this type of model.

VI INTERREGIONAL TRADE--OTHER PRODUCTS AND SERVICES

Products of agriculture, mines, forests, and fisheries are not usually in a form desired by consumers. The primary materials which ultimately become embodied in final products usually require a substantial processing to convert them to their consumable form. Some of these commodities never enter physically into final products but rather contribute to and facilitate desired changes in other materials.

Agriculture

Agriculture occupies two sectors of 1958 National input-output study. Sector 1 is "Livestock and livestock products" and Sector 2 is "Other agricultural products." Sixty-two percent of the output of the Livestock and livestock products sector was purchased by the Food and kindred products sector in 1958. Sector 2 has diverse outputs, including, among others, food grains, feed crops, cotton, tobacco, oil seeds and vegetables and therefore diverse markets. However, when more detailed data are examined, the markets for a particular agricultural commodity are revealed more specifically.

The U. S. Department of Agriculture has developed estimates of inter-industry sales and purchases for 17 agricultural sub-sectors. Sales of each of the 17 agriculture sub-sectors to each purchasing sector are shown by 4 digit SIC's for manufacturing industries. These data permit an extension of the published input-output table. They also provide valuable information for measuring interregional trade. For example, from these data it was estimated that 89 percent of the output of the "Meat animals" sub-sector (A1) was purchased by meat packing plants. The "Poultry and eggs" subsector (A2) sold 86 percent of its output to two sectors: (1) "Poultry and small game dressing and packing plants," and (2) "Personal consumption expenditures", or, in other words, households. These sales can be further subdivided, with sales of eggs being made directly to the Personal consumption expenditure sector, with the trade margin considered, and sales of poultry made to the dressing and packing plants.

Seventy-eight percent of the sales of the dairy products subsector are made to manufacturing industries producing creamery butter, natural cheese, condensed and evaporated milk, and fluid milk. Other agricultural subsectors show a similar pattern, whereby a large proportion of the output of a subsector is purchased by a small number of SIC's. A large proportion of wheat is purchased by the "Flour and other grain mill products" industry; cotton by "Broadwoven fabric mills, cotton" and "Yarn spinning mills"; and "Vegetables" by households and by canning, dehydrating and freezing firms.

Two other sectors should be mentioned briefly: Forestry and fishery products; and Agriculture, Forestry and fishery services. Forestry and fisheries products, Sector 3, can be disaggregated into Forestry, which will be relatively important in the Appalachian Region, and fisheries. Unpublished data available from OBE can be used for this breakdown.

In 1958, Sector 20, "Lumber and wood products" purchased a large percentage of the forestry products output. Virtually the entire output of the Agriculture, forestry and fisheries services are purchased by Sectors 1, 2 and 3.

Metal Ores and Petroleum

A metal ore or crude petroleum is converted into a finished product by a definite sequence of processes. Virtually all of a raw material will undergo the same initial processing; i.e., the first stage of processing will be the same regardless of the final product. Furthermore, there are substantial economies of scale in the early stages of processing minerals. Therefore, it is found that only a few industries (SIC's) purchase substantial quantities of these primary materials. The markets for the ferrous and non-ferrous metal ores mining industry will be examined as examples.

In 1958, the primary iron and steel industry purchased 84 per cent of the gross output of the "iron and ferroalloy ores mining" industry. If the sales and purchases within the mining industry are eliminated and a net production concept used, it is estimated that 89 per cent of the output of this mining industry was utilized by the primary iron and steel industry. The non-ferrous metal ores mining (Sector 6) has a slightly more diverse market. Primary non-ferrous metals manufacturing industries purchased 80 per cent of the net output of the non-ferrous metal ore mining industry in 1958.

According to the National input-output table, crude petroleum and natural gas industry (Sector 8) marketed 94 per cent of its net output to two sectors: the Petroleum refining and related industries, and Electric, Gas, Water and Sanitary Services (Sector 68). Actually, as additional detail showed, gas utilities purchased the natural gas outputs of the crude petroleum and natural gas sector while the refining industries purchased the crude petroleum sold by the primary industry. The aggregation of industries into the sectors, necessary for the input-output study, leads, as it did in this case, to the multiplication of the apparent markets.

Coal and Other Mining

In 1958, five sectors purchased 75 per cent of the net output of the coal mining sector in the United States. These sectors were (1) Primary iron and steel manufacturing, (2) Electric utilities, (3) Federal Government enterprises, (4) State and local government enterprises, and (5) Personal consumption expenditure. Industrial firms used mainly bituminous coal while households used anthracite. There is, however, no breakdown of expenditures by type of product.

Finally, we consider the last two primary product producing sectors: "Stone and clay mining and quarrying," and "Chemical and fertilizer mineral mining." The Stone and clay mining and quarrying sector sold 79 per cent of its output to the construction industry and to firms manufacturing stone and clay products. The Chemical and fertilizer mineral mining sector supplied a high percentage of its output to agriculture, and to chemical industries.

The cost of obtaining information concerning interregional trade in primary products will be relatively low. The necessary information could be obtained by asking firms using substantial quantities of a given primary product where they obtain their supplies. Electric utilities, iron and steel manufacturers and government installations could provide information concerning the locations from which bituminous coal is purchased. Anthracite coal retailers and wholesalers could be asked about the location of mines from which they purchase their coal supplies.

Interregional trade of agricultural products could be estimated from information obtained from purchasers of these products. Meat-packing plants would provide information concerning the locations of farms from which cattle are purchased. Flour mills would provide information concerning the location of their grain supply, etc.

Finance, Insurance, Real Estate and Services

The methodology which has been developed so far suggests that regions where shipments of primary products originate can be determined by surveying manufacturing industries in the Appalachian Region which purchase large quantities of these products. It was found that a few manufacturing industries used a large proportion of the output of any single primary industry. Demand for manufactured products, on the other hand, was found dispersed among many industrial and final demand sectors. A mathematical model was suggested to determine the region of origin of these products used in Appalachia. A third category of industries will now be examined, which, like manufacturing, finds the demand for its services dispersed among many sectors. These are non-manufacturing industries, some of which serve the business community exclusively, while others serve both households and businesses. The industries in this category include finance, insurance, real estate and services. Only those services which could be reasonably expected to be provided "outside the region" are considered; others, for example, personal services, must for all practical purposes be produced in the areas where they are used.

As was the case with primary and manufactured products, the major purpose of this work is to distribute the national input-output coefficients: (1) within the region where the service is used, (2) to other regions in Appalachia, and (3) to the "Rest of the World." In order to estimate these geographical origins of purchases, original data, not otherwise available, is needed. Characteristics of industries of this type in the Appalachian Region will be inferred from statistical samples. In order to draw these inferences, it is necessary to establish the statistical universe and a sampling design.

Trading patterns will differ within regions of Appalachia. It is probable, for example, that plants in Appalachia but near to SMSA's which are outside of the Appalachian region will tend to purchase more services as well as goods from these communities than will similar establishments farther away from these peripheral SMSA's. The interregional input-output coefficients for a particular region are weighted averages. For example, the coefficients in counties adjacent to outside SMSA's will show a relatively small proportion of the finance, insurance and services being provided within the Region. On the other hand, an establishment remote from outside SMSA's will probably purchase a larger proportion of these services within the Appalachian Region.

The Appalachian Region was broken up into groups of counties to enable the computation of interregional input-output coefficients to be made.[1] The following criteria were used for classification:

1. Region: North, Central, South
2. Location within Appalachia: Fringe, Interior
3. Type of area: SMSA, Other areas
4. Location within each region: North, South

The basic study regions (North, Central and South) are shown in Appendix Figure 1.

Interregional input-output coefficients could be established showing trade among these three regions, and between them and the "Rest of the World." A fringe area was defined because the trading pattern of a given establishment would depend upon its distance from the boundary of the Appalachian Region. This fringe was defined as that area of Appalachia which is within roughly fifty miles of the official border of the Region. A county-line approximation of the fifty-mile distance was employed. The fringe, therefore, consists of an area extending completely around the boundary and usually two counties in width. SMSA's were placed either entirely in the fringe or entirely in the interior.

The location within a region will affect the trading patterns with other regions of Appalachia and the "Rest of the World." The southern half of the Southern Region is likely to trade less with the Central Region than is the northern half. Therefore, to allow for this fact, northern and southern halves of each region are considered, again using county-line approximations.

On the basis of these factors the Appalachian Region was broken

---

[1] See Appendix, Figure 1.

into twenty-one groups of counties. It is assumed a priori that each county within a group will exhibit similar geographic trading relationships with the regions of Appalachia and the "Rest of the World." Data from several counties in each group can be pooled to give information which would be taken as typical for all the counties of the group. Appendix Figure 2 shows the 21 groups of counties which were delineated using the method described above. Appendix Table 5 lists the counties in the various groups and their approximate populations.

A questionnaire, which is shown in Appendix Figure 3, was prepared for the purpose of determining the characteristics of each of the 21 areas with respect to the locational pattern of purchases.[1] A preliminary test of this questionnaire was made in the area of Wilkes Barre, Pennsylvania in August and September, 1966. The questionnaire is designed for the collection of information concerning the origin of the transportation, insurance, business services, and other purchases by businesses.

A sample of business establishments was interviewed to determine the locational pattern of purchases of these services. The characteristics of all the firms in a group of counties could be inferred from the information obtained from the establishments interviewed. We should expect considerable variation in the locational patterns of expenditures of individual business establishments. However, we should

---

[1]A similar questionnaire designed for a mail survey is shown in Appendix Figure 4.

also expect to find a tendency for locational patterns of expenditures to be similar among firms in a given area.

The interregional input-output coefficients required for the analytical model will be weighted averages based upon the data collected from the sample of establishments. The information obtained from a firm would be weighted by the firm's estimated annual utilization of the particular service being considered. The annual utilization, in turn, would be estimated using (1) the average amount of the service used per worker, from the National interindustry study for 1958, and (2) the number of employees of the establishment, from the questionnaire.

From a survey of a sample of business establishments, we can develop estimates of interregional flows of these services. These estimates will be in terms of interregional flows per dollar of output in the purchasing industry (interregional input-output coefficients). Therefore, they are consistent with coefficients developed for primary products and manufacturing industries. Thus, a method has been developed for breaking each National input-output coefficient into its regional components.

Transportation

The National interindustry study was developed using the concept of "producers' value." The sale of a product from one industry to another is valued at the plant of the producing industry without allowing for transportation cost and trade "margins." Transportation costs are charged to the sector purchasing the goods which are being transported.

The distribution of payments for transportation according to regions can be estimated for each industry by considering the regions supplying products used in the production process. Services would be excluded from consideration in this computation. It could be assumed that payments for transportation service can be subdivided into terminal costs and costs of the actual movement of goods. It is suggested that, for the purpose of this study, transportation costs be allocated according to the proportion of products purchased from each region. Thus, for a particular industry, the coefficients relating to "product" sectors could be summed and the regional proportions calculated.

This procedure is equivalent to assuming that the transportation costs are proportional to the value of purchased inputs. It also assumes that the distance over which goods are transported is the same in all regions. Goods originating in the "Rest of the World" are probably transported over a greater distance in that region than goods originating in the regions of Appalachia. Thus, the proportion of expenditures made to the "Rest of the World" using this estimating procedure would be an under-estimate. This under-estimate would tend to provide an upward bias to the multiplier. However, the terminal costs in all regions are not considered. Therefore, since a major part of terminal costs always obtain in the region of destination, the regional income multiplier will tend to be biased downward. It is believed that this procedure will, on balance, provide a reasonable method for allocating transportation expenditures.

<u>Construction</u>

New construction services are produced and consumed at the same location. We do not, therefore, find significant interregional trade in construction. However, unlike the case in most industries, the point at which construction services are produced is often moved, causing workers to change locations of their work. The changes in locations of work has created a different commuting pattern for construction workers than is found in other industries. Supervisory personnel travel considerable distances from their homes, commuting either daily or on weekends. The commuting patterns of other construction workers is also likely to be extended.

The question of major importance with respect to interregional trade in the construction industry is: What per cent of the construction workers on a construction project in the region are likely to be residents of the region? Information concerning the residence of construction workers could be estimated or assumed depending upon the accuracy required. If it were decided to estimate the pattern of residence, a survey could be made of construction firms working in the region being studied.

Households, governments and industry all have recurring needs for maintenance and repair. Local service-type firms or local branches usually develop to perform this work. The employees of these establishments would have commuting patterns which would be similar to those of production, trade and service workers having similar incomes. This commuting pattern would be estimated at the same time as information is obtained from businesses concerning their locational pattern of purchasing business services, insurance, etc.

Questionnaires developed for both businesses and households include a question concerning the location of firms which performed maintenance and repair construction. Where it is determined that a local firm carried out the work, the in-commuting will be assumed to be equal to the average for all industries. Where a firm from outside the region carried out the work, the payment will be assumed to be made outside the region.

Utilities

Additional detail published for the 1958 input-output study shows the sales and purchases of Electric utilities, Gas utilities and Water and sanitary services. Previously the sales and purchases of these industries had been aggregated into a single sector. Firms do not generally import the services of the water and sanitary services sector. All services purchased from this sector would, therefore, be assumed to be supplied by utilities located in the region.

Electric and gas utilities both produce and transport their products. The pattern of electric transmissions is extremely complex in most areas because of the numerous interconnections of the lines and differences in the seasonality of production. However, we know the location of power plants and transmission lines in Appalachia, and using this information we could estimate roughly the proportion of power imported according to region of origin. The same type of analysis could be carried out for gas utilities.

VII. System for Estimating Economic Impacts

Investment

The National interindustry accounts and input-output model were based exclusively upon current accounts of businesses. The sales and purchases of new construction and capital equipment among individual industries, therefore, are not shown. Investment by businesses in new construction and new equipment is shown in a single column: "Gross private fixed capital formation." This column shows the purchases of these goods according to the supplying industry for all purchasing industries combined. What is not shown is the composition of net investment for a particular industry.

The formulation of the National input-output study is consistent with the Keynesian model, in which private investment is autonomous. The National model can be confronted with a final demand in which investment is low, giving rise to lower industrial outputs throughout the economy, other things being equal. The model, therefore, measures impacts upon the National economy of alternative final demands. Private investment is one of the elements outside the model which regulate the level at which the industrial sectors of the model are operated.

The purpose of the National model is to test alternative policies. For example, it might be used to trace the changes in industrial outputs resulting from a faster "write-off" of new investment. The change in desired investment in plant and equipment would first be determined. Then, the model would be confronted with a final demand sector in which the new level of investment was expressed.

In the regional model which is being discussed here, we are interested in private investments which might follow public investments. However, it is not possible within the scope of this work to estimate the relationship between these. What is possible, however, is to provide estimates of the type of capital goods purchased by a sector. For example, in 1958, 34 per cent of investment expenditures made by the Household furniture sector were for "Special Industrial Machinery and Equipment," and 32 per cent were for new plant. Appendix Table 6 shows expenditures for plant and equipment by industry.

Thus, if estimates can be made of investment in a sector, they can be expressed in the detail necessary for a model. For example, if an estimate were made of a one million dollar investment in the Household furniture sector, it would be that an estimated $340,000 would be spent for Specialized industrial machinery. However, only a portion of the $340,000 worth of machinery would be supplied from the region in which the investment was being made. The mathematical model would be used to distribute the final demand over the three regions of Appalachia and the "Rest of the World." This procedure would also be used to distribute other investment demands among regions.

<u>Value Added</u>

In the "Value added" row of the National interindustry accounts are recorded the payments of the respective industry for factors of production and other payments. This row must be broken into its components before it is possible to investigate the extent to which payments represent leakages from the economy of the region. The Office of Business Economics is in the process of disaggregating the Value added row. However, it will be late in 1966 or early in 1967 before these estimates will be ready.[1] A breakdown of Value added was prepared by Robert H. Haveman in an analysis concerning the impact of Water resources investment expenditures. H. Albert Green of Economic Research Service, U. S. Department of Agriculture, is also currently estimating the components of Value added.

A necessary procedure for estimating regional economic impacts requires that geographic detail be provided for each of these items. Estimates must be made of money-flow leakages from the regional economy. Knowledge of the extent of commuting into the Appalachian region will help determine the direct leakage of wages and salaries from Appalachia. Other estimating procedures are necessary for other categories included in Value added.

The survey of finance, insurance, real estate and services, which was discussed earlier, had as one of its objectives the measurement of interregional flows of these payments. Specifically, information was obtained from the survey concerning the extent of the interregional flows in rent and interest payments. It was assumed that proprietors would be residents of the region where their businesses are located. A question concerning the location of stockholders of local

---

[1]Conversation with Mr. Martin L. Marimont, Office of Business Economics, United States Department of Commerce.

corporations was excluded from the questionnaire because of an oversight. Profits of corporations with head offices outside of Appalachia, whether paid as dividends or undistributed, were assumed to move totally out of the region. Capital consumption allowances are assumed to move to the corporate headquarters. Sales, property and Federal excise taxes were included in Indirect business taxes. Receipt of these payments by government will be assumed not to affect the level of government activity.

Business transfer payments include corporate gifts to nonprofit institutions, consumers' bad debts, personal injury payments by businesses other than to their own employees, cash prizes, and unrecovered thefts of cash and capital assets from businesses. The distribution of these payments will be made arbitrarily because they represent an insignificant proportion of total Value added. The geographic distribution of the final item, "Current surplus of government enterprises less subsidies," will be treated like other government revenues.

Income-Consumption Relationship

The National input-output study was made using Leontief's "open" model. In the open formulation of the input-output model, the household sector remains outside the coefficient matrix. Demand by households for outputs from the economic system is expressed in the final demand vector under the heading "Personal consumption expenditure." The model is employed to yield projections of industrial output given levels of final demand, as we have discussed. However, the quantity of output consumed by the household sector, "Personal consumption expenditures," must be made consistent with the value of inputs supplied by the households.

Consider the earlier discussion of investment in the open system. Assume that the National model is confronted with a final bill of goods containing a higher investment component than previously while other components remain unchanged. The system, as always, will generate a set of industrial outputs consistent with the new final demand. However, the amount of income to factors of production will not automatically be consistent with Personal consumption expenditures in the final demand vector. It will be necessary in dealing with some problems to increase Personal consumption expenditures so that incomes earned and expenditures plus saving will be in balance. In the formulation of the National interindustry study the balancing of income with expenditures and saving is done outside the model.

Regional models have the objective of tracing the economic impacts of public investments and other changes in final demand for the region's output. It is therefore desirable to bring about an automatic equilibrium between income accruing to local residents and their consumption of goods and services. To accomplish this the local households sector would be brought into the coefficient matrix both as a row and as a column, just like all other industries. By treating the household sector in this way we form what is known as the "closed" model. To close the model it is necessary to define a relationship between income and personal consumption and to build this relationship into the model.

Any approach to the problem of predicting the economic impacts of an investment program in a region must consider, among other things, the effects of changes in consumption which result directly or indirectly from the investments. An early, but by now almost classical, approach was that adopted by Keynes to investigate the impact of investments on an economy. Keynes assumed that consumption expenditures were a linear function of income.

(20) $C = aY + b$, and income was the sum of consumption and investment;

(21) $Y = C + I$

where C means consumption

I means investment

Y means income

Thus, combining (20) and (21):

(22) $Y = aY + b + I$, and

(23) $(1-a)Y = b + I$, so that,

(24) $(1-a)\ \ Y = \ \ I$, or

(25) $Y = \frac{I}{1-a}$

Equation (25) may be interpreted as meaning that, for a given autonomous change in investment,   I, there will result a change in total income which will be $\frac{1}{1-a}$ times as great, where "a" represents the direct increase in consumption resulting from a one-unit rise in income.

The use of a regional input-output table permits a considerable refinement of this Keynesian technique. It allows for variations in indirect effects, which are due to the fact that consumption is spread over a number of industries with different multipliers, to be taken into account. This is done by using a "closed" input-output model, in which Households are treated as a sector within the matrix. As has been pointed out above, this sector will have its own row and column like any other sector. The entries in the row will show what proportion of each sector's output will accrue, as income, to households within the region. This will be equal to that proportion of Value added which represents payments (wages, rent, profits, etc.) received as factor incomes by persons living within the region.

To estimate this proportion, it is helpful to consider wage and non-wage income separately. All wages earned by workers employed within the region will be household income within the region, except for wages earned by workers who commute into the region from outside. There are two ways of estimating the proportion of wage income in the region which is earned by commuters into the region. The simpler method is to assume that this proportion is equal to the proportion of the total labor force commuting into the region. Data on this are given in the U. S. Census of Population. The use of this method implies the further assumption that the proportion of commuters in the labor force is the same for all sectors.

Neither of these assumptions is likely to be wholly accurate. In general, one would expect that persons in higher income groups would tend to travel longer distances to work, so that a larger proportion of wage income would go outside the region than this approach would imply. Furthermore, it seems quite possible that workers in some industries, such as construction, will commute further to work than those in other industries. So, if greater accuracy is desired, information could be obtained from employers directly by survey. Employers could be asked either about where their employees live, or preferably, what proportion of their wage bill goes to employees living in various areas.

Whether any wage income is "leaked" from a region or not, some of the non-wage income will certainly go to persons outside the area. However, simplifying assumptions could be made to make a reasonable estimate of non-wage income lost to the region. Corporations with head offices in the region could be asked about the location of their stockholders, but it will be assumed that all profits of other corporations will be withdrawn from the region entirely. On the other hand, all profits of non-corporate businesses will be assumed to remain in the region.

The computation of the entries in the column of the households sector would appear to present some problems. It will be remembered that one of the assumptions for the use of the input-output model is the assumption of "constant coefficients," which means that the proportion of the expenditures of any particular sector on the product of each sector is independent of the level of activity of that sector. In the case of the Household sector, this means that a household's consumption pattern does not change as income rises. BLS data shows that this assumption is quite unrealistic.[1]

---

[1] U. S. Bureau of Labor Statistics, Consumer Expenditures and Income, Report No. 237-93, February, 1965, p. 11.

Consideration of this assumption and of the basic mathematics of the input-output model indicates that what is really required is the following. If the output of an industry is expanded by one dollar's worth, the additional requirements of the various inputs must be the same, irrespective of the level of output at which the industry is operating. However, the data required to establish these "marginal" input requirements are generally not available directly, so the further assumption is made that the "marginal" coefficients, which are theoretically required, can be sufficiently well approximated by the average coefficients, which can more easily be computed.

In the case of households, this assumption that "average" coefficients are a reasonable surrogate for marginal coefficients is known to be invalid. Thus, BLS figures show, for instance, that in 1961 families with an income after taxes between $1000 and $1999, spent 23.9 per cent of their income on food prepared at home, and 6.6 per cent of their income on clothing, while families with an income after taxes between $7500 and $9999 spent 18.7 per cent on food prepared at home, and 11.2 per cent on clothing. This shows that average consumption patterns cannot be taken as a surrogate for marginal consumption patterns.

However, the same BLS data allow us to estimate the "marginal" requirements directly. Thus, the "average" household increased its expenditure for food prepared at home by about $150 for every $1000 dollars of additional income from $1000 to $6000. The household's expenditure for clothing increased by about $100 for every $1000 of additional income from $1000 up. Expenditures for shelter increased by about \$100 for each \$1000 of additional income, and for automobile transportation by \$150 - \$180 per thousand dollars. These "marginal" figures tend to be different from, and more stable with respect to various income groups than, the average figures.

Therefore, it is proposed to use such "marginal" coefficients in the Household column of the direct requirements table. These "marginal" requirements can be found by fitting a straight line regression to the BLS data giving the average expenditures on various items by households in different income classes.

In the normal input-output formulation, the basic relationship is given as $X - aX = Y$, where X is the vector of total outputs and Y is the vector of final demands. It is a matter of choice, depending on the assumptions and purposes of a particular study, whether personal consumption expenditures are considered as an element of final demand (an "open" model) or whether they are regarded as dependent on the level of economic activity and are to be predicted, (a "closed" model).

What is proposed here is something between the two. Personal consumption expenditure on the products of each sector is considered as being linearly dependent on, but not proportional, to income:

$$C_j = a_j Y + b_j$$

where C_j is a household's consumption of the output of the jth sector and Y is its income. The a_j (and the b_j, if needed), can be computed as described above, from BLS data. The a_j's will then go into the matrix of direct requirements, the b_j's into the final demand vector. As the b_j's are, by definition, independent of the level of activity, they are not affected by, and do not affect, the impact of autonomous investments.

One difficulty lies in distributing the consumer expenditures shown in the BLS tables among the sectors of the input-output model, because the bases of classification in the two are rather different. The interindustry study lists Personal consumption purchases from over 60 sectors; while the BLS Survey of Consumer Expenditures shows hundreds of categories, whose divisions do not, however, correspond with those of the interindustry study. It is therefore suggested that the following procedure be adopted: The Survey of Consumer Expenditures classification be divided into the groups listed in Table 7. Some of these groups can be assigned to single sectors of the interindustry study; others will be distributed to several sectors. In the latter case, the marginal expenditure coefficients appropriate to one of the groupings of the Survey of Consumption Expenditure classes will be prorated among the sectors of the interindustry study. The groupings of the Survey of Consumption Expenditures are arranged so that only one grouping is assigned to any input-output sector, for instance, as in Table 7.

Table 7. Survey of consumer expenditure groups and corresponding sectors in the National input-output study

Survey of Consumers Expenditures groups	1958 input-output study sector numbers
1. Food (all) Alcohol	1, 2, 14
2. Tobacco	15
3. Household textiles, Floor coverings	16, 17
4. Clothing (except footwear)	18, 19
4a. Footwear	34
5. Furniture	22
6. Reading	26
7. Personal care	29, 72
8. Fuel oil, auto gas	31
9. Major appliances, small appliances	54
10. Radio, television	56
11. Auto purchases, other auto	59, 75
12. Other travel and transportation	61, 65
13. Telegraph, telephone	66
14. Gas, electricity, water, sewage, etc.	68
15. Insurance, mortgage	70
16. Rents	71
17. Recreation	76
18. Medical care, education	77
19. Misc. expenses, all other	All except 64
20. Prorating of groups 1-6, 9, 10, 11, 19	64

The Household coefficients, computed from the National input-output study and the Survey of Consumer Expenditures, would then be adjusted to account for the locational pattern of consumers expenditures. The Household coefficients which would be used in the model would be estimates of the change in purchases by households from a sector within the region, given a change in income.

A questionnaire, which is shown in Appendix Figure 5, was prepared for the purpose of determining the locational pattern of purchases by households. A preliminary test of this questionnaire was made in Wilkes Barre, Pennsylvania in September, 1966.

State and Local Government

Expenditures for public works projects in Appalachia and changes in exports from the region will probably not affect most State and local government expenditures. The expenditures which are influenced by these changes will have to be estimated outside the model. One change which is likely is in expenditures of Federal, State and local welfare agencies, which are likely to decline in areas experiencing increased economic activity.

In cases where the model is employed to measure changes in outputs and incomes resulting from an increase in final demand, it will be necessary to consider reductions in payments of welfare agencies to residents of the region. However, the reduction in payments of welfare agencies need not be considered when the purpose of the analysis is the measurement of what Maass has called "Appalachian benefits" or local secondary benefits.

VIII. Evaluation of Surveys

A test of three sets of questionnaires was conducted for the purpose of determining if information required for the analytical system which was not otherwise available could be obtained in this way. Another purpose of this test was to improve the questionnaires where experience indicated that changes would be helpful.

Survey of Businesses by Personal Interview

The Transportation, Finance, Insurance, Real Estate and Services questionnaire (Appendix Figure 3) was tested in Wilkes-Barre, Pennsylvania and in the surrounding communities of Pittston, Dallas, Trucksville, Mountaintop, Kingston, Wyoming, Plains, Exeter, and West Pittston. These places are in Luzerne County, Pennsylvania and within fifteen miles of Wilkes-Barre.

A directoy published by the local Chamber of Commerce was used to select the business establishments to be surveyed. An attempt was made to visit a representative cross-section of firms, according to their products or services and number of employees.

Colonel Lee's letter of introduction generally enabled the interviewer to speak to a person who could provide the necessary information or give others permission to provide it. In small firms the owner usually answered the questions himself. The principal sources of information in medium-sized firms were accounting departments and the traffic or plant managers. Interviews at large manufacturing establishments usually required clearance from the president or vice-president. The interviewer was then referred to the general manager or accounting department. In several instances branch offices requested clearance from their headquarters prior to granting interviews. Interviews were not successful if owners or executives were unavailable. However, interviews were granted by 50 of the 52 establishments contacted.

The persons interviewed were usually cooperative and in some cases they devoted considerable time and energy to finding records which helped them answer the questions. There was a general interest in the ultimate purpose of the study and a curiosity about why this area had been chosen for the survey. This test indicated that the information necessary for the construction of the analytical system could be obtained by personal interviews using the questionnaire which was developed.

The proposed method for estimating the area from which inputs originate is not adequate for advertising. The assumption on which this method is based is that the areas supplying inputs of a particular type will not vary between purchasing input-output sectors. However, advertising expenditures of a firm tend to be made in areas where its products are marketed and the market areas of firms vary widely, depending, among other factors, upon the product produced. In other words, the geographic pattern of advertising expenditures varies among input-output sectors. For the purpose of allocating advertising expenditures among regions it is suggested that input-output sectors be defined as either "national" or "local," according to the marketing areas for their products. The "national" sectors would include the input-output sectors in the major groups: Agriculture, forestry and fisheries; Mining; and Manufacturing; and the input-output sectors, Transportation and warehousing, Communications, except radio and television broadcasting. "Local" sectors would include the major groups: Wholesale and retail trade; Finance, insurance and real estate; Services; and Personal consumption expenditure.

Using this breakdown it was estimated that "national" sectors purchased roughly 60 per cent of the advertising services compared to 40 per cent for "local" sectors in the United States as a whole. According to the suggested procedure, "national" sectors would be assumed to make all payments for advertising services to firms outside the region, whereas "local" sectors would be assumed to make all payments for advertising services to firms within the region where they are located.

At the time when the questionnaire was prepared for Transportation, Finance, Insurance, Real Estate and Services, it was believed that it was best to estimate the pattern of expenditures for transportation and warehousing by direct survey. However, since that time another method has been developed which is considered preferable to the survey. Whereas the original method considered transportation costs required to deliver the output of a firm to the purchaser, the new method considers transportation costs on inputs. The procedure was described earlier under the heading "Transportation."

Mail Survey of Businesses

Ninety-four questionnaires were mailed to business establishments to determine if the information necessary for the construction of the model could be economically obtained in this way.

The names and addresses of the establishments surveyed were obtained from an alphabetical list of firms in the Pennsylvania Industrial Directory which also gave the employment of establishments. Questionnaires were sent to large, medium and small size firms producing various goods and services.

Each questionnaire (Appendix figure 4) was accompanied by a map showing the major regions of Appalachia (Appendix Figure 1) and a letter explaining the need for the requested information (Appendix Figure 7).

Twenty usable questionnaires were returned out of the 94 mailed. It appeared from examining the completed questionnaires that persons who had provided the information had an adequate understanding of the questions which were asked. It also appeared that the questionnaires which were returned were usually based upon estimates of the various percentages rather than records of the firm.

It is not known whether the data provided in the mail survey are representative of business establishments in general because, with a response of roughtly 21 per cent, the sample of firms providing usable information is to a large extent self-selected.

Survey of Households

A survey of households was carried out in the area of Wilkes Barre, Pennsylvania for the purpose of testing the questionnaire and determining if the information needed from households could be obtained in this way.

Households were selected in clusters in high, middle and low income areas of Wilkes Barre, Hudson and Plains, Pennsylvania. A letter from Colonel Lee (Appendix Figure 8) introduced the interviewer and generally indicated the types of questions which would be asked. The questionnaire which was used is shown in Appendix Figure 5.

Persons who were contacted displayed various reactions to the interview. Some did not want to or could not take the time to provide the information. Others considered the questions to be an invasion of their privacy. In most cases, however, the person contacted did provide the information requested. It was necessary to contact 65 households in order to obtain 50 complete questionnaires.

Respondents generally understood and could answer the questions, although they often asked the interviewer to clarify or rephrase some point. Therefore, no substantial change in the questionnaire is necessary. It was concluded from this test that the information from households needed for the analytical system could be obtained by personal interviews using the questionnaire which was developed.

IX. Conclusion

We have completed our description of the components of the analytical system. We have also discussed briefly how national and regional input-output models can be used to estimate the direct and indirect effects of exogenous factors. We shall now consider the use of the suggested model for estimating economic impacts of investments and of changes in "exports" from Appalachia.

An interregional input-output matrix can be constructed by the methods presented. Each coefficient in this matrix is an estimate of the direct inputs per dollar supplied by a sector in Appalachia to another sector in Appalachia per dollar output of the purchasing industry.[1] This table provides some regional detail within Appalachia by considering trading relationships among the three regions. It shows estimates of inputs supplied by a particular sector in a given region which are required per dollar of output of a sector in another region. Interdependence coefficients, estimating the direct and indirect production needed within a sector within Appalachia per dollar of shipments by a sector to final demand, can be found from the inverse of this matrix.

For each sector there will be an interdependence coefficient for Households, which will be shown in the column corresponding to the sector being considered. This coefficient will estimate the total

---

[1]The coefficients along the main diagonal estimate within-sector supplies of inputs per dollar output of the sector.

income accruing to the Households sector in Appalachia per dollar of final demand for the products of the sector being considered. Thus, if we know the change in final demand, estimates can be made of direct and indirect economic effects on Appalachia by use of the interdependence coefficients, and especially the interdependence coefficient for Households.

As an illustration, consider a change in final demand in the Household furniture sector in the Southern Region of Appalachia. We would be primarily interested in the interdependence coefficient in the Households row of the Household furniture column for the Southern Region. The change in incomes of all Households in the Southern Region as a result of a one dollar change in final demand in the region could be estimated by multiplying the change in final demand (in dollars) for the products of the Household furniture sector by the interdependence coefficient for Households. The total change in incomes in Appalachia would be estimated by first adding together the three Household interdependence coefficients in the Household furniture column for the Southern Region (one coefficient in each region), and then multiplying by the change in final demand.

The change in final demand in Appalachia which results from an investment in Appalachia is not equal to the value of the investment. Some of the goods and services supplied will be "imported" from outside the Appalachian region. These imports will represent increases in final demands in other regions.

The graphical or mathematical models described in this paper could be used to estimate the value of manufactured products required for the investment which are supplied by the Appalachian Region. Surveys and other procedures could be used to estimate from which regions other goods and services would be supplied. This preliminary step would yield an estimate of the change in final demand for goods and services produced in Appalachia. Once this change has been determined, the effects can be estimated in the same way as the direct and indirect effects of final demand for exports.

The report has described a practical method which could be used to estimate the economic effects in Appalachia of Public investments and other exogenous influences. The system combines National technological relationships with regional trading patterns. Models based upon published statistics were suggested to estimate interregional trade in manufactured products. A direct survey and a mail questionnaire were tested to determine if information required for the system which was not otherwise available could be obtained in this way.

APPENDICES

TABLE OF CONTENTS

(NOTE: NONE IS REPRODUCED HERE, FOR REASONS GIVEN BELOW.)

(NOTE: ALL OF THE ABOVE TABLES WERE PUBLISHED IN THE SURVEY OF CURRENT BUSINESS, SEPTEMBER, 1965.)

(NOTE: THE ABOVE TABLE WAS PUBLISHED IN THE SURVEY OF CURRENT BUSINESS, APRIL, 1966.)

Published in original report submitted to Corps of Engineers - from U.S. Department of Labor, Bureau of Labor Statistics. Not available for publication or distribution - on file with the Office of Appalachian Studies.

(NOTE: APPENDICES V TO IX ARE ON FILE AT THE OFFICE OF APPALACHIAN STUDIES. THEY ARE NOT REPRODUCED HEREIN AS THEY ARE NOT NECESSARY FOR UNDERSTANDING THE METHOD DEVELOPED BY THIS STUDY.)