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Multiregional Input-Output Accounts, 1977 - Volumes 1 - Introduction and Summary

Jack Faucett Associates, Inc.

MULTIREGIONAL INPUT-OUTPUT ACCOUNTS, 1977. VOLUME 1. INTRODUCTION AND SUMMARY

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JUL 1983

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The multiregional Input-Output (MRIO) accounts provide estimates for 1977 of (1) output (by industry and commodity), (2) value added, (3) intermediate uses, and (4) final uses of goods and services, by sector and state. Interregional flows balance the production and consumption of goods and services between states. The project was also supported by the Department of Commerce (Economic Development Administration), the Federal Emergency Management Administration, and the Army Corps of Engineers.

This volume provides and introduction to and summary of the accounts.

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PREFACE

This volume describes the model structure and summarizes the data development. It also describes the procedures used to balance the national and state tables, including the commodity and service flows among the states. Comparisons and reconciliations of the final data with the NIPA accounts are also presented. A separate report, Commodity Flow Data, 1977, presents detail on commodity flows by sector and state.

The other volumes in this series were completed earlier and in a few cases describes procedures or present data summaries that were modified in the balancing of the data. Therefore this final volume should be consulted on points that may be in question when reviewing the earlier reports.

ACKNOWLEDGMENTS

The methods and procedures described in this report and the data compiled in accordance with these procedures were developed by Jack Faucett Associates (JFA) for the Department of Health and Human Services (HHS). The data development described herein was directed by Jack G. Faucett with the assistance of Linda K. Lent and Harry J. Chmelynski. Additional contributers to this report include Bernard Sobin, Hilary Kaufman and Joseph R. Morris. Special thanks are due to Nathaniel Ng and Ken Rogers for their painstaking efforts in handling the voluminous data processing that was involved in completing and balancing the data. Advisory support was provided by several members of our Research Advisory Board, notably Roger Bolton, Jack Alterman and Saul Gass. In addition, Karen R. Polenske of MIT provided valuable advice and suggestions. Further support was provided by our government advisory panel, especially Paula Young of BEA and representatives from HHS and other agencies involved in data development for the Federal Government.

Secretarial effort was coordinated by Leila Snyder assisted by Pamela Brockington. Robert Skarr compiled the bibliographic material.

CHAPTER 1

INTRODUCTION AND SUMMARY

This report summarizes the composition of and methodology used for the Multiregional Input-Output (MRIO) accounts under development by Jack Faucett Associates (JFA) for the U.S. Department of Health and Human Services. The MRIO accounts provide estimates for 1977 of (1) output (by industry and commodity), (2) value added, (3) intermediate uses and (4) final uses, by sector and state. Interregional flows balance the production and consumption of goods and services between states. For more detailed and comprehensive information on the development and quality of each component of the accounts, the reader is referred to the separate reports that are being released by JFA on each major component. These reports include:

- Vol. II - State Estimates of Outputs, Employment and Payrolls, 1977 (December, 1981)
- Vol. III - Development of Value Added Estimates by MRIO Sector By State, 1977 (December, 1981)
- Vol. IV - State Estimates of Final Demands, 1977 (April, 1982)
- Vol. V - State Estimates of Inputs to Industries, 1977 (May, 1982)
- Vol. VI - Interregional Commodity Flows, 1977 (August, 1982)

The balance of Chapter 1 discusses the overall structure of the accounts, compares the MRIO to other multiregional models and contrasts the accounts with other data sets. Chapter 2 provides a summary of the methodology used to develop the data sets by major components. Chapter 3 describes the development of interregional flows of commodities and services within the model. The quality of the estimates developed for each major component of the accounts is summarized in Chapter 4 and potential applications of the model are offered in Chapter 5. The appendix contains a complete sector concordance, procedures papers relating to specific aspects of model development a reference guide to all data sources referred to in this report, arranged numerically by the source numbers used throughout the report.

JFA welcomes comments on this report or any of the reports listed above and requests that suggestions or criticisms be submitted to the authors.

1.A STRUCTURE OF THE MRIO ACCOUNTS

The MRIO accounts are structured with the objectives of:

1. implementing a model that will provide a means of ascertaining the impact on selected economic variables of significant changes in national economic policies,

2. providing an economic data base at the state level useful in many types of economic analysis,

3. providing an analytical tool that is closely calibrated with national income and product accounts data (Gross National Product and Gross Product Originating data), and

4. keeping the model to a manageable size and complexity to facilitate its application, updating and modification over time.

In view of the last objective, every effort has been made to define variables in the model consistent with definitions in the principal data sources commonly available and to avoid adjustments to these data that were not deemed essential in satisfying the first three objectives.

The accounts include detail for:

- approximately 120 intermediate industries or sectors that produce all goods and services in the economy
- nine final demand sectors that account for the final use of these goods and services
- four accounts for the income flows and capital consumption allowances that constitute value added in each producing activity.

These accounts are developed for each state and the District of Columbia, and for the national total. Thus, there are approximately 51 x 130 activities in the model, each with approximately 120 possible input transactions plus the four components of value

added. The actual number of cells, however, is only a fraction of this possible total since each industry does not "sell" to every other industry. In constructing the data, worksheet detail was carried for many subsectors (and functions in final demand) which were aggregated in the final balancing of the accounts.[1]

In addition to these basic accounts, the state activities are linked together by interstate flows of commodities and services. These flows, representing trade among the states, act to balance production and consumption in each state (they include foreign imports and exports as well as trade among the states).

In the national table the following balance is achieved for each commodity:

Production = consumption by all intermediate industries + final demand ± inventory change + foreign exports - foreign imports

In the state tables the balance satisfies the same equation for each commodity with the following addition to the right hand-side of the equation:

+ shipments to other states
- shipments from other states

In practice, foreign imports and foreign exports are shown only for the states of entry and exit respectively, and are co-mingled with domestic shipments for inland-to-port movements and port-to-inland movements respectively.

The basic measure of output of each MRIO sector was developed primarily from establishment-level data. Since establishments tend to produce, in addition to their primary output, goods or services that are primary to other sectors, there is not a one-to-one correspondence between industry (sector) output and commodity and service output in the table. The nonprimary outputs for each MRIO sector are considered secondary production and generally are treated as "by-products" of the producing industry. The by-product treatment enables each industry to potentially produce

[1] *The worksheets and/or computer files that were developed in greater detail than the actual accounts have been archived by Jack Faucett Associates so that they may be referred to for future updates or for specific uses should additional detail be required.*

multiple outputs by denoting the secondary products or services as negative inputs in the equations (i.e., as outputs). This method insures that an industry's primary product production will not be increased in response to an increase in the demand for the secondary products or services that the industry produces in secondary activities. The demand for the primary output of each industry "drives" each industry in the model; secondary production in other industries simply reduces the demand from the primary industry. This treatment also avoids the necessity for redefining sector output and inputs to represent only primary production and thus preserves the integrity of the establishment data as reported in most available sources.

The major exception to this treatment of secondary production of commodities and services in each industry is the agricultural and construction sectors. In the MRIO both of these groups of industries are defined on an activity or product rather than an establishment basis. Farms (the "establishment" in agriculture) produce multiple crops and livestock products; the establishment data for farms have been restructured so that agricultural sectors are made up of groups of similar products. Similarly, construction establishments perform multiple types of work, cutting across normal grouping of construction products, and these establishment data have been restructured to form sectors along product lines. In addition to construction performed by commercial construction firms, a large amount of construction is performed by "in-house" or force account personnel within establishments in other industries. This force-account construction, both new and maintenance construction, has been redefined from the sectors in which it is performed to the appropriate construction sectors. The output and input data for the sectors performing the construction work have been adjusted as appropriate.

The output of industries within each state is measured generally by the total production of the industry's establishments located in the state. There are two exceptions in the MRIO accounts. In the construction sectors, output is located in the state in which the construction is performed. The second exception is transportation services which cannot be identified uniquely with the location of transportation establishments. Transportation services revenues have been assigned to states based on formulae which give weight to state origins, state destinations and states traversed by freight shipments and passenger travel. Output in the transportation sectors, however, is assigned based on payroll in each state as reported by establishments in the state. Since certain overhead functions that service other states are included in the state

output measures, the traffic revenues so assigned do not necessarily equal the output measures. Therefore, it was necessary to introduce service flows among the states that balanced output with the revenues assigned to each state (e.g., consumption). This was done in the final balancing procedure described in Chapter 4.

The measure of value-added in each industry is based on the state location of establishments except as noted above for the construction sectors. The components of value-added are: employee total compensation, employee payroll (a subcomponent of total employee compensation), business taxes and fees (other than income taxes), and property type income (before income taxes and interest costs). The sum of value-added for all industries in the state constitutes a measure of gross state product. The sum of gross state product for all states equals to National Gross Product Originating and also to Gross National Product.

On the other side of the accounts, the components of final demand include: personal consumption expenditures, Federal government purchases (separate for defense and non-defense), state and local government expenditures, private fixed investment (construction and producers durable equipment), and inventory changes. The sum of these final demand components represent gross state consumption. (The sum of gross state consumption for all states plus foreign exports minus foreign imports is equal to Gross National Product.) The difference between gross state product and gross state consumption is accounted for by shipments of goods and services to and from other states. This difference is financed by income and capital flows among the states, including the net of Federal taxes paid by each state and transfer payments received from the Federal government (social security, welfare, medical and health, highway funds, and other).

1.B COMPARISONS WITH PREVIOUS MULTIREGIONAL MODELS

The Jack Faucett Associates Multiregional Input-Output Model and the associated Accounts Matrix for 1977 was formulated as an improved version of the 1963 MRIO developed by Dr. Karen Polenske and others during work with the Harvard Economic Research Project.[1] Jack Faucett Associates provided substantial portions of the data

[1] *The U.S. Multiregional Input-Output Accounts and Model, Karen R. Polenske, Lexington Books, D.C. Heath and Co., Lexington, Massachusetts, 1980.*

development for this earlier model, which was developed between 1967 and 1972 for the Economic Development Administration, U.S. Department of Commerce. Although significant differences exist between the two models, these differences mainly appear in the number of sectors, the treatment of secondary products, and in the estimation of trade and transportation margins. Mathematically, the two models have identical commodity flow assumptions, and thus stand apart from other multiregional input-output and regional econometric models. A brief but informative history of the development and applications of nineteen multiregional models currently in use is given by Dr. Polenske in Chapter 3 of the reference above, which is sixth and last volume in a series of reports that document the development of the 1963 MRIO accounts.

The transportation assumptions used to model commodity flows are a key element in distinguishing among the various regional models, since the primary advantage of a regional model over a national model in most applications is that the regional model can supply multipliers which indicate the total impact of a change in final demand for commodity x in state i on industry y in state j. These interstate multipliers arise as a direct result of the assumptions used to link the states through commodity and service flows. Although detailed data on interstate flows of services are impossible to obtain for all service sectors, data on commodity flows between states are available for each mode at varying levels of coverage. The foremost feature of the MRIO model is that its formulation permits the direct use of these commodity flow data in forecasting applications.

Data on shipments of manufactured products by all manufacturers were assembled from the Census Bureau's Commodity Transportation Survey, supplemented by data from the one-percent Railroad Waybill, Waterborne Commerce tapes, and airline data. Data on shipments of agricultural and mineral products in 1977 by truck were assembled for JFA by the staff at MIT from USDA data. After imputation for undercoverage these data, which detail the flows of each commodity within and among the states, form the basis for the interstate linkages in both the 1963 and 1977 MRIO models. Both models are mathematically formulated so as to hold fixed the proportions of total demand for a commodity in a given state that are supplied locally and by all other states. In forecasting applications the proportions are fixed to base year values. Thus for a given industry each state industry's share of the market for a commodity in other states is held fixed. In addition, the modal split between the various transportation modes for a given commodity flowing from state i to state j are held constant.

Although both the 1963 and 1977 MRIO models are based upon the same commodity flow assumptions, the two models differ in the way the assumptions are implemented. In the 1977 MRIO, the fixed-proportions-of-supply assumption is implemented by the introduction of "dummy" state-level distribution sectors for each commodity. These function as the supplier of the good to all users in the state. The distribution sectors in turn purchase their supply of goods and margin services in fixed proportions from the producing sectors for that good or service in each state. Thus, for example, in the 1977 MRIO model the total steel requirement (intermediate uses plus final demand) in Ohio is satisfied in fixed shares by steel producers in Ohio, Pennsylvania, Michigan, etc. Fixed state shares of supply were also used in the 1963 model. However, by using the device of state-level distribution sectors in the 1977 model, it is possible to attach transportation margins to the goods in a way that reflects the state of production and state of use of the good. In the model, users of steel in states close to their sources of supply are charged a lower transportation margin than users of the same good in states which are far from their sources of supply. Hence, for example, users of Pennsylvania steel in Ohio pay less freight margin than users of Pennsylvania steel in Michigan. As a result of the methods used to assign trade and transportation margins, the MRIO model is constructed with inputs measured in purchasers value and output measured in producers value.

This methodology may be contrasted with the 1963 MRIO method for estimation of transportation margins, which uses the standard margin matrix tables at the national level to attach the total margins by mode as an input to the consumer of the good, regardless of location. Non-margin inputs were then expressed in producers value in the 1963 MRIO. Both models adopt a fixed modal split assumption.

It is important to note that the assumptions of fixed proportions of supply across states and fixed modal shares and that of user-specific margins are closely interrelated in the 1977 MRIO model. Using these assumptions in the base year, it is possible to construct a weighted-average transportation margin coefficient for each mode, which appears in the column of the state-level distribution sector. These same weighted-average transportation margin coefficients may than be used in forecast years, without alteration of the weights. This fortuitous outcome permits the use of a single state distribution sector for each commodity, which has "fixed technology" coefficients in its columns. Here the "technology" coefficients actually consist of commodity flow and margin coefficients.

The commodity flow and transportation margin assumptions of the 1977 MRIO model represent a uniquely appropriate extension of fixed-technology input-output modeling to the problem of modeling trade flows between regions and their associated freight margin requirements. The fixed-technology assumption for transportation, however, suffers from the same short-comings that the fixed technology assumption has when applied to industries, i.e., the assumption of fixed proportions may not hold true in the future. This criticism concerns the question of the stability of the transportation coefficients and modal splits over time.

In addition to the differences in treatment of transportation margins the 1977 MRIO treats production of secondary products differently than in the 1963 model. The methodology used for secondary products is based on the assumption that each industry produces secondary products in fixed proportion to its production of primary product, as would be the case for its by-products. With this treatment, demands for secondary products do not induce direct impacts on the primary product output of each industry in the solution of the model. Rather the demand for the primary product alone determines the industry's level of output. This treatment of secondary products is thus quite similar to commonly held ideas about production of by-products. The assumption is equivalent to treating all secondary products as by-products. Where this assumption did not appear tenable, the secondary activity involved was redefined to become a part of the industry to which the secondary product is primary. A complete discussion of the secondary product methodology in the 1977 MRIO is given in MRIO Procedures Paper No. 3, attached as an appendix to this report.

Despite the differences mentioned here between the 1977 and 1963 versions, the two MRIO models are quite similar in concept and together will be referred to as the MRIO model in the remainder of this section. We now turn to a comparison of the MRIO model to other interregional economic models. Other major interregional models currently in use may be grouped as regional econometric, linear programming and input-output models. Large scale regional econometric models are generally based on a top-down procedure in which the impacts generated by a national econometric or input-output model are disaggregated to the state or even the county level using "shares" equations. A large number of such models exist and will not be described here individually. In general top-down models suffer from the lack of balanced state-level detail on the consumption and production of goods and services. When the state-level

results of these top-down models are examined in detail, it is often the case that surprisingly drastic changes occur in some regions which cannot be reconciled with the state's available industrial, labor and transportation capacity. Since the anomalies often result from the iterative or simultaneous application of many econometrically estimated relationships, it is impossible to precisely locate the cause of the anomaly. In addition, the anomalous results often lead to other questions about which the model is unable to supply additional details. Questions such as "From where do the required inputs come which would permit such an expansion of industry x in region j?" often cannot be answered adequately. Similar issues arise when the output of an industry is forecasted to fall. Here the often unanswerable question is "From where do the other industries which use the output of this industry now obtain their needs?"

The MRIO model avoids such problems by imposing a strict discipline of balancing the accounts for all state-industries. Forecasts prepared with the MRIO for future years retain this desirable balance, albeit through the use of fixed proportions as discussed above. Thus, although the forecast results may not be exact, the forecasts are, at a minimum, logically sound since all changes in output and consumption are in balance with the changes generated in all other state industries.

Another class of top-down multiregional models use linear programming methods to share national impacts down to the state or county level, a device which is based on the premise that the highest gains in production should occur in state where the marginal cost of production, including transportation requirements, is lowest. This approach is highly theoretical in nature and ignores many of the institutional relationships which exist in the economy. It is possible, of course, that institutional relationships will bend when sufficient marginal cost differences arise. The LP solution, however, is known to be overly sensitive to small marginal cost differences due to the "flip-flop" nature of the LP solution; i.e., a small difference in costs can serve to switch large amounts of production from one region to another.

A second difficulty with the LP "shares" methodology is that cross-hauling of the same commodity both ways between a given pair of regions is treated as a non-optimal solution. Actual trade flow data show, to the contrary, that significant levels of cross-hauling do occur in practice. The degree of cross-hauling is very sensitive to the level of aggregation of the model, and even at the four-digit SIC level represents a significant portion. Since the fixed-coefficient version MRIO model is based on actual commodity flows in the base year, cross-hauling is permitted in the model to the extent that it occurred in the base year.

1.C COMPARABILITY WITH OTHER DATA SERIES

The MRIO accounts represent a unique set of establishment-based state-level data. As such, the accounts are not directly comparable with any existing data set at the state or national level. Characteristics that limit comparison are the sectoring plan and the definition of industry activity primarily on an establishment basis. When it is completed, the 1977 BEA I-O table will provide the closest comparable data at the national level, but the comparison will require an aggregation of the 496-order BEA sectoring plan to the 123-order MRIO and will differ with respect to the different handling of establishment versus product-based sector definitions.

Comparability with the Bureau of Labor Statistics (BLS) 1977 output controls, which have been released, is awkward because the BLS output controls (though based for the most part on 1977 data as was the MRIO) were adjusted (by redefinitions) based on BEA's 1972 I-O methods. In 1972, BEA made many more redefinitions and adjustments than are intended in 1977. BEA plans to eliminate many of the redefinitions that are of lesser importance and difficult to duplicate. Direct comparison of national MRIO output totals with BLS totals would require extensive research into the nature and effect of BEA 1972 methods as used in the development of the BLS controls. For these reasons, no effort has been made to compare the MRIO to the BLS update of BEA's 1972 table, nor is any intended. Instead, comparison of the MRIO accounts with a national table will be delayed until the fully documented and final BEA 1977 table is released.

In lieu of a comprehensive data set for use as a national control on MRIO totals, data were controlled to the best data available by component for a given sector or sectors. Thus, for output, employment and payroll, manufacturing data are being controlled to Census of Manufactures data, service sectors covered by Census to available Census totals, and so on. Summary information on the actual controls used for each component are described in subsequent chapters, while complete discussion of all data development are described in separate reports.[1]

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[1] *See JFA reports: State Estimates of Output, Employment and Payrolls, 1977, December, 1981; Development of Value Added Estimates by MRIO Sector by State, December, 1981; State Estimates of Final Demands, 1977, April, 1982; State Estimates of Inputs to Industries, 1977, May, 1982; and Interregional Commodity Flows, 1977 August, 1982.*

The progress of BEA in developing their national table is explained in the next section. A discussion of the adjustments required to reconcile the MRIO accounts with the BEA 1977 table follows.

The 1977 BEA I-O Table

Development of the national 1977 table is currently underway in BEA's Interindustry Economics Branch. The 1977 table is not scheduled for completion until 1983 and thus many aspects of the table are still being developed. Nonetheless, BEA has made considerable progress in the development of their national level output files and was able to supply JFA with preliminary output worksheets for numerous four-digit SIC's during output data development. For the limited number of MRIO sectors that were completed by BEA during the development of MRIO output, data development for SIC's within the MRIO was compared with available BEA data and differences between the two data sets were analyzed. Since the completion of the MRIO output files, many more sectors have been completed by BEA, though their files are not fully completed and all data now available are preliminary. When BEA has completed their files, a more comprehensive sector-by-sector comparison can be undertaken.

Departures From BEA's 1972 Methodology

The methodology used in developing the MRIO sector output totals departs from that of BEA principally in that industry redefinitions that involve the adjustment of establishment data have been kept to a minimum in the MRIO accounts. Industry redefinitions that do not involve the adjustment of establishment data follow closely the treatment by BEA. For example, government enterprises that produce services that are competitive with private enterprise, e.g., transit systems and electric power, have been classified within the appropriate private sectors. (These cases are a function of the classification system only, since they do not involve the adjustment of establishment data). Further, adjustments to sector output totals (as derived from published sources) for undercoverage of important flows have been made similar to adjustments made by BEA. Imputations for implicit service flows, e.g., rent on owner-occupied housing and banking services in lieu of interest payments on deposits, have also been made following BEA concepts and the treatment of these flows in the NIPA accounts.

The adjustments made to establishment data, and the treatment of secondary products in the MRIO data, are described in the appendix to this report. Adjustments made by BEA and not made in the MRIO data are also noted.

The conceptual difficulties in measuring transportation output by state, not relevant in the BEA data, lead to tedious state assignments of output for freight transportation sectors. The assignment procedure is described in the appendix, along with a description of the treatment of both trade and transportation margins in the MRIO. The methods for handling margins in the MRIO differs from the BEA methods but do not affect the output measures for these sectors at the national level.

CHAPTER 2

DATA DEVELOPMENT METHODOLOGY

This chapter summarizes the methods and procedures used to develop the data files which form the basis of the MRIO. The first section below explains the construction of output, employment and payroll files on an establishment basis and details the procedures that are used to sort these data to a commodity basis. The procedures used to estimate value-added, the difference between an industry's output and its intermediate inputs, are described in the second section below. The third section of this chapter, final demands, explains the techniques used to estimate the amount of end-use demand for each sector's output. The fourth and final section, intermediate transactions, summarizes the methods used to estimate the purchases of goods and services made by each industry from all other industries.

2.A OUTPUT, EMPLOYMENT AND PAYROLL

The output, employment and payroll estimates[1] developed for the MRIO provide a measure of 1977 activity by state for each MRIO sector. Output is measured in 1977 dollars, employment in number of employees or in some cases, full-time equivalent employees for 1977 and payroll in 1977 dollars. Employment and payroll data represent only paid employees, i.e., no estimation is made for self-employment or unpaid workers. Where data were available, a further estimate of production/nonsupervisory workers, worker hours and payroll was included. Because no other data base precisely follows the definitions and coverage of the MRIO sectors, this data base is not readily comparable to any existing data set.

Data Sources

The data source that provided the most comprehensive and reliable data available for establishment-based output, employment and payroll estimates was the quiquennial Bureau of the Census data, e.g., the Census of Manufactures, and the Census of Service Industries. Where Census data were unavailable, in whole or in part, other reliable data sources were used. For the measurement of output it was usually necessary to make use of industry-specific data, e.g., U.S. Department of Agriculture's crop data and

[1] *A complete description of methodology is presented in the JFA report State Estimates of Output, Employment and Payrolls, 1977.*

insurance association data for life insurance. Internal Revenue Service data were used in some cases to develop output data, but because of the sample selection technique and

IRS coverage of companies rather than establishments, the appropriateness of these data is considerably limited.

If output data sources included employment data (number of employees and/or payroll), these data were also developed. However, use of employment data from industry-specific sources was made only after the data were compared with large scale employment data sources such as the Bureau of the Census' County Business Patterns or the Bureau of Labor Statistics' Employment and Earnings. The appropriateness of these large scale data sources as a mode of comparison or as a primary data source is described below.

In sectors where Census or other output data sources did not include data on employment and payroll, or where primary data required refinements due to suppression or combination, employment and payroll data were frequently drawn from the Bureau of the Census' County Business Patterns (CBP) or the Bureau of Labor Statistics' Employment and Wages data. CBP data were drawn from hard copy and cover most industries by state by four-digit SIC. The data are based on first-quarter FICA taxable payroll data supplemented by data collected by the Bureau of the Census' Annual Organization Survey. Data are tabulated on an establishment basis and are suppressed for any state having less than 50 employees within an industry.

Data from the Bureau of Labor Statistics were developed from ES-202 (Unemployment Insurance) data (referred to as UI data) from microfiche (Annual Averages 1977) or from Computer Tape No. 120380 (Monthly Employment and Quarterly Wage Data.) These data are developed for workers covered by state unemployment insurance laws and for Federal civilian workers covered by the Unemployment Compensation for Federal Employees program. The number of employees includes supervisory and nonsupervisory workers as well as employees on leave and part-time employees. The data are reported by individual establishments and workers are reported in the state of the physical location of the job. Total wages are reported by calendar quarters for all services performed. Within the UI tape, data are provided by four-digit SIC by state and are suppressed only where fewer than three establishments have reported.

The primary data sources used to develop output, employment and payroll estimates, by major industry groups, are shown in Exhibit 2-1. Details on the methods and procedures used to develop these data into estimates by MRIO sector follow.

Full bibliographic citations for each data source referenced by the source numbers appearing in the exhibit, are provided in the appendix.

Estimates of output, employment and payroll for most sectors coincide with the operating unit, i.e., the establishment, since most of the input and employment data are available on an establishment basis. The major exceptions are agriculture and construction which were developed on a product basis. The oil and gas well data were also divided somewhat synthetically into two separate activities or products. The rental and royalty components of the real estate and rental sector are also defined on an activity basis. Force account construction is redefined for the most part to the construction sectors where other construction activity is performed. There are only a few other minor cases where establishment definitions and data were not preserved.

Data Estimation Techniques

While national level data sources were available for all sectors, many of the available data sets failed to include the required data elements in state detail. Various estimation techniques were utilized in the development of output, employment and payroll to overcome suppressions in state-level detail or lack of state-level detail in the principal data source. Data suppressions can be characterized in three categories:

- data are available at the required level of detail but suppressed for individual states,
- state-level data are provided at a broader level of aggregation than required,
- data may be both at a broader level than required and also suppressed for some states.

Data suppressed for individual states occurs frequently in Census data. Suppressed items are, however, included in national totals. Moreover, whereas output, employment and payroll data were usually suppressed, the number of establishments was included,

EXHIBIT 2-1: DATA SOURCES

MRIO Sector	Output	Employment and Payroll
Agriculture, Forestry and Fisheries (Sectors 001-006)	Agricultural Statistics (Source 02001) Economic Statistics Service's Crop Reporting Board reports (Source 02131-6) 1978 Census of Agriculture (Source 03105) 1977 Census of Manufactures (Source 03105) Timber in the United States Economy 1963, 1967, 1972 (Source 02301) USDA Analysts National Marine Fishery Service Data (Source 03811) International Association of Fish and Wildlife Agencies Data (Source 22091)	1978 Census of Agriculture (Source 03105) Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1979 (Source 02111) Bureau of Labor Statistics' Employment and Wages: Monthly Employment and Quarterly Wage Data 1977 (Computer Tape No. 120380, (Source 12110).
Mining (Sectors 007-013)	1977 Census of Mineral Industries (Source 03106) 1977 Minerals Yearbook: Metals and Minerals (Source 10101) 1978-9 Minerals Yearbook: Area Reports - Domestic (Source 10101) Bituminous Coal and Lignite Production and Mine Operations, 1977 (Source 06103) Coal: Pennsylvania Anthracite for the Calendar Year 1977 (Source 06103) Gas Facts, 1978 (Source 22011) Basic Petroleum Data Book (Source 22031)	1977 Census of Mineral Industries (Source 03106) 1977 County Business Patterns (Source 03114)
Construction (Sectors 014-019)	1977 Census of Construction Industries (Source 03104) Value of New Construction Put in Place, 1977, C-30 Series (Source 03122)	1977 Census of Construction Industries (Source 03104)
Manufacturing (Sectors 020-084)	1977 Census of Manufactures (Source 03105)	1977 Census of Manufactures (Source 03105) Bureau of Labor Statistics' Employment and Wages: Monthly Employment and Quarterly Wage Data 1977 (Computer Tape No. 120380, Source 12110). 1977 County Business Patterns (Source 03114)
Transportation (Sectors 085-091)	Transport Statistics, 1977 (Source 16111) Transit Fact Book (Source 22081) 1977 Census of Transportation (Source 03107) Taxicab Operating Characteristics (Source 23041) National Energy Accounts (Source 23011) Transport Economics (Source 16131) Survey of Current Business (Source 03501)	Employment and Wages (Source 12109) Railroad Retirement Board, unpublished tabulations (Source 16601) Yearbook of Railroad Facts (Source 22051) Employment and Earnings: States and Areas (Source 12104) 1977 Census of Governments (Source 03110) County Business Patterns (Source 03114)

EXHIBIT 2-1: DATA SOURCES (cont.)

MRIO Sector	Output	Employment and Payroll
Transportation (cont.) (Sectors 085-091)	Waterborne Commerce of the United States, 1977 (Source 04111)	
	Energy Data Reports (Source 06103)	
	Revenues and Traffic of Class A and B Water Carriers (Source 16114)	
	1979 Supplement to the Handbook of Airline Statistics (Source 17211)	
	BEA's preliminary 1977 Analysis Input-Output Control Worksheets	
	Trinc's Green Book of Air Freight and Freight Forwarders, 1977 (Source 24041)	
	1977 Census of Service Industries (Source 03103)	
Communications and Broadcasting (Sectors 092, 093)	1977 Statistics of Communications Common Carriers (Source 16203)	1977 County Business Patterns (Source 03114)
	1980 Independent Telephone Statistics (Source 22041)	1977 Employment in the Broadcast Industry (Source 16211)
	1977 Cable Television Revenues (Source 16206)	
	1977 AM and FM Broadcast Financial Data (Source 16202)	
	1977 TV Broadcast Financial Data (Source 16201)	
	1980 Status Report of Public Broadcasting (Source 20101)	
	1977 Employment in the Broadcasting Industry (Source 16211)	
Utilities (Sectors 094-096)	Statistics of Privately Owned Electric Utilities in the United States (Source 06103)	1977 Census of Governments (Source 03110)
	Statistics of Publicly Owned Electric Utilities in the United States (Source 06103)	Bureau of Labor Statistics' Employment and Wages: Monthly Employment and Quarterly Wage Data 1977 (Computer Tape No. 120380, Source 12110)
	1977 Census of Governments (Source 03110)	
	Governmental Finances in 1977-1978 (Source 03103)	
	1977 Annual Statistical Report of Rural Electric Borrowers (Source 02201)	
	Statistical Yearbook of the Electric Utility Industry for 1977 (Source 22021)	
	1977 Gas Facts (Source 22011)	
	1977 Statistics of Interstate Natural Pipeline Companies (Source 06104)	
	Main Line Natural Gas Sales to Industrial Users (Source 06103)	
	1977 Statistics of Income (Source 15101)	
Trade (Sectors 097-102)	1977 Census of Wholesale Trade (Source 03102)	1977 Census of Wholesale Trade (Source 03102)
	Statistics of Income (Source 15101)	1977 Census of Retail Trade (Source 03101)
	1977 Census of Retail Trade (Source 03101)	
	1977 Census of Service Industries (Source 03103)	

EXHIBIT 2-1: DATA SOURCES (cont.)

MRIO Sector	Output	Employment and Payroll
Trade (cont.) (Sectors 097-102)	1977 Census of Retail Trade (Source 03101) 1977 Census of Service Industries (Source 03103) Current Business Report "1977 Retail Trade Annual Sales and Purchases, Year-End Inventories, and Accounts Receivable by Kind of Retail Store" (Source 03119)	
Finance, Insurance and Real Estate (Sectors 103-105)	Annual Report of the Federal Reserve Board of Governors, 1977 (Source 16401) Bank Operating Statistics, 1977 (Source 16302) Combined Financial Statements FSLIC-Insured Savings and Loan Associations, 1977 (Source 16802) Annual Report, National Credit Union Administration, 1977 (Source 17101) State-Chartered Credit Unions, 1977 Annual Report (Source 17102) NCFA Research Report on Finance Companies in 1977 (Source 22112) Mortgage Banking, 1977: Financial Statements and Operating Ratios (Source 22121) Annual Report of the Securities and Exchange Commission, 1977 (Source 16501) Life Insurance Fact Book, 1978 (Source 22071) BEA's preliminary "1977 Analysis Input-Output Control Worksheets" 1977 Statistics of Income (Source 15101) Survey of Current Business (Source 03501) 1970 Census of Housing (Source 03112) 1977 Survey of Housing (Source 03115)	Bureau of Labor Statistics' Employment and Wages: Monthly Employment and Quarterly Wage Data 1977 (Computer Tape No. 120380, Source 12110) Annual Report of the Board of the Governors of the Federal Reserve System, 1977 (Source 16401)
Services (Sectors 106-117)	1977 Census of Service Industries (Source 03103) 1978 Census of Agriculture (Source 03109) Catholic Schools and Their Finances (Source 22061) Basic Financial Data on Catholic Elementary Schools (Source 22062) Digest of Education Statistics (Source 08101) Survey of Current Business (Source 03501)	1977 Census of Service Industries (Source 03103) 1978 Census of Agriculture (Source 03109) Unpublished data from the National Catholic Educational Association and the National Center for Education Statistics Survey of Current Business (Source 03501) County Business Patterns, 1977 (Source 03114)

EXHIBIT 2-1: DATA SOURCES (cont.)

MRIO Sector	Output	Employment and Payroll
Government Enterprises	Budget of the U.S. Government (Source 01102)	Budget of the U.S. Government (Source 01102)
	Army and Air Force Exchange Service Annual Report to the Secretaries (Source 04001)	Army and Air Force Exchange Service Annual Report to the Secretaries (Source 04001)
	Federal Civilian Work Force Statistics (Source 17001)	Federal Civilian Work Force Statistics (Source 17001)
	1977 Census of Governments (Source 03110)	1977 Census of Governments (Source 03110)
	Highway Statistics (Source 14401)	
	Postmaster Accounts, Government Fiscal Year Revenue List 1977 (6/7/78) (unpublished data, Source 16902)	
	Distribution of Federal Payrolls Paid During CY 1977 in the United States by State of Residence December 31, 1977 (unpublished data, Source 16901)	
	Outlays by Appropriation and Program for Community Services Administration (Federal Information Exchange System Printout 9/30/77, Source 16903)	
	Metropolitan Washington Airports Combined Statement of Revenue and Expense (Source 14302)	
	Treasury Bulletin (Source 15002)	
	Annual Report of the Panama Canal Company and Canal Zone Government, 1977 (Source 16701)	

and for the manufacturing sectors, the establishment size by employment interval was given. Though estimation based on the number of establishments can result in error because of the potential variability of establishment size, the number of establishments provided an adequate means of estimation where only a small portion of the total data were suppressed, e.g., less than three percent. However, where relatively larger suppressions were involved, more time-consuming (and accurate) methods were utilized. Methods used include development of employment and payroll from supplementary sources, and estimation of suppressed output based on an appropriate (usually national) ratio of employment or payroll to output. In all cases, the national total of all state-level data (estimated and available) was compared with the national total available from Census and scaling was applied to the imputed data, if required, to reconcile the two.

Where state-level data were available in combination with other elements, a split of these data were required. The split was accomplished by taking the "closest" reasonable ratio available. For example, if Census data were disaggregated by state by four-digit SIC for establishments with payroll but not for establishments without payroll, the distribution of the state output data for establishments without payroll were estimated based on with-payroll establishments. Where both the level of disaggregation and state level suppressions occured, appropriate ratios and supplementary data sources have been used to distribute requisite data at the state level.

For sectors not covered by Census data, sometimes the only output data available were national totals. However, in almost all cases, employment and payroll could be developed from the UI data base and/or County Business Patterns. Thus, one procedure used to estimate state distribution of output values was to apply ratios of payroll or employment to output. However, sometimes state distribution of output could be more accurately accomplished from other sources, e.g., a 1976 or 1978 state distribution pattern. Thus, the actual pattern of distribution was decided only after weighing all the alternatives and selecting the most accurate option available.

In some cases, no measure of output data could be located for an identified type of establishment at the subsector level of detail. In this case, a similar activity for which data were available was used to inflate payroll to an estimated measure of output. Thus, in the case of state savings and loan associations not insured by the Federal Savings and Loan Insurance Corporation, output was inflated by the corresponding output-to-payroll-ratios of insured savings and loan associations.

General Methods and Procedures

Output, employment and payroll files were developed on an industry-by-industry basis from the data sources shown in Exhibit 2-1. As a rule, data from the Bureau of Census' quinquennial censuses were used wherever available. The estimating techniques described above were used in instances where the data sources (Census or other) failed to contain complete state-level detail. The following section summarizes, by major industry category, the techniques used to develop output, employment and payroll estimates. Within each major industry, the methodology used to estimate output is presented first and followed by the techniques used to estimate employment and payroll.

Agriculture

Unlike other censuses, the Bureau of Census quinquennial data collection on agricultural producers is conducted in 1978. Bureau of Census data was therefore not relied upon in the development of the requisite 1977 estimates, except for several minor commodities which were not available from 1977 data sources. Instead, output estimates for agriculture were developed primarily from data collected by the U.S. Department of Agriculture's (USDA) Crop Reporting Board (Sources 02131-6) and from various other sources as required.

The estimates for agricultural sectors were developed on a commodity basis (rather than establishment) because output data are almost always collected by type of commodity rather than by type of farm.

Though output data are available by commodity, employment and payroll data are collected at the establishment (farm) level. The procedure used to estimate hired labor by commodity was to adjust data in the 1978 Census of Agriculture (Source 03109) to represent a pure data set of payroll estimates by type of farm for 1978, estimate ratios of payroll to commodity group within each type of farm, and apply these coefficients to 1977 output by commodity. Scalers were used to control the payroll by state to actual 1977 payroll for each state and 1977 wage rates by state were used to estimate full-time equivalent employment from payroll. The estimates of payroll and employment do not include any adjustment for unpaid family labor or operator employment, which was estimated at 69 percent of the total work force in 1977.

Mining

Output estimates by mining sector were developed from the 1977 Census of Mineral Industries (Source 03106) and supplemented, as required, from other data series on mine production to estimate suppressed data. Special adjustment was required to split oil and gas extraction from combined totals in Census data.

Employment estimates by mining sector were developed from Census data utilizing data from 1977 County Business Patterns (Source 03114) to estimate suppressions.

Construction

Construction output was developed on an activity basis. Output, employment, and payroll data for contract construction were available on an establishment basis from the 1977 Census of Construction Industries (Source 03104). Output data on an activity basis were also available from the Census. The Census data was supplemented with activity-based output data from the Value of New Construction Put in Place (VIP, Source 03122). Extensive adjustments to the data from both series were required to (1) overcome definitional inconsistencies, (2) prevent double-counting of subcontracted activities, and (3) estimate output for nonemployer establishments.

Total construction output is made up of contract construction plus force-account construction (construction work performed by the work force of the consuming industry). The Census provides output data for contract construction only, while the VIP provides data for total construction. Force-account construction was estimated by deducting contract construction (Census data) from total construction (VIP data). State distributions of force-account construction were imputed from a variety of data sources.

Most of the state-specific data in the Census is given by the location of the establishment rather than by the location of the construction work. State data by location of construction is provided only for establishment receipts by type of contractor, not by type of construction activity. Adjustments were made for each state at the MRIO level, using relationships between gross receipts by construction location and gross receipts by establishment location for SICs that most closely match the types of construction activity within a given MRIO.

Employment and payroll data were developed for construction sectors for supervisory and nonsupervisory workers. The estimates for each MRIO activity were developed from Census in tandem with the procedures used to transform the Census output data to an activity basis.

Manufacturing

Data for output, employment, payroll and value-added in all manufacturing sectors were derived from the 1977 Census of Manufactures (Source 03105), Industry Series, Table 2. In this table, the values for number of establishments, employment, payroll, value-added and cost of materials were given for each state and four-digit SIC. Since the value added data in the Census include cost of services, the sum of value added and cost of materials equals the total output for the state and four-digit SIC. Suppressed data were estimated using employment data from the Bureau of Labor Statistics' Employment and Wages: Monthly Employment and Quarterly Wage Data, 1977 (Source 12110, hereafter referred to as UI data) and 1977 County Business Patterns (Source 03114). Employment and payroll were also developed from Census data and estimates for suppressed elements were made from the two sources noted above.

Transportation

National controls for the output of all sectors except MRIO 085: Railroads were available from the published sources cited in Exhibit 2-1. The national total for the output of railroads was taken from the 1977 Bureau of Labor Statistics' input-output table (an update of the 1972 BEA table to 1977). State distributions of output for all transportation sectors were made based on payroll data for these sectors.

Employment and payroll estimates for private establishments, by state, were tabulated from Employment and Wages: Annual Averages 1977 (Source 12109) where available. Data on the employment and payroll of publicly-owned transit systems, by state, were tabulated from the 1977 Census of Governments (Source 03110), "Compendium of Public Employment." Development of estimates for (1) data that were suppressed in Employment and Wages, (2) expansion of publicly-owned transit system payroll data for October 1977 (from the "Compendium of Public Employment") to an annual basis, and (3) estimating data not available for MRIO 086 was based on data contained in 1977 County Business Patterns (Source 03114) and Employment and Earnings (Source 12103).

Communications

Output data are not available for these sectors necessitating estimation of total output from the sources listed in Exhibit 2-1. In MRIO 092: Communications, Except Radio and Television, the output of some activities, e.g., radar stations, were not available from published sources and were estimated based on ratios of employment to output in activities where data were available. In Sector 093: Radio and Television Broadcasting, it should be noted that most of the sector's output is time sales and these are redefined to advertising in the MRIO.

Employment and payroll were developed from 1977 County Business Patterns (Source 03114) and 1977 Employment in the Broadcasting Industry (Source 16211).

Utilities

The utility sectors include electric utilities, gas production and distribution and water and sanitary services. Data on sanitary services is included in the 1977 Census of Governments (Source 03110), but electric and gas production and distribution are not covered within the quinquennial censuses. These data were developed from the various data sources noted in Exhibit 2-1.

Employment and payroll data were developed from the UI data (Source 12110) and the 1977 Census of Governments (Source 03110).

Trade

The output of all trade establishments except MRIO 098: Eating and Drinking Places, is defined as a margin value. Thus, the output is defined so as to exclude the cost of goods purchased by trade establishments. The total output of trade establishments is therefore expressed as the difference between total receipts and the cost-of-goods-sold. The output of Eating and Drinking Places is measured similar to nontrade establishments and therefore represented as gross receipts.

The output of wholesaler's is measured by data from the 1977 Census of Wholesale Trade (national, Source 03102) by type of wholesale operation, i.e., merchant wholesalers, manufacturers' sales offices and branches, and agents and brokers. Census provides data on the gross margin for merchant wholesalers, but not for sales offices and branches or agents and brokers. The gross margin for these types of establishments is estimated based on operating expenses plus profits, operating expenses from Census and profits from IRS. Output is developed at the state level utilizing margins by three- and four-digit SIC (national) multiplied by state sales by SIC.

The output of MRIO 098: Eating and Drinking Places was developed from receipts data in the 1977 Census of Retail Trade (Source 03101).

Output of retail establishments were developed from receipts data in the 1977 Census of Retail Trade and the 1977 Census of Service Industries (Source 03103) multiplied by gross, margins in 1977 Merchant Wholesalers: Measures of Value Produced, Capital Expenditures, Depreciable Assets, and Operating Expenses (Source 03121). Output was developed for each state by kind-of-business from the national margins based on state sales by kind-of-business.

Wholesale trade margins are linked to goods in the MRIO through the distribution sectors described in MRIO Procedures No. 2 (see the appendix to this report). Margin rates are computed by estimating the percentage of each sector's goods passing through wholesale trade and multiplying the most appropriate national margin (by kind-of-business) by the value of goods passing through wholesale trade. The margin rate is also adjusted to reflect an estimate of the goods that pass through wholesale trade twice and scaled to yield final margin rates that imply a total wholesale output equal to the controls by state discussed above.

Retail margins are specified in the MRIO as a subcomponent of final demand. These margins are defined by multiplying the final demand purchases in Personal Consumption Expenditures (less sales taxes) by the national margin rates of the most appropriate kind-of-business. The final rates are specified after scaling to the state output controls described previously.

Employment and payroll estimates for all the trade sectors were made from Census data. Employment and payroll estimates were not augmented to include establishments with no payroll and self-employment which may be significant for some SIC's within an MRIO sector.

Finance, Insurance and Real Estate

Census data do not cover these services and it was therefore necessary to rely upon many other data sources to measure output (see Exhibit 2-1). The output of financial services was defined as nonfinancial expenses-plus-profits. The output of some subcomponents of the banking sector was not included in any regularly published data sources. The components of output not included in data sources accounted for about eight percent of total payroll for MRIO 103. These components were estimated using payroll-to-output ratios of closely related financial services which were included in available data series.

Output for insurance carriers was estimated in three ways from the data sources in Exhibit 3-2. The output of life insurance carriers was measured by operating expenses plus dividends paid to stockholders while the output of all other carriers was estimated on a net basis, i.e., premiums received less benefits and dividends paid. The output of insurance agents and brokers and insurance services was measured by operating expenses plus profit.

This output of real estate and rental services is comprised largely of financial flows not identified with a "real" industry. The only establishment-defined activity included is the sales and management function of the real estate industry. For this reason estimates were developed from the diverse sources noted in Exhibit 2-1 in component detail by state and summed to provide state "industry" totals for the following categories:

1. Owner-Occupied Dwellings (non-farm)
2. Tenant-Occupied Dwellings (non-farm)
3. Farm Dwellings (owner occupied and tenant occupied)
4. Permanent Guests of Hotels
5. Non Profit Institutions
6. Rental Payments by Business
7. Royalty Payments by Business
8. Rental Payments by Government

Employment and payroll estimates were primarily based on the UI data (Source 12110) except the employment and payroll of Federal Reserve Banks which was estimated from the 1977 Annual Report of the Board of Governors of the Federal Reserve System

(Source 16401). It should be noted that the only component of real estate and rental with associated employment and payroll is the sales and management function of the real estate industry.

Services

The output of service sector was developed from the 1977 Census of Service Industries (Source 03103) for almost all sectors. Exceptions include:

- veterinary services, from the 1978 Census of Agriculture (Source 03109)
- religious schools, from various sources (see Exhibit 2-1)
- religious organizations, based on personal consumption expenditures for religion by BEA's National Income and Wealth Division.

Employment and payroll estimates were developed from Census data supplemented by UI data (Source 12110), 1977 County Business Patterns (Source 03114), and various sources for religious school employment (see Exhibit 2-1).

Government Enterprises

A government activity is classified as an enterprise if the "operating costs are at least to a substantial extent covered by the sale of goods and services, in contrast to the general activities of government which are financed mainly by tax revenues and debt creation."[1] BEA has refined this definition to include activities wherein (1) at least 50 percent of costs are covered by sales of goods and services, (2) sales are equal to $10 million or more, and (3) if there is any capital stock, most of the capital stock is held by a government corporation or agency.

Within this definition, Federal government enterprises may be divided into four components:

1. U.S. Postal Service
2. Federal utilities
3. Commodity Credit Corporation
4. Other Federal government enterprises

Of these four components, the output of only two is included in MRIO Sector 118: the Postal Service and other Federal government enterprises. The outputs of Federal

[1] *National Income, 1954 Edition, A Supplement to the Survey of Current Business.*

utilities are considered to be the same commodity produced by their private sector equivalent (MRIO Sector 094: Electric Utilities, Sector 095: Gas Production and Distribution or Sector 096: Water and Sanitary Services). It is therefore added to the commodity output of the corresponding private sector and not included in this sector. The Commodity Credit Corporation has inputs but no output and thus does not contribute to the output of Sector 118. In general, the output of Federal enterprises is measured by the value of revenues (if the enterprise is not subsidized) or the operating expenses (a surrogate for revenues plus subsidy) if the activity is subsidized.

The output of Federal government enterprises was developed from the numerous data sources noted in Exhibit 3-2.

State and local government enterprises were tabulated from the 1977 Census of Governments (Source 03110) and the 1978 Highway Statistics (Source 14401). For activities included in the 1977 Census of Governments (Source 03110) the larger of revenues or expenditures was recorded. These activities include airports, parking facilities, water transportation and terminals, housing and urban revenual and liquor stores. Receipts for road, bridge and ferry tolls were drawn from Highway Statistics. Output is calculated as a simple sum of these activities. State and local utilities are included in their respective utility sectors (094, 095, and 096), and thus are not included in this tabulation. No data were available on miscellaneous state and local enterprises such as city markets and thus these activities were not included in government enterprises.

Employment and payroll estimates for Federal enterprises were developed from the same data sources used to measure output. Employment and payroll for state and local government enterprises were developed from the 1977 Census of Governments.

2.B VALUE-ADDED

For the MRIO accounts, three components of value added have been estimated for each MRIO industry in each state: compensation of employees, indirect business taxes plus business transfer payments (abbreviated IBT + BTP below), and property-type income (abbreviated PTI below.)

The components of value added comprise a three dimensional matrix of 18,819 cells: three components in each of 123 industries in 51 states. In most instances, it was not

feasible to develop data for specific cells of the matrix. Rather, the general procedure was to develop totals for components or subcomponents at the state level for all sectors (or for broad groups of sectors), or at the U.S. level for individual sectors, or both; and to allocate the totals to state-level MRIO sectors based on the distributions of output, employment or payroll by state by sector as explained in the previous section, or by other proxy variables developed for this task.

The following section summarizes the underlying value added data that were developed for the accounts. The second section describes the various scaling and allocation procedures that produced the complete matrix of value added by component by sector by state. The methods are fully documented in the JFA report Development of Value Added Estimates by MRIO Sector by State.

Underlying Data and Totals Developed

The state and industry totals for components and subcomponents of value added, together with the proxy variables used in the allocation procedures, are the basic data underlying the value added estimates. The sets of data developed, by component of value added, are summarized in Exhibit 2-2.

The most frequently used sources included:

- the Economic Censuses, which provided (with some exceptions) state-level data for supplements to wages and salaries and total value added in the manufacturing, construction, and mining sectors;
- gross national product by industry (in approximately two-digit SIC industry detail) and by components, tabulated by the Bureau of Economic Analysis (BEA), referred to below as the GPO (Gross Product Originating) data;
- Department of Agriculture state aggregate farm income statements;
- a variety of U.S. Treasury, Census, and other sources on business taxes;
- the 1972 BEA input-output table, which provided estimates of purchased services not deducted from value of production in the Census computations of value added;
- Department of Labor, Social Security Administration, and BEA sources on supplements to wages and salaries by state and by industry.

EXHIBIT 2-2: SUMMARY OF DATA SETS UNDERLYING THE VALUE ADDED ESTIMATES

VALUE ADDED COMPONENTS	SECTORS					
	Farms MRIO 1-4 (excluding agricultural services)	Mining MRIO 7-13	Construction MRIO 14-19	Manufacturing MRIO 20-84	All other sectors MRIO 4 (ag. services), 5, 6, 85-119, 122, 123	All Sectors
Compensation of Employees	• Supplements, total for all farm sectors by state	• Ratio of required supplements to wages & salaries, U.S. average, by sector. • Ratio of voluntary supplements to wages and salaries, U.S. average, by sector.	• Required supplements, total for all construction sectors, by state • Voluntary supplements, total for all construction sectors, by state • Required supplements, U.S. total, by construction sector • Voluntary supplements, U.S. total, by construction sector	• Required supplements, total for all manufacturing sectors, by state • Voluntary supplements, total for all manufacturing sectors, by state • Required supplements, U.S. total, by manufacturing 4-digit SIC • Voluntary supplements, U.S. total, by manufacturing 4-digit SIC	• Ratio of required supplements to wages and salaries, U.S. average, by sector • Ratio of voluntary supplements to wages & salaries, U.S. average, by sector • Federal government required supplements, U.S. total; state government pension contributions, by state; Railroad Retirement contributions, U.S. total	• Wages & salaries by sector by state (from Task 2) • Required supplements, total for all sectors, by state • Voluntary supplements total for all sectors, by state
Indirect Business Taxes plus Business Transfer Payments	• Business taxes, total for all farm sectors, by state	• Severence taxes, by sector by state.		• Federal manufacturers' excises, alcoholic beverage, and tobacco excises; U.S. totals by sector	• State and local excises and sales taxes, by sector by state • Federal retail excises, U.S. total by sector • Customs duties by state	• Property taxes, by three sector groups (industrial, real estate, other commercial) by state • U.S. total IBT + BTP by approximately 2-digit SIC industry • U.S. average assets per employee, by sector (for allocating property taxes)
Property-type Income; or Total Value Added	• PTI, total for all farm sectors, by state • PTI, U.S. total by sector	• Census-definition value added, by sector by state • Estimated purchased services U.S. total, by mining sector	• Census-definition value added, total for all construction sectors, by state • Census-definition value added, U.S. total, by construction sector • Estimated purchased services, U.S. total, by construction sector	• Census-definition value added, by 4-digit SIC, by state • Estimated purchased services, U.S. total by manufacturing sector	• PTI. U.S. total, by approximately 2-digit SIC	

Estimation of State- and Sector-Specific Components of Value Added

The data sets described in the preceding section are for the most part not disaggregated to individual state-level MRIO sectors. The estimates of value added components for state-level sectors employed several allocation procedures, utilizing the sector-by-state distributions of output, employment, and payroll developed previously by JFA (see Section 2.A).

Exhibit 2-3 is a summary of these estimating procedures. In the exhibit, each box indicates a common estimation procedure, employing analogous data sets, for the group of sectors and components of value added corresponding to the box's row and column position. These methods are described in the following sections, by sector group.

Farm Sectors (MRIO Sectors 001-003, 004 (excluding agricultural services))

Value added components by sector by state for the farm sectors were estimated independently of the estimates for all other sectors. Supplements to wages and salaries, total for all farms by state, were available for the farm sectors, and were allocated proportionally to wages and salaries in each farm sector within each state. Compensation of employees is the sum of supplements, and wages and salaries. IBT + BTP, total for all farms by state, was allocated proportionally to the output of each farm sector within each state.

Both totals by state and U.S. totals by MRIO sector were available for farm PTI. Therefore PTI was allocated by iterative scaling on the matrix of output by farm sector by state from JFA's previous work on employment by state. The resulting PTI estimates sum across sectors to each state total, and across states to each sector total.

Construction (MRIO Sectors 014-019)

Supplements to Wages and Salaries

Required supplements[1] for all construction sectors at the state level, and U.S. total required supplements by MRIO construction sector, were available. These row and column totals were allocated to state-level construction sectors by iterative scaling on the matrix of payroll by sector by state developed as explained in Section 2.A.

[1] *employer contributions for social insurance plus private-carrier workers' compensation insurance*

EXHIBIT 2-3: METHODS OF ESTIMATING VALUE ADDED COMPONENTS BY SECTOR BY STATE

COMPONENTS OF VALUE ADDED			SECTORS: Farms MRIO 1-4 (excluding agricultural services)	Construction MRIO 14-19	Manufacturing MRIO 20-84	Mining MRIO 7-13	All Other Sectors MRIO 4 (agricultural services) 5, 6, 85-119, 122, 123 and manufacturers administrative and auxiliaries.
VALUE ADDED	Compensation of Employees	Wages & Salaries	Developed in Task 2				
		Required Supplements	Department of Agriculture data by state; scaled to GPO U.S. total; allocated to sectors within states proportionally to wages and salaries.	State totals for all sectors, and U.S. totals by sector, from Economic Censuses; allocated to sector by state by iterative scaling on payroll by sector by state.		U.S. average rates ((req. suppl./(wages & salaries)) times state payroll in sector; scaled to state total required supplements.	
		Voluntary Supplements		Same method as required supplements		Same method as required supplements	
	Indirect Business Taxes and Business Transfer Payments (IBT + BTP)	Property Taxes	Same method as supplements; except allocated proportionally to output.	State totals (by industrial, real estate, and other commercial and industry groups) allocated to sectors within each state proportionally to assets by sector by state. Assets estimated as U.S. average (assets/employment) by sector, times employment by sector by state.			
		Excises, Sales Taxes, Customs Duties		Federal excises allocated to appropriate sector (or subsector) in each state proportionally to state output in that sector (or subsector). Customs and state and local taxes assigned directly to appropriate sector within each state. Excluded from producing sector value-added; appear as margin component in distribution sectors.			
		Other IBT + BTP		U.S. IBT + BTP by five components by GPO sector (approximately two-digit SIC level) allocated proportionally to output by sector by state, then scaled to state totals by component.			
	Property-type Income (PTI)		State totals for all farm sectors, and U.S. totals by farm sector, allocated to sector by state, by iterative scaling on output by sector by state.	Residuals: Value added less compensation of labor less (IBT + BTP). State total value added for all sectors, and U.S. total by sector, allocated to sector by state by iterative scaling on output by sector by state.	Residuals: Economic Census value added by sector by state, plus excises, less estimated purchased services, less compensation of labor, less IBT + BTP.		GPO U.S. PTI (at approximately 2-digit SIC level) allocated to sector by state proportionally to output.

State totals, and U.S. totals by sector were also available for voluntary supplements, and these were allocated by the same method as required supplements. Compensation of employees is the sum of required supplements, voluntary supplements, and payroll in each state-level construction sector.

Indirect Business Taxes plus Business Transfer Payments

Property taxes were estimated simultaneously for all construction, manufacturing, mining, agricultural services, forestry and fisheries, transportation, and utilities sectors (MRIO 004 (agricultural services part), 5-92, 94-96), the group of sectors corresponding most closely to the "industrial" classification of assessments reported in the Census of Governments. Estimated control totals for property taxes paid by this group of sectors were available by state. The state control totals were allocated to sectors proportionally to estimated taxable assets in each sector in each state. Taxable assets in a state-level construction sector were estimated as U.S. average assets per employee for the sector, times employment in that sector in the state.

Four components of IBT (motor vehicle, corporation, other licences, and severance taxes) were estimated for construction, as well as all other non-farm sectors, by allocating totals in each state proportionally to U.S. average rates (per dollar of output) by GPO sector times output in each sector in the state. NIPA U.S. totals by GPO sector for the "non-taxes" component of IBT, and for BTP, were allocated to state level sectors proportionally to output in each sector in each state. All sales and excise taxes were excluded from the IBT estimates in all sectors; these taxes appear in the distribution sectors in the MRIO table.

Property-type Income

PTI in construction was computed as a residual: total value added in each state-level sector less (IBT + BTP) less compensation of labor. Value added was computed before the inventory valuation and adjustment in all non-farm sectors.

Value added (excluding excise and sales taxes and the inventory valuation adjustment) was available for the total of all construction sectors by state, and for U.S. total by MRIO construction sector. The totals were allocated to state-level sectors by iterative scaling on the matrix of output by construction sector by state.

Manufacturing (MRIO Sectors 020-084)

Supplements to Wages and Salaries

All value added computations in the manufacturing sectors were carried out for state-level four-digit SIC industries, and aggregated to MRIO sectors as the final step. With this exception, the available data and allocation procedures for value-added components in the manufacturing sectors were analogous to those for value added in construction, described above.

Indirect Business Taxes and Business Transfer Payments

The estimation method for IBT + PTI in manufacturing was that described in the section on construction IBT + BTP above. The manufacturing estimates were carried out for four-digit SIC industries. Gross assets-per-employee ratios by SIC in the Census of Manufactures were employed in allocating state control totals for property taxes to manufacturing sectors.

Property-type Income

Total value added was available by four-digit SIC manufacturing industry by state. PTI was computed for state-level four-digit SIC industries as value added, less compensation of labor, less the included components of (IBT + BTP). As in the estimation of construction PTI, this method excludes inventory valuation adjustment and excise taxes from the estimates of MRIO manufacturing producing sector value added.

Mining (MRIO Sectors 007-013)

Supplements to Wages and Salaries

Supplements for the mining sectors, together with MRIO sectors 005, 006, 085-119, 122, 123, and 004 (agricultural services part), and manufacturers' administrative and auxiliary establishments (i.e., all sectors other than farms, construction, and manufacturing) were estimated in a single procedure. The available data were state total required supplements for all sectors, state total voluntary supplements for all sectors, and U.S. average ratios of required supplements to payroll and of voluntary supplements to payroll for each MRIO sector. An initial estimate of required supplements in each sector (excluding farms, construction, and manufacturing) in each state was computed as the product of the U.S. average required supplements to payroll ratio times payroll in the sector in each state. These initial estimates were then scaled

within each state to state total required supplements less required supplements in farms, construction, and manufacturing. The procedure was repeated for voluntary supplements.

Indirect Business Taxes and Business Transfer Payments

IBT and BTP in the mining sectors were estimated by the methods described in the section on construction IBT + BTP above.

Property-type Income

Total value added by sector by state was available for mining. PTI by sector by state was computed as value added less compensation of labor less (IBT + BTP).

All Other Sectors (MRIO 004 (agricultural services part), 005, 006, 085-119, 122, 123)

Supplements to Wages and Salaries

Supplements in this group of sectors were estimated in the procedure described above in the section on supplements in mining. Employer contributions to social insurance funds in the Federal government, and state and local government sectors, and Railroad Retirement contributions in MRIO 085, were allocated explicitly to these sectors as a final step.

Indirect Business Taxes and Business Transfer Payments

IBT + BTP for these sectors was estimated by the methods described in the section on construction IBT + BTP above.

Property-type Income

PTI for these sectors was available only as U.S. total by approximately two-digit SIC industry from the GPO. The totals (before inventory valuation adjustment) were allocated to all MRIO state-level sectors within each GPO industry proportionally to output. In the cases of some MRIO sectors comprised of parts of several two-digit SIC industries, PTI values for the corresponding GPO industries were first allocated to MRIO sectors at the U.S. level proportionally to output, and then allocated to states within each sector. Within an MRIO sector in this group of sectors, the ratio of PTI to output is constant across all states.

The value added in these establishemtns is comprised of labor compensation only since all PTI and IBT + BTP have been assigned to the operating establishments. Payroll in central administrative and auxiliary establishments was available by state in the detail shown below. The procedures employed in estimating value added resulted in employee compensation in these establishments being included in PTI in manufacturing, mining and construction but not in the other sectors. The result of this appears to be that total value added is understated by the approximate 12.5 billion dollars compensation in these establishments in the wholesale trade, retail trade and services sectors. This error was discovered too late to correct the voluminous calculations involved.

As it stands these payments are shown in separate sectors in the auxiliary tape containing the employment and payroll data, as additions to wages and salaries and a corresponding reduction in PTI, in the sector detail below (no net change in value added). This adjustment is not incorporated in the value added data in the Use Matrix since there is no satisfactory way to allocate this adjustment to individual sectors and states. In applying the model it will be necessary to stipulate, or separately calculate, any changes in CAO compensation. Actually, the accuracy of the results may be improved by this procedure since CAO employment cannot be expected to change linearly with output. In any event, CAO's present a complication and are difficult to handle without an undue expansion of the model detail. Fortunately, the values involved are not sufficiently large to cause significant distortion in applications of the model, even if they are completely ignored (we refer to distortions in changes in employment and value added, not levels — levels may always be adjusted to include any such omissions in the model structure).

	All CAO's and Auxiliaries		
	Establishments (number)	Employees (number)	Annual payroll ($1,000)
United States, Total	30,941	2,073,283	36,557,975
Mineral Industries	1,116	76,913	1,635,713
Construction Industries	344	13,355	299,275
Manufacturing	9,455	1,073,810	21,970,349
Wholesale Trade	5,471	221,224	4,121,474
Retail Trade	10,997	608,880	7,396,567
Selected Service Industries	3,558	79,101	1,134,597

Source: 1977 Enterprise Statistics: Central Administrative Offices and Auxiliaries (ES 77-2), May 1981.

2.C FINAL DEMAND

Final demands cover personal consumption expenditures, private investment in plant and equipment, private investment in net inventory accumulation, net exports, and purchases of goods and services by the Federal government and by state and local governments. All of these purchases were estimated at purchaser values (including all transportation and trade margins plus indirect taxes), and all estimates used NIPA control totals for corresponding gross national product categories.

A state allocation of a particular final demand sector's purchase of a product is usually to the state of residence of the purchaser, but there were exceptions for reasons of both principle and data. Exports and imports are allocated to the state of exit and entry, respectively. Federal expenditures are allocated to states producing the goods and services, largely because the data are in that form, but also because the use of the purchase is ordinarily not a identified with a specific state. The state of purchase is also used for private sector purchases of aircraft, ships, and railroad rolling stock because there is no single state which can be denoted as the state of use. Some personal consumption expenditures of travelers are also allocated to the states where the purchases were made rather than to the states of residence of the purchasers.

The subsections that follow outline the methodology for each final demand sector. Further details can be found in the JFA report, State Estimates of Final Demand - 1977.

Personal Consumption Expenditures

The NIPA control totals for PCE were taken from the Survey of Current Business supplement for July, 1981, National Income and Product Accounts, July 1981, Table 2.4 (Source 03501) and from unpublished detail supplied by the Bureau of Economic Analysis in telephone conversations. The detail was often insufficient, though, to yield firm national values for MRIO sectors, and it gave no indication of state distributions. An outline of how distributions were made among supplying sectors and among states follows.

Most of the estimating problem for sectoral distribution of NIPA controls occurred in expenditures for commodities. For most commodities, the 1977 national estimates were adjustments of 1972 consumption, with a final step of scaling to NIPA control totals. The easiest cases occurred for categories of expenditure that were major components of domestic production (plus, frequently, net imports). It could then be considered to change from 1972 PCE in proportion to the total supply available to all buyers, including intermediate sectors. More frequently, the 1972 consumption was assumed to have changed in constant dollars from 1972 in proportion to the constant dollar change of some NIPA category or other index considered complementary to PCE use of the commodity. The selection of complementary expenditures was judgmental rather than econometric.

Much of the state distribution of commodities was in proportion to what were considered appropriate "merchandise line" statistics in the 1977 Census of Retail Trade (Source 03101). State personal income data were also used frequently, and armed forces employment was the basis for distribution of PCE categories of goods and clothing as armed forces payments in kind. As in NIPA, the MRIO model treats such payments in kind as purchases by consumers with the cash equivalent of those payments.

The NIPA controls for services required much less distribution than for commodities to arrive at national totals for MRIO sectors. There was considerable use of other sources, though, for state distributions. The Census of Service Industries (Source 03103) played much the same kind of role in distribution of service purchases as the Census of Retail Trade played in distribution of commodity purchases. Regulatory agency publications of financial accounts of public utilities contained "residential" revenue components that served as indexes for distribution of national control totals, and American Water Works Association publishes revenue data and residential rate data that, together with population statistics, permitted distribution of national controls for water and sanitary services. A variety of insurance statistics were available in A.M. Best's Executive Data Service: Property and Casualty Insurance (Source 24031), in the Health Insurance Association of America publication Sourcebook of Health Insurance Data (Source 22171), and in Life Insurance Fact Book (Source 22071); and state detail in these statistics were bases for proration of control totals for NIPA categories of insurance. Travel-related expenditures were initially distributed to states where the expenditures were made, but data from the Census Travel Survey, discussed in the

section of Service Flows, provided bases for distributing some of those purchases to the states of residences of the consumers. A contract study for the U.S. Postal Service (Institute for Social Research, Household Mailstream Study Final Report) provided data on how mail use is related to income. Together with Federal government statistics of population and income, it provided bases for distributing values of owner-occupied housing and of housing rents.

Private Fixed Capital Expenditures

Private fixed capital expenditures consist of private expenditures for producer durable equipment and for new construction. The July 1981 supplement to the Survey of Current Business (Source 03501) has each of those totals, a table of construction by type with enough detail to identify MRIO construction industries, and a breakdown of SIC codes of the durable equipment that, together with unpublished BEA data, permit a rough MRIO identification of the equipment also. The construction detail covers government construction and private combined, so that its use here required subtraction of estimates of government construction that were made in other phases of the final demands research. There was no such problem for producer durable equipment.

Most of the research and analysis centered on state distribution of the national totals. The 1977 Census of Construction (Source 03104), was a major source of state data by type of construction, but it was flawed for MRIO purposes by having its geographic detail based on states of residence of construction establishments rather than on states where the construction was put in place. Wherever practical, adjustments were made. The equipment distributions among states were based on a wide variety of sources. For manufacturing industries, the Census of Manufactures (Source 03105) provided total expenditures for equipment by state and SIC code of using industry, and the 1972 interindustry study included estimates of the mix of industry codes of equipment items purchased by each manufacturing industry (Source 03517). The 1972 mix was used with the 1977 totals. The censuses of mineral industries and of agriculture, and of construction provided identifiable kinds of capital expenditure for the using industries they covered, and FCC Statistics of Communication, Common Carriers (Source 16203) provided state distribution of telephone installations. The 1977 EEI Statistical Yearbook (Source 22021) provided state statistics of new generating capacity of electric utilities.

Some more tenuous distributions of equipment purchases by state used the Census of Construction (Source 03104) data on particular kinds of construction to distribute requirements for particular kinds of equipment, and the Ethyl Corporation's estimates of business use of gasoline in each state (Source 03071) were used as indicators of business purchase of automobiles.

Purchases of aircraft, ships, trucks, buses, and railroad rolling stock were allocated to states in proportion to outputs of those commodities. No effort was made to identify the states of use of such mobile equipment, as the state of production correctly identified the states where employment and other income would be generated by orders for these equipment items.

Net Inventory Change

Net inventory change is the change in value of inventories at current prices for the aggregate of producers, wholesalers, retailers, and business users of the products involved. The classification of inventories is by commodity and includes goods in process as well as finished commodities. Margins are included in the inventory values. The NIPA controls are classified by broad industry group of the holder, with no commodity breakdowns.

There were three major sources for producer inventory change. The Department of Agriculture provided unpublished data on changes in farm inventories of agricultural products. The 1977 Census of Mineral Industries (Source 03106) contained inventories at the beginning and end of the year for mined and quarried products. For manufacturing industries, the Census of Manufactures (Source 03105) collected change in inventories of finished products and goods in process by SIC code and by state, but did not publish combinations of SIC code and state. It was possible to approximate the inventory change for SIC and state combinations, though, by estimating inventory change as value-added plus cost of materials consumed minus value of shipments.

The 1977 Census of Wholesale Trade (Source 03102) provided most of the data for distributing wholesale inventories by commodity and by state. The source included the inventory change by class of wholesaler, and also the sales of each wholesaler class distributed by merchandise line, which could, in turn, be classified by MRIO code. The ratio of inventory change to sales for the classes of wholesalers accounting for most of

the sales of a commodity was considered applicable to all changes in inventories of the commodity for all wholesalers dealing in the commodity.

The 1977 Census of Retail Trade (Source 03101) was used in the same way to distribute retail inventories.

Except for user inventories of coal and oil held by electric utilities and of ores at processing plants, for which changes were distributed with data from Energy Data Report (Source 06103), and Minerals Yearbook (Source 10101), respectively, net inventory change was left for estimation as part of the matrix balancing process.

Foreign Trade

The foreign trade vectors include a vector for each of imports and exports, the former including an entry for directly allocated imports, imports for which there is no row of comparable domestically produced commodities. The comparable imports are at domestic port value including duties; the directly allocated imports are at foreign port value, with shipping costs to the United States port of entry treated as a margin. Exports are at domestic port value. The Virgin Islands, Puerto Rico, and other U.S. possessions are treated as foreign countries.

There were three major data sources: the 1977 Census publications U.S. Imports of Consumption and General Imports: IA 245-A (Source 03118) U.S. Exports: EA622 (Source 03118), and "Service Transactions in the U.S. International Accounts, 1970-1980," in Survey of Current Business, November 1981, (Source 03501). Identification of directly allocated imports in the Census aggregates came from a BEA paper, Commodity Detail on Noncomparable Imports BEA, 1977 (Source 03512), and separation of trade with possessions from the major Census data was provided by 1977 Census report U.S. Trade with Puerto Rico and U.S. Possessions: FT800 (Source 03118). Duties came from Table D of the April 1979 Survey of Current Business (Source 03501). Other sources were used to disggregate service transactions data and to provide translations from published foreign trade categories to MRIO codes.

Federal Government Purchases of Goods and Services

Federal government purchases of goods and services were estimated in MRIO detail for each of defense and non-defense. Although NIPA and budget statistics include many other agency purchases (of comparatively small aggregate value) in the defense category, it was practical here to think of defense as consisting only of the Department of Defense (DOD) purchases other than for civil functions of the Corps of Engineers, and Department of Energy (and predecessor agencies) purchases for nuclear weapons. The purchases include capital expenditures of government enterprises, but not the current account purchases of such agencies, which is in accord with the NIPA treatment.

NIPA accounts as published in the July 1981 supplement to the Survey of Current Business, National Income and Product Accounts, 1976-79, Tables 3.7B and 3.9 (Source 03501), and augmented by further detail furnished in telephone conversations, provided considerable information on the character of expenditures, but these data were not easily translatable to MRIO codes. The NIPA data are based primarily on financial accounts, which tend to be classified by appropriation rather than by SIC codes of commodities and services purchased; and appropriations can finance many more kinds of purchases than indicated by the titles. As a result, much of the available detail had to be aggregated before use as control totals. Another difficulty was inclusion of force-account construction labor and materials purchases for force-account construction in NIPA categories other than construction.

The principal data sources for distributing control totals other than employee compensation among MRIO sectors and states were two Census reports dealing with manufacturer sales to the Federal government and two tapes summarizing categories of Federal contract awards. The Census reports were "Shipments to Federal Government Agencies," Current Industrial Reports, MA-175 (78)-1 (Source 03129); and "Distribution of Sales by Class of Customer," 1977 Census of Manufactures, SR-13 (Source 03105). For a large number of SIC codes, SR-13 distributes product shipment among those to manufacturers, wholesalers, retailers, Federal government, and state and local governments. It is a sample survey, with substantial errors and suppression of estimates for the largest errors. The MA-175 report covers a smaller set of SIC codes and distributes establishment shipments to the Federal government among agencies that

include DOD and a DOE predecessor (ERDA), so that defense shipments are indentifiable. The tapes are a DOD tape for FY77 and a GSA tape for FY79, both of which provide detailed Federal Supply Catalog (FSC) and service codes plus location of supplying establishment for contract awards exceeding $10,000. The DOD tape distinguishes between awards for civil functions of the Corps of Engineers and for other functions, and the GSA tape distinguishes DOD and DOE from an aggregate of all other agencies that excludes agencies financed primarily with other than current Congressional appropriations, corresponding roughly to exclusion of MRIO government enterprises. Other sources are used for purchases of items not covered by the above sources, or to permit adjustment of excessive coverage. An example of the former is individual travel expenses, which are neither manufacturer shipments nor purchases by contracts of at least $10,000. Other examples are Commodity Credit Corporation inventory accumulation, investment expenditures of Federal enterprises strategic and petroleum stockpile purchases, and sales (negative purchases) of timber, petroleum, nuclear enrichment services, and other services. The principal example of excess coverage is Federal purchases of military equipment and construction for which there is reimbursement by foreign governments.

Although there are differences in MRIO sectors covered by the major data sources, there is also a great deal of overlap. The overlap was dealt with by a priority system. Census data received a higher priority than contract award data because they dealt with actual shipments during the calendar year of interest, and because the SIC classification of the Census data avoided substantial coding errors that were inevitable in conversion of contract award data to MRIO sectors. The SR-13 data were preferred to the MA-175 data because they had greater SIC coverage and because they classified shipments by commodity rather than by establishment. This was despite the fact that the SR-13 data needed adjustments to estimate the portion of ultimate Federal use that was through initial shipments to wholesalers and to account for discrepancies between aggregate product shipments as estimated in that survey and in the more complete Census surveys of the 1977 Census of Manufactures.

The FY77 contract award data were, of course, preferred to the FY79 data because of their closeness in timing to the calendar year of the MRIO project. The FY79 data could be used for direct estimates of Federal purchases only after scaling in broad aggregates by a ratio between FY77 and FY79 obligations in budget classifications.

The FY79 data had a special use in the adjustment of SR-13 to transfer some of the shipments to wholesalers to the Federal government. The FY79 data had both FSC coding of the commodities purchased and SIC coding of the suppliers. Where one of the suppliers of a major portion of the FSC commodity had a manufacturing code, that could be considered to be the SIC coding of the commodity, and the fraction of the total purchases that were from establishments classified as SIC wholesale trade establishments was considered to be the fraction of corresponding SR-13 shipments ultimately to the Federal government through wholesalers.

An outline of the priority system follows. Total Federal purchases of an MRIO commodity were taken as given by the adjusted data of SR-13 wherever there was SR-13 coverage. If MA-175 had coverage of the same item, the defense portion was considered to be that of MA-175, with non-defense allocated the rest of the SR-13 total. If MA-175 did not have coverage, the FY79 data were used. The FY79 data were also used for defense portions of MRIO codes not covered by SR-13, and FY79 data were used for non-defense.

For items not covered by the basic data sources, other sources, such as Treasury tabulations of receipts and expenditures, annual reports of the TVA and CCC, telephoned information from the U.S. Postal Service and other agencies provided estimates of purchases and sales. The dollar values were usually deleted from NIPA controls before the data from the major data sources were scaled to sum to those NIPA controls and they were added to the final demands only after the scaling.

The NIPA totals for employee compensation were coded to MRIO 122, government industry. Compensation for foreign nationals employed abroad were excluded. This compensation was included along with purchases of other services and nondurable commodities abroad, in directly allocated imports (Sector 120).

The final adjustment of national data was subtraction of some of the government industry and various material inputs and additon of an equal dollar value to MRIO 018, other construction. The amounts of each were at levels of consistent with construction input coefficients and an estimate from other parts of the MRIO project that Federal force-account construction amounted to $556 million.

In distribution to states, the FY79 data were bases for proration of national totals scaled to sum to NIPA controls in the cases of estimates for which there was representation in the FY79 data. Other state distributions used such indexes as forest and park acreage for timber sales and park usage fees, locations supplied by DOE for nuclear enrichment services, outputs of agricultural commodities for CCC purchases, armed forces employment for imputed sales of food and clothing in place of payments in kind, Federal employment and payroll data for government industry, and imports for items purchased abroad. A small amount of net Federal purchases was left unallocated to states.

State and Local Government Purchases of Goods and Services

Nearly all data used to estimate state and local government purchases of goods and services come from a Census tape prepared from the 1977 Census of Governments (Source 03110), and a BEA worksheet from the 1972 interindustry study that detailed the input requirements per unit of activity for a large number of state and local government functions.

The Census tape provided expenditures for each of many functions that were classified by major object class and that distinguished between current and capital account expenditures. Also included were offsetting receipts for services rendered, major items of which included receipts for sale of food and lodging at educational institutions. This tape was analyzed to eliminate expenditures that were not purchases of goods and services and to distinguish between expenditures of government enterprises and other agencies. The screened data were classified to fit the BEA vectors of input coefficients for detailed functional categories.

The next phase of the analysis applied the BEA coefficients, properly updated for price changes, to the functional expenditure data derived from the Census tape to yield purchases of MRIO commodities for each state. This assumed that the expenditure for an MRIO code per dollar of a functional class expenditure for each state in 1977 was the same, after adjusting for price changes, as the average over all states in 1972.

As in the case of Federal purchases of goods and services, there were numerous special problems not indicated in this broad outline of procedure, including adjustment for force-account construction.

2.D INTERMEDIATE TRANSACTIONS

Intermediate transactions refers to the use of commodities and services in the production of other goods and services. Thus this part of output is duplicated when output is summed across all producing sectors. This duplication is netted out in measuring Final Demand or Gross National Product since only final uses are included in this measurement.

Development of the input data followed two general approaches. For four categories of inputs — energy, real estate, noncomparable imports, and scrap — the availability of single data sources and/or data development techniques that were appropriate across almost all consuming industries led to separate development of data for these inputs. For other input categories, data development proceeded on an industry by industry basis.

The data for the intermediate transactions were developed from a number of sources, principally from the data provided on materials and services consumed by industries covered in the economic censuses, supplemented by data from the Bureau of Economic Analysis, 1972 Input-Output Table updated for relative price changes since 1972. In some cases, notably agriculture and manufacturing, 1977 data covered as much as 90 percent of the inputs at the national level. When 1977 input data were not available, the inputs were based on BEA 1972 input coefficients updated for prices to 1977. State-specific data on detailed inputs are severely limited but the national data were imputed to states in great sector detail, usually the four-digit SIC. For example, the data for the agricultural sectors were developed mostly from the 1978 Census of Agriculture, adjusted to reflect 1977 production and 1977 prices. These data were generally available at the state level. Most of the other inputs were from 1977 data only available at the national level, and not completely identified by specific product sector.

The inputs to the mining industries are developed mainly from materials and fuels consumption data reported in the 1977 Census of Mineral Industries. Except for fuels, these data are generally not available at the state level and it was necessary to impute

the data to states based on cost of materials totals for each sector in each state. The remaining inputs were estimated based on price-updated coefficients from the BEA 1972 Input-Output Tables.

The inputs to the construction sectors are based almost entirely on price-updated coefficients from the BEA 1972 Input-Output Table, except for inputs of fuels from the 1977 Census of Construction Industries, and inputs to highway construction available from the Federal Highway Administration. These inputs were available for approximately 50 new and maintenance construction activities in the BEA table, and were imputed to states based on output detail for 37 new construction activities, and 37 maintenance constrution activities, as developed from the 1977 Census of Construction Industries.

Inputs to the manufacturing sectors are derived for the most part from the materials consumed data collected in the 1977 Census of Manufactures. These data account for over 80 percent of materials consumed in manufacturing sectors on the average (excluding fuels) and are tabulated for each SIC four-digit industry at the national level. These data have been imputed to the state level based on four-digit industry output for each state. Data on inputs of fuels and electric energy were obtained by state in SIC three-digit industry detail from the 1977 Census of Manufactures. With a few exceptions the remaining inputs to manufacturing sectors were estimated by applying coefficients from the BEA 1972 input-output table, updated to reflect relative price changes between the output of the industry and each input over the period 1972-77. These coefficients were applied to state output data in approximately SIC four-digit detail, and the results were aggregated to the MRIO codes for each state.

Fuel and electric energy inputs for the transportation, communications, utilities, trade, finance and service sectors were based mainly on 1977 data from a number of diverse sources. Selected other inputs, for example, maintenance and repair parts for transportation, were available for these sectors from sundry sources. However, for the most part, the other inputs to these sectors were based on the price-updated coefficients from the BEA 1972 Input-output Table. These coefficients were applied to state output levels in the sector detail of the 496-sector BEA table, thus providing state weights for these coefficients in the most detail possible. The input data so derived at the state level were then aggregated to the MRIO codes.

CHAPTER 3

INTERREGIONAL TRADE FLOWS

Interregional trade flows of commodities and services are the links among the state economies, representing the "purchases" of each state from each state to satisfy its consumption of each commodity and service. The trade flow matrix is similar to a "make" matrix in the sense that it shows the state of origin of the commodities and services consumed in each state, including commodities and services produced and consumed in the same state. It is important to note that the flows are not shown separately for each consuming industry; instead they are "pooled" in the sense that the flows reflect the origin of the aggregate supply only of each commodity and service consumed in each state.

The commodity flows are fairly straightforward, representing physical movements of commodities by the various transportation modes (although the data have serious gaps in coverage, especially for the trucking mode). The service flows are less obvious, are much more difficult to quantify, and involve conceptual problems of measurement. For example, in the case of interstate flows of transportation services, the state location of the "production" of these services is difficult to define. The objective is to identify the output by the location where inputs are supplied; this is conceptually difficult since inputs may be obtained along a transportation route, not necessarily in fixed proportions. Similar difficulties are associated with other services, e.g., financial services, in cases where the location of the facility that collects the receipts for the service is not necessarily the location in which the service is rendered. The objective of the development of the service flows described in this chapter has been to reduce the distortion in the model results (in terms of impacts on supplying industries and labor) over that of more arbitrary methods.

3.A COMMODITY FLOWS

The commodity flow data represents shipments of commodities between the states as well as intra-state shipments of these commodities. The shipments into each state are "pooled" with the amount produced in each state that is also consumed in the state, for distribution to each consuming sector. These flows in and out of each state act to balance supply of the commodity in each state with consumption in each state.

The principal sources of the commodity flow data are:

1. Commodity Transportation Survey (CTS), Census of Transportation, 1977. This source provides data on state-to-state shipments for each transportation mode for shipments by manufacturing establishments in three-digit Transportation Commodity Code (TCC) which is closely equivalent to SIC codes. Tonnage and value of shipments are given but no data on transport revenues are given. Modal detail represents the primary mode of transport for each shipment. Separate data are given for commercial and private truck shipments. These data are based on a scientific sample and inflated to represent the universe of such shipments.

2. Rail Waybill Sample data collected by the Federal Rail Administration for 1977. These data represent a one-percent sample of carload waybills for rail freight which were aggregated to MRIO commodity codes and state origins and destinations. Tonnage and transport revenues are given for each shipment but no data on the value of the commodities shipped are given.

3. Waterborne Commerce data collected by the Corp of Engineers, U.S. Department of the Army, 1977. These data represent a near 100 percent sample of waterborne shipments by both commercial and private carriers, with the commodity detail aggregated to MRIO codes, and the port-to-port origins and destinations aggregated to state-to-state origins and destinations. Only tonnage data are provided.

4. Selected surveys of grain shipments and fruits and vegetable shipments sponsored by the U.S.D.A.

The CTS data were utilized for all shipments of manufactured products for transport modes except water for which the Waterborne Commerce data were utilized, and rail, for which the Rail Waybill Sample data were used. For non-manufactured commodities, the rail Waybill Sample data were used for rail shipments, the Waterborne Commerce data for shipments by water, the U.S.D.A. data for shipments of agricultural products by truck, and U.S. Department of Energy data for shipments of coal by truck and for shipments of crude petroleum by pipeline.

The only important gaps in the above data are shipments of other agricultural products by truck (e.g., livestock), other mineral products by truck (e.g., ores of all types, and sand and gravel), and shipments of imported manufactured products by truck. These shipments are estimated in the final balancing of the table since there is no central data source for these truck shipments in the commodity detail required.

3.B SERVICE FLOWS

The service sectors broadly defined include all sectors that do not produce tangible products or commodities. As such they include the trade, finance, insurance, real estate, business services, personal services, medical and health, education, freight transportation, passenger transportation, and other miscellaneous service activities. The utility sectors (electric energy, gas utilities and water and sanitation) are also grouped with the service sectors for purposes of exposition. The treatment of the service sector inter-state flows are described under separate headings below that distinguish the methods used in developing the flows for different sectors.

Freight Transportation

Common Elements of the Methodology

A first step in all freight service analysis was estimation of the portion of the total output (revenue) that can be geographically located at origins and destinations. Any remaining output (revenue) was distributed, again with the national mix, along routes between origin and destination, with the fraction along any portion of the route proportional to the distance.

Since output (total revenues) for each transportation mode was originally allocated to states based on the distribution of payroll, the allocation of revenues (generated by movements on each state-to-state link) to each state as described above did not necessarily equal to the state controls for output (revenues). Imbalances in each state were eliminated by creating service flows among contiguous or nearby states so as to eliminate surpluses and deficits in each state. This procedure is the same as the final step in balancing commodity flows and is described in Chapter 4, Data Quality.

MRIO 085: Railroads

As part of the work of estimating interstate commodity flows and associated margins on a national basis, regressions were calculated for each commodity having the form

$R/T = a + bD$, where

R is revenue; T, tons; D, distance; and a and b, constants calculated in the regression. These equations could be multiplied by T to yield

$R = aT + bDT$, implying

that the revenue requirement for each origin and destination pair could be distributed between two components: a first component involving only the amount shipped, and a second component that is related also to distance. For each commodity flow, therefore, an estimate could be made for a component that was not distance-related and for a component that was. The former was tentatively associated with costs at originating and destinating states in a 60:40 ratio; the latter was considered to be associated with states of all regions on the route, including the states of origin and destination.

There are often a variety of rail routes that can be used between an origin and a destination. If, however, the routes are defined in terms of fairly large regions that have to be crossed, the number of practical routes declines sharply.

The distribution to a region along a route was proportional to the distance across that region as compared with the total distance between the states of origin and destination. This left the problem only of distributing costs among states within a region, and the procedure used here was to distribute in proportion to the payrolls estimated in other tasks.

Exhibit 3-1 and 3-2 define each region. Regional boundaries were drawn to keep down the number of alternative routings, to make the distance across a region relatively insensitive to the direction of the crossing, and to keep down the number of states across which to prorate costs in proportion to payrolls. Alaska and Hawaii are excluded as not reached by rail or motor transportation from other states.

Exhibit 3-3 shows the regional routings assumed for all interregional shipments. It may be noted that comparatively few alternative routings were considered. Alternative

EXHIBIT 3-1:

RAIL REGIONS

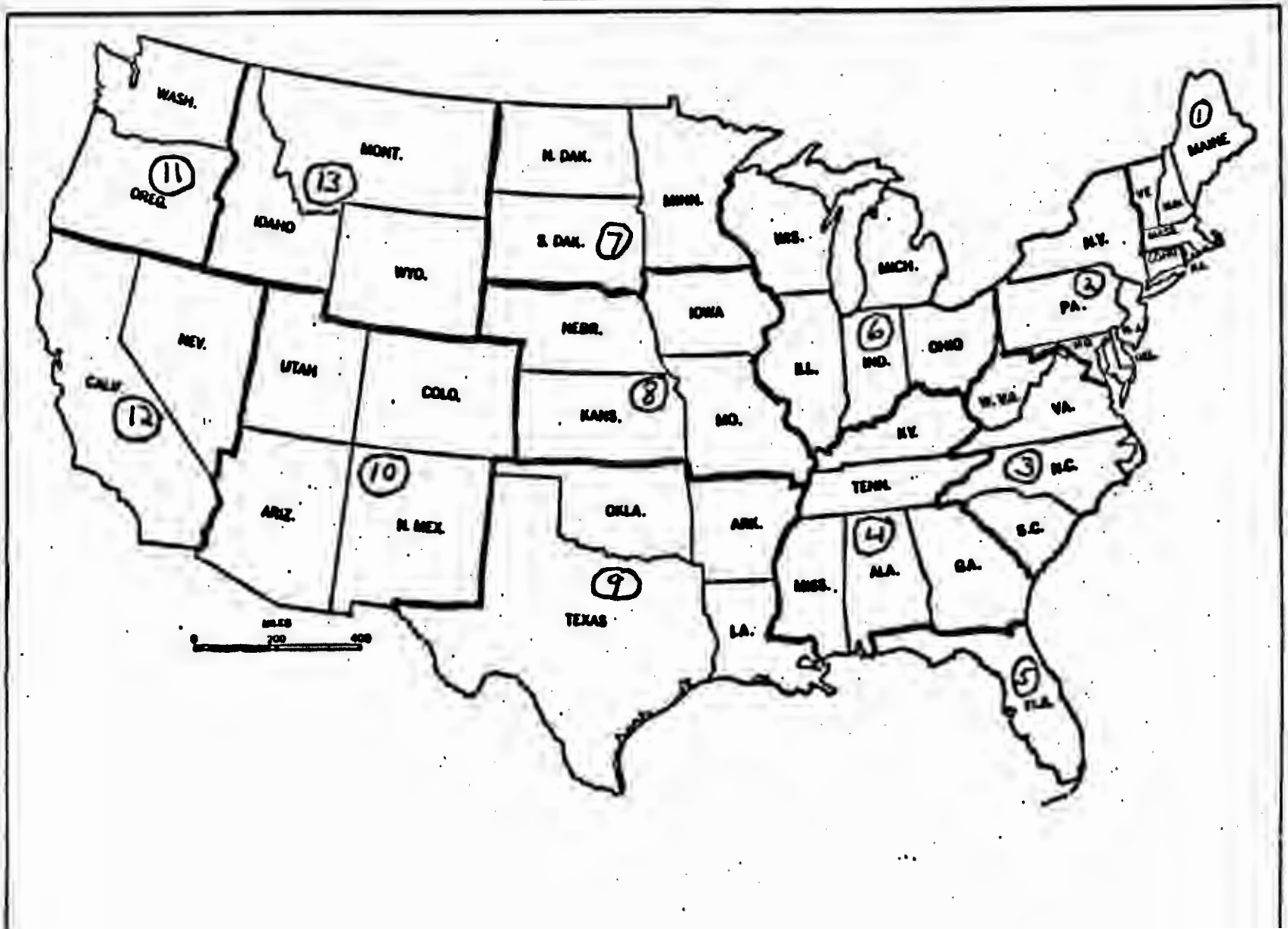


EXHIBIT 3-2:
STATES IN EACH RAIL REGION

1. Maine, New Hampshire, Vermont, Massachusetts, Rhode Island
2. New York, Connecticut, Delaware, Maryland, Pennsylvania, District of Columbia
3. Virginia, West Virginia, North Carolina, South Carolina
4. Mississippi, Alabama, Georgia, Kentucky, Tennessee
5. Florida
6. Michigan, Wisconsin, Illinois, Indiana, Ohio
7. Idaho, Montana, Wyoming, North Dakota, South Dakota, Minnesota
8. Nebraska, Iowa, Kansas, Missouri
9. Oklahoma, Texas, Arkansas, Louisiana
10. Utah, Colorado, Arizona, New Mexico
11. Washington, Oregon
12. California, Nevada
13. Montana, Idaho, Wyoming

EXHIBIT 3-3:
RAILROAD ROUTINGS BETWEEN REGIONS

O & D	Routing	O & D	Routing
1-2	1, 2		
1-3	1, 2, 3	2-3	2, 3
1-4	1, 2, 3, 4	2-4	2, 3, 4
1-5	1, 2, 3, 5	2-5	2, 3, 5
1-6	1, 2, 6	2-6	2, 6
1-7	1, 2, 6, 7	2-7	2, 6, 7
1-8	1, 2, 6, 8	2-8	2, 6, 8
1-9	1, 2, 3, 4, 9	2-9	2, 3, 4, 9
1-10	1, 2, 6, 8, 10	2-10	2, 6, 8, 10
1-11	1, 2, 6, 7, 11	2-11	2, 6, 7, 13, 11
1-12	1, 2, 6, 8, 10, 13, 12	2-12	2, 6, 8, 10, 13, 12
1-13	1, 2, 6, 8, 10, 13	2-13	2, 6, 8, 10, 13
3-4	3, 4		
3-5	3, 5	4-5	4, 5
3-6	3, 6	4-6	4, 6
3-7	3, 6, 7	4-7	4, 6, 7 or 4, 8, 7
3-8	3, 4, 8 or 3, 6, 8	4-8	4, 8
3-9	3, 4, 9	4-9	4, 9
3-10	3, 4, 9, 10 or 3, 6, 8, 10	4-10	4, 9, 10 or 4, 8, 10
3-11	3, 6, 7, 13, 11	4-11	4, 6, 7, 13, 11
3-12	3, 6, 8, 10, 12 or 3, 4, 9, 10, 12	4-11	4, 8, 10, 11 or 4, 9, 10, 12
3-13	3, 6, 7, 13	4-13	4, 6, 7, 13 or 4, 8, 13
3-6	5, 4, 6		
5-7	5, 4, 6, 7	6-7	6, 7
5-8	5, 4, 8	6-8	6, 8
5-9	5, 4, 9	6-9	6, 8, 9
5-10	5, 4, 9, 10	6-10	6, 8, 10
5-11	5, 4, 6, 7, 13, 11	6-11	6, 7, 13, 11
5-12	5, 4, 9, 10, 12	6-12	6, 8, 10, 12
5-13	5, 4, 6, 7, 13 or 5, 4, 8, 13	6-13	6, 7, 13

EXHIBIT 3-3:
RAILROAD ROUTINGS BETWEEN REGIONS (cont.)

O & D	Routing	O & D	Routing
7-8	7, 8		
7-9	7, 8, 9	8-9	8, 9
7-10	7, 10	8-10	8, 10
7-11	7, 13, 11	8-11	8, 7, 13, 11
7-12	7, 10, 12	8-12	8, 10, 12
7-13	7, 13	8-13	8, 13
9-10	9, 10		
9-11	9, 10, 13, 11 or 9, 8, 13, 11	10-11	10, 13, 11
9-12	9, 10, 12	10-12	10, 12
9-13	9, 10, 13	10-13	10, 13
11-12	11, 12		
11-13	11, 13	12-13	12, 13

routes were weighted in the analysis in proportion to the relative outputs of the regions that were unique to each route.

Exhibit 3-4 has the assumed distance across each region. Where the origin and destination were for different states in the same region, it was assumed uniformly that the distance was one-half of the full crossing distance. The assumed distances were the same for all commodities.

The distances between each state of origin and each state of destination, including distances for intrastate shipments were calculated as total ton-miles across all commodities divided by total tons. The ton-miles and tons were those of the MRIO task that measured revenue per ton as a function of distance.

Surpluses and deficits between allocated revenues and revenue controls by state were eliminated in the final balancing procedure (Chapter 4).

MRIO 087: Motor Freight

Motor freight differs from rail transportation in that, except for fuel and tolls, there is little cost along the route of a trip. The costs are primarily where the crews and rolling stock are based, which is likely to be where there are many origins and destinations, but not necessarily at each origin and destination.

The procedure assumed that all revenue (costs) were at origins and destination in a 60:40 ratio. Surpluses and deficits between allocated revenues and revenue controls by state were eliminated in the final balancing procedure (Chapter 4).

MRIO 088: Water Transportation

The water transportation industry is an aggregation of operations that are very different with respect to the kind of treatment of service flows that would be correct in principle even if all desired data were available. Most of the business is along rivers and canals and has characteristics for present purposes that are much like railroad freight transportation. Tugs pull or push barges, with barges leaving or joining the "train" along the routes as freight cars join or leave a locomotive along a railroad route. Transportation along the Great Lakes and along the coasts is by cargo ships that

EXHIBIT 3-4:
DISTANCES ACROSS RAIL REGIONS

Region	Direct Miles
1	126
2	379
3	537
4	537
5	379
6	600
7	632
8	600
9	695
10	632
11	505
12	379
13	411

operate entirely differently and with different input mix for what is required by tug and barge "trains." There is little basis for distinguishing between costs that are distance-related and costs that are not, for either category of water transportation, and it is not clear that a great deal of the distance-related cost uses inputs between origin and destination in states other than the origin and destination.

Nevertheless, it was not necessary to make full use of the last-resort approach of assuming that each state requiring water transportation buys from all other states in proportion to outputs of these other states. Even if not all of the inputs are at origins and destinations, a large fraction of them are, and inputs that are elsewhere are limited in where they are likely to be. The procedure assumed that all costs are at origins and destinations in a 60:40 ratio. Surpluses and deficits between allocated revenues and revenue controls by state were eliminated in the final balancing procedure (Chapter 4).

MRIO 089: Air Transportation

Air freight transportation, even including mail and express, is of comparatively minor importance both in total transportation margins and in air transportation revenues. Moreover, there are problems of defining inputs to freight revenue service in a useful way, because a large part of the cargo of aircraft is carried on passenger flights for which variations in amount of cargo have negligible impact on costs.

Under these circumstances, no major effort at tracing impacts of air transportation requirements to air transportation operations in particular states seemed justified. A major portion of the activity is clearly associated more with origins and destinations than elsewhere. Airplanes must be serviced at each landing, and crews and maintenance centers are more likely to be based where there are many arrivals and departures than where there are few. Therefore, the estimates of input requirements assumed that all requirements for inputs were at origins and destinations and, as for other transportation modes, in a 60:40 ratio. There was no balancing because the transportation output controls include passenger transportation, which is of dominating importance. The balancing of requirements against supply was done in the passenger transportation analysis.

MRIO 090: Pipelines, Except Natural Gas

Pipelines have the bulk of their activity in the petroleum producing states, although some activity is needed at destinations and to maintain pumping stations along the routes. The output controls for the MRIO project suggest that the petroleum producing states have about two-thirds of the output of the industry.

The procedure for distributing requirements among states was to assume that all of the revenue for margin payments by a state using petroleum or petroleum products by pipeline was in states of origin and destination in a 70:30 ratio. Surpluses and deficits between allocated revenues and revenue controls by state were eliminated in the final balancing procedure (Chapter 4).

Service Sectors

There is a large group of service sectors for which inter-state sales are not available. For these sectors, varying percentages of output were assumed to be sold to residents or businesses in other states, and similarly, that varying percentages of the consumption of these services in each state were supplied from other states. For this purpose part of the output of each sector in each state was relocated to a natural clearinghouse activity (NCH), designated as state 53 for computational purposes. Similarly, part of the consumption in each state was drawn from the NCH. The amounts of these trade flows were determined as described below.

National Clearinghouse (53rd State)

This procedure was used when the services are national in nature, i.e., they are widely distributed among the states from a given source state and distance is not a major factor in limiting the service area. This procedure also applies to services rendered to tourists who may come from any other state.

The procedure is designed to insure a minimum of service flows into and out of the state regardless of the ratio of $\frac{\text{production (P)}}{\text{consumption (C)}}$ in each state. When $P \geq C$, a constant proportion of state consumption is satisfied by state production and a constant proportion is imported. When $P \leq C$, a constant proportion of production is exported and a constant proportion is consumed in the state. Conversely, when $P > C$ an

increasing share of production is exported as P increases relative to C, and when $P \leq C$, an increasing share of consumption is supplied by P as P increases relative to C.

The procedure works as follows. Trade to and from the 53rd state is calculated as:

For $P > C$, $E = P - aC$; $I = (1-a)C$

For $P \leq C$, $E = (1-a)P$; $I = C - aP$

where

E = exports to 53rd state

I = imports from 53rd state

P = state output

C = state consumption

The value of the coefficient (a) will vary over the different services depending upon the extent of interstate trade in each service. The value of the coefficient for each service is given in Exhibit 3-5.

Other Service Sectors

Special treatment of a few sectors is discussed in this section.

Maintenance Construction

The output measures of maintenance construction were originally allocated to the states where the work was performed based on incomplete data in the Census of Construction. Inherent errors in this procedure, and in the estimates of consumption, caused relatively small imbalances in most states, with sizeable imbalances only in New York, Pennsylvania, Illinois and California. It was decided to balance surpluses and deficits among all states using the final balancing procedure described in Chapter 4 that effects balances among contiguous or nearby states as far as possible.

Other Construction Sectors

The methods of estimating consumption of the output of each construction sector by state insured that output and consumption would be in balance except for minor statistical differences that were balanced in the final balancing procedure described in Chapter 4.

EXHIBIT 3-5:

TRADE THROUGH THE NATIONAL CLEARINGHOUSE: COEFFICIENT VALUES

MRIO	086	Local Transit	0.20
MRIO	089	Air Transportation	0.50
MRIO	091	Transportation Services	0.30
MRIO	092	Communications	0.40
MRIO	093	Radio & Television Broadcasting	0.40
MRIO	098	Eating & Drinking Places	0.10
MRIO	099	General Merchandise Stores	0.05
MRIO	100	Food, Drug, Liquor Stores	0.05
MRIO	101	Auto, Dealers, Gas Station	0.05
MRIO	102	Other Retail Stores	0.05
MRIO	103	Banking, Credit Agencies	0.30
MRIO	104	Insurance	0.30
MRIO	105	Real Estate	0.30
MRIO	106	Hotels	0.20
MRIO	107	Personal, Repair Services	0.10
MRIO	108	Miscellaneous Services & Advertising	0.20
MRIO	109	Miscellaneous Professional Services	0.10
MRIO	110	Auto Rental, Repair	0.10
MRIO	111	Amusements	0.15
MRIO	112	Doctors, Dentists	0.05
MRIO	113	Hospitals	0.10
MRIO	114	Other Health Services	0.10
MRIO	115	Educational Services	0.20
MRIO	116	Nonprofit Organizations	0.20
MRIO	118	Federal Government Enterprises	0.25

Electric Utilities

Imbalances between production and consumption by state for electric utilities were eliminated by introducing flows with contiguous or closely states within the same regional power grid.

Gas Utilities

The gas utilities sector includes the interstate pipelines in addition to local utility gas distribution. Imports of gas from Canada and Mexico were not assigned to specific states due to lack of data but, instead, were assigned to the International Clearinghouse sector (ICH — state 52). Deficits between supply and consumption in each state were filled from the ICH and from surpluses which existed in a number of states. The balancing was achieved using the final balancing procedure (described in Chapter 4) which involves balancing net deficits states with flows from nearby surplus states as far as possible.

Water and Sanitary Services

Differences between production and consumption by state were assumed to be due to errors in the consumption measures and the consumption measures were adjusted accordingly.

CHAPTER 4

DATA QUALITY

This chapter is presented in six sections. Sections A through E present an overview of the quality of the estimates contained in the MRIO accounts by component: (A) Output, Employment and Payroll, (B) Value Added, (C) Final Demand, (D) Intermediate Transactions and (E) Interregional Flows. More detailed information on data quality by sector may be found in the separate reports available on each major data component (see Chapter 1). Section 4.F provides a summary of the balancing techniques used to adjust the accounts at both the national and state levels.

4.A OUTPUT, EMPLOYMENT AND PAYROLL

Output, employment and payroll estimates for all sectors except agriculture, construction and real estate were developed on an establishment basis from data contained in the quiquennial efforts of the Bureau of Census wherever available. As such, the bulk of the estimates of output, employment and payroll represent the best available measure of industry-by-state activity at the establishment level. Even for sectors not covered by Census, it was possible to estimate state level employment and payroll from other comprehensive data sets so that these estimates may be considered highly reliable throughout all sectors. Where industries were covered by Census but contained gaps due to suppression rules, estimates of the suppressed cells were made using a number of techniques, depending on the severity of the suppression, and final scaling was utilized to re-establish the appropriate control total from more aggregated Census data.

Activity-Based Sectors

For meaningful inclusion in the MRIO accounts, it was necessary to restructure sectors involved in agriculture (Sectors 001-006), construction (Sectors 104-019) and real estate and rental (Sector 105) to an activity basis. To a limited extent, the activity-based nature of these sectors weakened (relatively) the requisite data development, as follows:

- Employment in agriculture Sectors 001-004 was imputed from the 1978 Census of Agriculture (Source 03109) and total 1977 dollars of hired farm

labor from the USDA's Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1979 (Source 02111). These data were establishment-based and were imputed to a product basis (other agriculture data were available from reliable sources on a product basis).

- Construction estimates were derived from the 1977 Census of Construction Industries (establishment-based, Source 03104) in combination with the 1977 "Value of New Construction Put in Place" (product-based, Source 03122). To the extent that these data sources did not completely match in coverage imputations were required and the reliability of estimates was somewhat weakened.

- Real estate and rental output has two components: (1) financial flows (activity-based for rental payments by all sectors) and (2) the sales and management function of the real estate industry (establishment-based). Only national controls were available for the first component (rental payments). Though these rental activities (actual and imputed) were allocated to states based on the best available data, some error may be expected at the state level.

Though coverage for most establishment-based sectors were included in the censuses of wholesale trade, retail trade, services, mineral industries, manufactures and governments, it was necessary to estimate the output, employment and payroll of some sectors from non-Census sources. The quality of these data vary with the specific sources noted in Chapter 2. A complete discussion of the data quality limitation can be found in JFA's previous report State Estimates of Outputs, Employment and Payrolls, 1977 (the last sections of each of Chapter 2-24 discuss limitations of data on a sector-by-sector basis). Notable data limitations are described below.

While the national output for transportation sectors were, for the most part, available from quality data sources, consistent and reliable measures of state output for transportation are not available. In the MRIO, modal transportation sectors were allocated to states based on the assignment of transportation margins to commodity flows while transportation service sector outputs were distributed based on payroll/employment. The resultant quality of these estimates at the state level may thus be considered less reliable than other output measures within the model.

Output, employment and payroll data for communications sectors were not available from Census. These estimates were developed from the sources noted in Chapter 2 which suffered some limitations in coverage and state detail.

In utility sectors (gas, electricity, water, sanitary services), data were for the most part collected from non-Census but highly reliable sources. Some imputations were required, however, for small establishments and for splitting the output of combination utilities. It was also necessary to impute state output based on employment measures for some services, particularly private steam, irrigation and water services.

In trade sectors, whereas data were available on state sales by kind of business, no data were available at the state level on the margin of these sales (output of trade sectors is measured on a margin basis in the MRIO). State output was, therefore, controlled to margin data available at the national level imputed to the states based on sales. Since to some extent trade margins may be expected to vary across states and since the margin assignment procedure was less than exact, state-level outputs of margin sectors are not highly reliable. The state level margin totals, however, are controlled to reliable data at the national level.

Data on finance, insurance and real estate services were not available from Census. These estimates were based on the many sources noted in Chapter 2 and while adequate national controls were utilized, the state level measures of output are subject to considerable error (distribution of output based on employment was frequently required).

For the most part, data development for the remaining service sectors were based on Census data. In a few instances, notably religious-type services (organizations and schools), the estimates were not available from Census and were estimated based on supplementary data sources. State level estimates for government enterprises other than the postal service were developed based on employment, but the total output of these enterprises is small in comparison with the postal service.

4.B VALUE-ADDED

As the data development section describes, the value added estimates for MRIO relied heavily on imputations. Except in the manufacturing and mining sectors, little primary data on value added components at the level of individual state MRIO sectors were available. Therefore quantitative estimates of confidence intervals are not possible for most of the estimates; however, some qualitative assessments of data quality, as follow, can be made.

Although many of the value added estimates at the state-by-sector level have considerable uncertainty, most of the estimates are reliable at some intermediate level of aggregation. For example, state totals for components of indirect busines taxes and business transfer payments (IBT + BTP), and for supplements to wages and salaries, are derived directly from primary data sources, and are considered to be reliable; and sums of value added components across all construction sectors within a state are based closely on Census data and are therefore more reliable than individual construction sector estimates, which are rendered uncertain by the transformation from Census SIC data to MRIO activity-based sector estimates.

As a final general observation, it should be noted that the MRIO value added estimates depend closely on the estimates of output, employment, and payroll for state-level MRIO sectors developed as described in Section 2.A, and any errors in that data will be reflected in the value added estimates. Ratios of value added components to other quantities (e.g. supplements/payroll, PTI/output) are less dependent on the output, employment, and payroll estimates; but in those cases where state-level control totals were distributed across a group of sectors (as with supplements, IBT, and construction total value added) a large error in the output, employment, or payroll estimate for a single sector could significantly bias the value added estimates in all other sectors in that group and state.

Supplements to Wages and Salaries

Considering all MRIO sectors, supplements are the most reliable of the value added component estimates. Primary data were available for state-level supplements in manufacturing, construction, farms, and all sectors in total, and for U.S. average

supplements-to-wages ratios for 46 NIPA non-manufacturing sectors, all by two components of supplements: required and voluntary. Because of the amount of information available, ratios of supplements to wages and salaries for all the state-level MRIO sectors are believed to be fairly precise.

Indirect Business Taxes and Business Transfer Payments

State-level totals for the business property taxes, license fees (three categories) and severence taxes components of IBT + BTP are fairly reliable, but the allocations to state-level MRIO sectors are uncertain. In general, NIPA U.S.-level ratios of IBT + BTP components to output, in GPO 68-sector detail, were the basis of the sector allocations. NIPA's sector allocations are themselves based on extensive imputations employing distributions developed in special studies from data of various vintages, and are not regarded of publishable quality by BEA.

Property - Type Income and Total Value Added

Property type income in the non-farm sectors was computed by one of two methods: as a residual (value added less employee compensation less (IBT + BTP)) in the mining, construction, and manufacturing sectors, for which total value added data were available from the Censuses; or by allocating U.S. sector-total PTI to states proportionally to output, in all other non-farm sectors.

The MRIO estimates of total value added are most reliable in those sectors for which state-level Census value added data were available, but the necessity of deducting estimates of purchased services from the Census totals introduces uncertainty in these estimates. Since PTI in these sectors was computed as a residual, the ratios PTI/output and PTI/(value added) are highly variable across states in some sectors. These variations probably exaggerate the true stable variation in industy structure and the capital share across states.

In the sectors for which state-level total value added data were unavailable and U.S. PTI was allocated proportionally to output, the opposite problem prevails: obviously there is no state-to-state variation in the PTI/output ratio, and the estimates contain little information about true state-level variation in the capital share.

4.C FINAL DEMANDS

NIPA Control Totals as Bases for Error Limitation

By definition, a NIPA control total limits the error for the aggregate controlled by it to the error in the NIPA account. Where the NIPA account controls a single MRIO at the national level, no further error analysis of that MRIO is needed. As the number of MRIO codes controlled by a NIPA account increases, its ability to control errors in individual MRIO codes declines, although the amount of underestimation of any single MRIO code is limited by the control total, and this limitation can be important if the MRIO code value is a large fraction of the value of the aggregate that is controlled. NIPA controls do nothing for state distribution of a final demand.

It is plausible to expect that the less the amount of scaling required to make the elements of an aggregate sum to a control total, the less is the amount of error in individual elements of the aggregate, provided that the estimation procedure before scaling is independent of the control total. With large errors in the individual elements of the aggregate, it would be a remarkable coincidence for all of the errors to sum algebraically to something very near zero, as would be implied by no need to scale for equality of the aggregate estimate with the control total. Where the scale factors have been preserved in the analysis, factors approximating unity are indications of relatively high accuracy.

Accuracy of MRIO Estimates at the National Level

The PCE estimates are quite reliable at the national level. Many are equal to NIPA control totals, and few are included in sets of large numbers of MRIO values controlled to a single NIPA account or aggregate of accounts. The commodity estimates had somewhat bigger aggregations to be controlled by NIPA accounts than did the service estimates, and the commodity estimates suffered from heavier reliance on 1972 patterns of consumer expenditure than did the services. It is not implausible, however, to expect some continuity in patterns of consumer expenditure. Moreover, the scale factors needed to make the individual MRIO values of an aggregate sum to the control total were always very near unity. This test was biased, however, in many cases by the estimation of some elements as adjusted (for price change) values of 1972 purchases

times the ratio of 1977 to 1972 values of the PCE accounts controlling the aggregates to which those elements belong.

The national estimates for gross capital formation had fairly narrow NIPA controls, so that the final estimates should tend to be good.

The national estimates of inventory change are good for producer inventories, since they come directly from Census and other hard data, much weaker for wholesale and retail trade, and nonexistent as part of the final demand research for all but strong estimates for coal and oil inventory change of electric utilities and inventories of mineral ores held by users.

The national estimates for commodity exports and imports are all strong numbers taken directly from Census tabulations of values of goods passing through customs check points. The service data are less reliable.

National estimates of Federal government purchases of goods and services suffer both from difficulties of matching NIPA control totals to MRIO codes and from weakness of the data used to derive the purchases before scaling to control totals. The purchases of manufactured products are the best estimates derived from the major sources, because they are derived from Census data coded for compatibility with MRIO codes. The Census data, however, are a subject to considerable sampling error and required considerable adjustment, with more errors so introduced, before they were conceptually the numbers needed for analysis. Within the category of manufactured products, the estimates for non-defense are subject to larger errors than each of total or military, because they are residuals in subtraction of the military purchases from total purchases.

The national estimates for service MRIO codes derived from the contract award data are the weakest, especially for non-defense, which involves contract award patterns two years later than the calendar year of interest. The basic problem of contract awards is that they tend to precede the economic acitivity by unknown lengths of time. Contract awards may greatly exceed the amount of service provided in some years and fall far short in others.

The data obtained directly from government agencies (e.g., commodity inventory accumulations of CCC, capital expenditures of TVA, production of enriched uranium, etc.) are fairly solid.

The state and local government purchases have only broad NIPA control totals, but the object classes provided by the Census data are good substitutes. The detail within those aggregates provided by the BEA input coefficients for state and local government functions may have been rather questionable even in 1972, and they are no stronger for 1977.

State Distributions

The state distributions are generally much weaker than the national estimates of final demand, but some of the state distributions have a great deal of justification.

Much of the PCE distribution is based in a fairly reliable way on retail sales of goods and services for roughly comparable kinds of products. PCE categories involving housing, public utility, and insurance services are derived in a quite straightforward way from statistics by state of those very services. The MRIO codes distributed by income or population may be fair as estimates of the actual distribution, but they do not permit use of the data for later research on how consumption is related to income and population. We have assumed proportionally.

The state distribution of private fixed capital formation is generally weak. The procedure generally involves estimating aggregate capital expenditure, sometimes just construction expenditure, of individual industries of a state, and then using rough estimates, generally based on 1972 mixes, of the relative importances of particular kinds of equipment and construction. These relative importances are unlikely to be very stable.

The state distribution of inventory change used essentially the same data as were used for the national estimates, since much of the national data were broken down in the original sources by state, so that the state distribution was only slightly weaker than the national estimates.

For foreign trade, state distribution was defined as the states of entry of imports and exit of exports from and to the United States. There was no attempt to identify ultimate users of imports or original sources of exports. Within the framework of the state identification attempted, the results should be considered quite accurate.

For Federal purchases of goods and services, state distribution was defined as states where the goods and services were produced. In general, the estimates should be fair, even though most of the 1977 distribution among states is based on FY79 patterns. A weakness for some commodities is the fact that the supply state may be that of a wholesaler, so that a wrong indication is given as to where manufacturing income and employment are generated. Major items of procurement, though, are ordinarily bought directly from manufacturers. A weakness for these major items, however, is that the sources of supply can change drastically over a few years. One airplane may be bought in California, another in Georgia. Current contract awards may be distributed differently from current shipments. In any application of the MRIO model to defense purchases, the possibility of using actual shipments for individual weapon systems should be considered.

The state distributions of state and local government purchases are all strong. The national estimates are all built up from state estimates. Assuming random errors in the state estimates that partially cancel one another at the national level, the national estimates should be a little stronger, but they are based on no better data than the state estimates.

4.D INTERMEDIATE TRANSACTIONS

High quality data includes the data available for 1977 with appropriate state and industry detail. The lowest quality ranking applies to data that were adopted from an year earlier than 1977, that were not available in state detail and were not available in the appropriate industry detail. The availability of data in greater industry detail than required by the MRIO codes tended to offset to some extent the effects of not having state detail provided state output weights were available in the greater detail (based on the assumption that technological relationships of input to output were less variant across states at the finer industry detail).

In general, the data on inputs of materials is of higher quality than data on inputs of services; much more data are collected for materials usage, reporting is of higher quality since there is less ambiguity of definitions, and the larger quantities involved mean that record keeping is more nearly complete. Probably the best data are the data on fuels and electric energy consumption followed by the materials input data to agriculture, manufacturing and mining. The poorest data include inputs from service industries (such as business services, advertising, rental payments and repair work), inputs to the service industries and inputs to construction.

The input data for the agricultural sectors are considered to be of good quality even though they are imputed to products based on input data collected by farm in the 1978 Census of Agriculture (Source 03109), and aggregate data on farm usage of materials and supplies in 1977. The input data for the mining sectors is rated only fair since very little specific state data were available except for fuels and electric energy. The data were based largely on incomplete national industry data for 1977 from the Census of Mineral Industries (Source 03106) supplemented by data from the BEA 1972 Input-Output Table (adjusted to 1977 prices and for changes in production levels) which were imputed to the states based on state production weights.

The input data for the construction industries is considered to be among the poorest in quality since there are no data collection systems on materials consumed by construction activities. The development of such data from engineering plans is very tedious due to the many variations in building types and other construction projects, and represents a large effort far beyond the scope of this project. For the most part, coefficients from the BEA 1972 Input-Output Table were used (after price adjustment) to estimate the inputs. These coefficients were in extensive detail by construction activities, and were imputed to states utilizing state weights for similar detail in construction activities from the 1977 Census of Construction Industries. Unfortunately, one of the primary sources for the BEA coefficients — BLS surveys of labor and materials usage in selected construction activities undertaken during the late 1960's and early 1970's — has not been updated in recent years.

The input data for the manufacturing sectors are considered generally good. This rating is based on several reasons. First, the Census of Manufactures for 1977 has extensive coverage on materials consumed by SIC four-digit industries at the national level, with over 80 percent of materials accounted for on the coverage. These data were imputed to the state level using state cost of materials weights also at the SIC four-digit level.

Secondly, a close comparison of the coefficients developed from the 1977 data with coefficients from the BEA 1972 Input-Output Table (after adjustment for relative price changes) showed a remarkable stability in the coefficients between 1972 and 1977, with major differences explainable generally by technological trends. This provides confidence in the reporting accuracy of these data and, perhaps, of technological stability across states. Finally, the fuels and electric energy inputs are reported by state in SIC three-digit detail in the 1977 Census of Manufactures, and are of high quality.

The input data for transportation and utilities is rated good for fuels and only fair for other inputs. Data for the other service sectors is rated fair to poor since there are no comprehensive sources on materials and services consumed in these sectors. These sectors are not important consumers of materials generally and therefore the low quality of the data does not significantly affect the quality of the model results for industries producing materials, components, machinery and other products other than services. These sectors are important users of services and therefore the low quality of the data does affect the accuracy in the model results for requirements from the services industries. However, it is believed that major inputs of services are accounted for with reasonably good data or estimates and that serious distortion is not a problem.

In spite of the limitations of available data, the main flows of goods and services are represented well in the model. Data improvements can readily be introduced for sectors of especial interest in applications of the model without a rebalancing of other parts of the model. This also applies to updating of the model; specific rows of the input-output table may be updated without a rebalancing of the input columns with minimum effect on the accuracy of the model results for those sectors of principal interest. For example, JFA has performed tests in updating selected energy rows in the input-output table without rebalancing the rest of the table with results that closely approximated those of a table of later vintage that was completely balanced. Obviously this is very important in that selective data improvement and updating can be introduced in the model with a minimum of effort.

4.E INTERREGIONAL FLOWS

The data on interregional flows are among the weakest in the input-output table due to the limitations of the samples in the surveys. The data are considered reliable for major flows of materials among states but subject to considerable error for the less important flows. The weakest data are for truck shipments for which coverage is incomplete in the surveys. A significant part of the trucking flows are estimated as residuals in the final balancing of the state tables.

4.F PROCEDURES FOR NATIONAL AND STATE-LEVEL BALANCING

International Clearinghouse (ICH — State 52)

Before proceding with the national balance it was necessary to enter certain international transactions into the final demand accounts so as to reconcile with the National Income and Product (NIPA) accounts of the Department of Commerce. These are largely sales of services (e.g., insurance) to foreigners and, similarly, purchases of services from foreign sources by U.S. residents and businesses. Included also were certain commodity transactions, e.g., sales by the military to foreign governments that did not enter the export statistics, and exports and imports of scrap which were inadvertently left out of the regular import and export data. Further, foreign income received, and foreign income paid, largely in the form of investment income but including some wages and salaries, were entered as exports and imports respectively, as elements of the Rest-of-world sector. Finally, foreign tourist purchases in the U.S. are shown as a negative adjustment to total PCE purchases (in the rest-of-world row) since data were not available to adjust the individual items in PCE.

Since these international transactions could not be assigned to specific states they were entered in an International Clearinghouse (ICH) sector, labelled as the 52nd state. The imports and exports of services were allocated implicitly to states through the National Clearinghouse (NCH) sector as part of the development of state-to-state flows of services. The few transactions for commodities were allocated to states as part of the final balancing procedure described later in this chapter.

Procedures developed for balancing production and consumption in the MRIO accounts involved a two-step approach. First, a national balance was obtained for all model components, with row detail at the MRIO 124 industries level of aggregation and column detail at the BEA 494 industries level of aggregation. The columns of the balanced national use table, referred to here as the BEA-level input vectors, were then used to impute intermediate uses of goods and services for the MRIO state-level industries by weighting the BEA-level input vectors by the BEA state-level cost of materials data assembled for each state. Similar procedures were used to impute secondary production of the state MRIO industries using the balanced national by-product matrix. Finally, the state balance of production and consumption was attained by adjusting interstate trade flows to account for apparent inequality between production plus imports and consumption plus exports for each commodity. Since production data in the by-product matrix are expressed in producer value while consumption data are in purchaser value, a necessary first step for both the national and state-level balances was to add the appropriate wholesale trade and transportation margins to the production data for commodity-producing industries before comparison with consumption data. Since retail margins and sales taxes were subtracted from PCE and investment before summing the columns of final demand, these data were not directly involved in the balancing process.

National Balancing

The following preliminary data sets were available before entering the national balancing procedure:

(a) National use matrix with BEA industry columns and MRIO commodity rows, denoted by $U_{i,j}$ with $i = 1,...,124$ and $j = 1,...,494$.

(b) National by-product matrix with BEA industry columns and MRIO commodity rows, denoted by $B_{i,j}$ with i and j as in (a) above.

(c) National final demand matrix with nine columns (PCE; investment; state and local government, current and capital; Federal government, defense and non-defense; imports; exports; and inventory change) and with MRIO commodity rows, denoted by $Y_{i,j}$ with $i = 1,...,124$ and $j = 1,...,9$.

(d) National transportation margin matrix in dollars by six modes of transport for each MRIO commodity. This matrix is denoted by $M_{i,j}$ with $i = 1,...,124$ and $j = 1,...,6$, with the understanding that the service industry rows ($i = 85,...,119$ and 122, 123, and 124) contain null entries.

(e) Preliminary national wholesale trade margins by commodity (for non-service rows, as above), expressed in percentage of producer value plus transportation margins and denoted by w_i for $i = 1,...,124$, with similar restrictions on i as in (d) above.

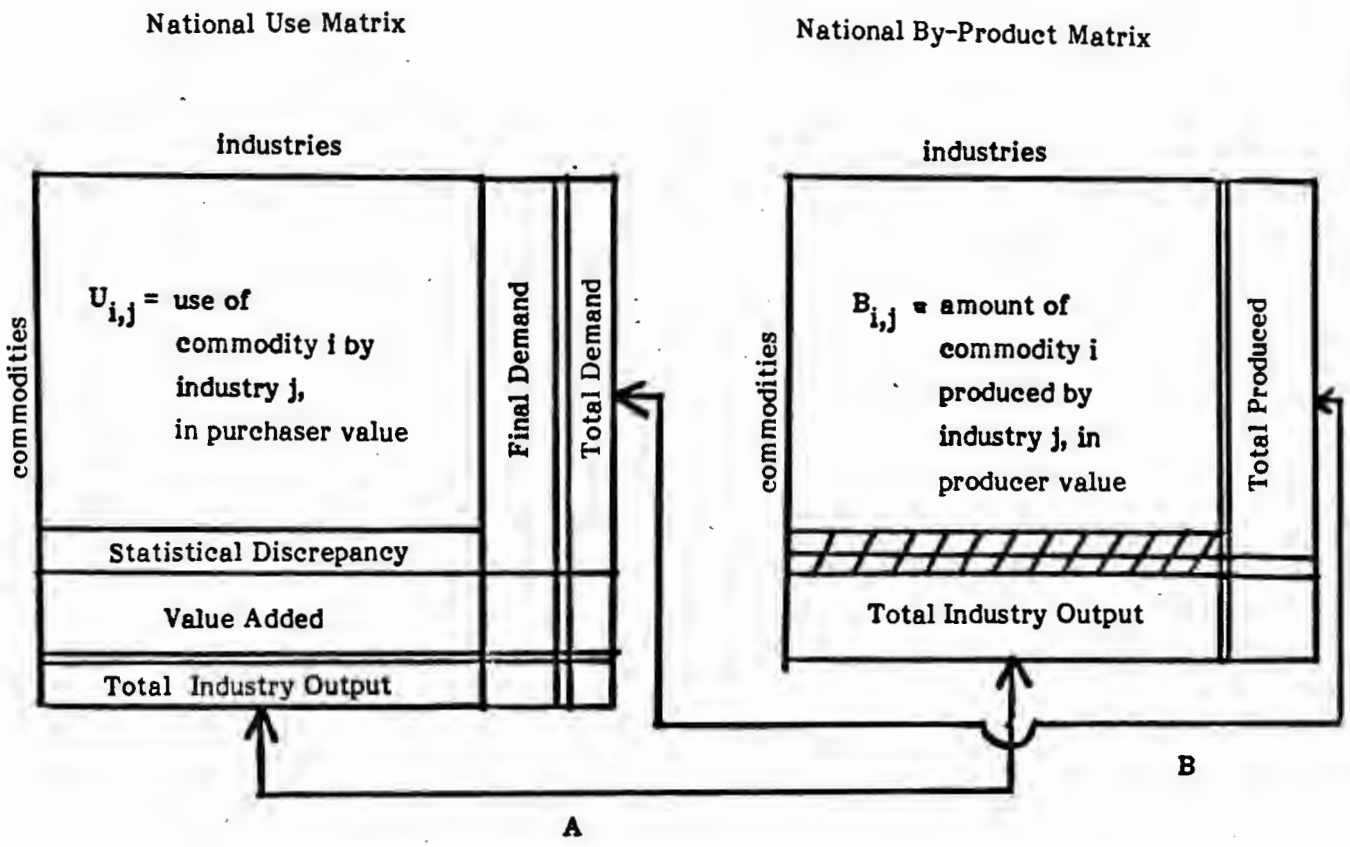
(f) National retail margins ($j = 1$) and sales taxes ($j = 2$) in dollars by MRIO commodity, denoted by $R_{i,j}$ with $i = 1,...,124$ and $j = 1,2$, and with restrictions on i as in (d) above.

The first step for obtaining a national column balance, comparison A in Exhibit 4.1, was the iterative scaling of the by-product matrix using an RAS procedure, to equal the national industry output controls, X_j, as its column sums and to equal the set of controls for output of manufactured commodities as its row sums. Since accurate data for the primary product production of manufacturing sectors were entered as the diagonal elements of the preliminary by-product matrix, these diagonal cells were held fixed during the RAS procedure. The row sums of the scaled by-product matrix resulting from the column balance step are denoted here by $B_i = \sum_j B_{i,j}$, $i = 1,...,124$, and represent the national production of each commodity in producer value. Also total transportation margins, $M_i = \sum_j M_{i,j}$, total intermediate uses, $U_i = \sum_j U_{i,j}$, and total final demand less retail margins and sales taxes, $Y_i = \sum_j Y_{i,j} - \sum_j R_{i,j}$, were calculated for each commodity, along with the cost of materials, CM_j, for each industry obtained by subtracting value-added from industry output for $j = 1,...,496$.

Procedures for National Row Balancing

The following five steps were used for achieving a national row balance (comparison B in Exhibit 4-1). The national row balance was achieved by altering either inventory change or the wholesale trade margins or by scaling the rows of the use matrix to achieve a row balance for each commodity. The resulting national use matrix and wholesale trade margins were then converted to coefficients based on cost of materials and to percentages of purchaser value respectively. These are denoted by $u^*_{i,j}$ and w^*_i.

EXHIBIT 4-1:
NATIONAL BALANCING OF USE AND BY-PRODUCT MATRICES



Comparison A = industry or "column" balance

Comparison B = commodity or "row" balance, including margins

(1) Addition of preliminary wholesale margins, and transportation margins to the producer value of national commodity production to yield national production in purchaser value, $P_i = (1 + w_i)(B_i + M_i)$

(2) Comparison of the resulting commodity production data in purchaser value to the total demand for commodity i which is the sum of intermediate uses and final demand adjusted for retail margins and sales taxes, $D_i = U_i + Y_i$.

(3a) Selective adjustment of the inventory change component of the national final demand matrix for rows which were almost in balance. Replace $Y_{i,9}$ by $Y^*_{i,9} = Y_{i,9} + (P_i - D_i)$ in row i. Hence the revised total demand is $D^*_i = U_i + Y^*_i = P_i$.

- and/or -

(3b) Selective adjustment of wholesale trade margins where relatively high quality 1977 data existed for both production and consumption of commodities, leaving intermediate uses fixed. In this case w_i was replaced by $w^*_i = ((D_i/(B_i + M_i)) - 1$ and $U_{i,j}$ by $U^*_{i,j} = U_{i,j}$ in row i.

- and/or -

(3c) Selective adjustment of intermediate uses by row scaling of the use matrix where intermediate consumption data was largely provided by using price-updated 1972 BEA coefficients; in particular, the service inputs to all industries. Replace $U_{i,j}$ in row i by $U^*_{i,j} = U_{i,j}\ (P_i - Y_i)/U_i$, j = 1,496 and leave w_i fixed; i.e., $w^*_i = w_i$.

- and/or -

(3d) Adjustment of a few specific allocations to PCE, investment, government (both Federal and State and Local), and imports and exports.

(4) Calculation of the statistical discrepancy row, which measures the degree of imbalance in the columns resulting from the row balancing procedures. The statistical discrepancy is defined as $S_j = CM_j - \sum_i U^*_{i,j}$ for j = 1,496.

(5) Conversion of the balanced national use matrix $U^*_{i,j}$, to coefficients based on cost of materials, $u^*_{i,j} = U^*_{i,j}/CM_j$, and conversion of the by-product matrix to coefficients based on industry output, $b^*_{i,j} = B_{i,j}/X_j$. The

balanced wholesale margins were then converted to percentage of purchaser value, $w_i^* = w_i^*(B_i + M_i)/D_i^*$.

Thus the national row balance procedure leaves most final demand, retail margins, sales taxes, transportation margins, and the scaled by-product matrix fixed while allowing adjustments to inventory change, wholesale margins, intermediate uses and a few specific allocations to PCE, investment, and government. The choices depend on the degree of imbalance and the relative quality of the data items. As a result of the national row balance, the column balance, denoted by A in Exhibit 4-1, is no longer satisfied. Rather than adopting a comprehensive RAS balancing procedure, it was decided to do an interative scaling on the intermediate columns and rows until the column imbalances were reduced to an acceptable minimum. Two iterations were performed that reduced the column imbalances generally to less than one percent. The remaining imbalance was left in a statistical discrepancy row. Use of the statistical discrepancy row to complete the national balance gives the result that value-added and output are also unchanged by the national balancing procedure, and it eliminates the need for a complete RAS procedure to achieve a balanced national table. The decision to use the statistical discrepancy row was based on the desire to introduce the smallest possible changes into the actual 1977 materials consumed data collected for the use matrix.

It is useful to point out some of the principal adjustments that were made in the national balancing. After review of the imbalance between supply and consumption, the output measures were reviewed and revised for a number of sectors. These included major revisions to the output of Livestock, Communications (except Radio and TV), Gas Utilities (duplication in output for resales was eliminated), Water and Sanitary Services (expenditures rather than revenues were used originally when they were the higher of the two — adjusted to an all revenue basis), Eating and Drinking Places (adjusted to include tips), Banking, Insurance, Real Estate and Rental, and Other Health Services. A negative entry was made in the PCE column for supply of scrap, sufficient to balance the scrap row. Corrections were made in product totals for a number of manufacturing sectors, to reflect adjusted amounts produced as secondary products — the Census data in Table 5 sometimes was difficult to interpret, especially for products that Census treats as primary to more than one industry.

Significant changes were made to the original PCE allocations in a number of sectors: Fruits, nuts, and vegetables; Forestry products; Dairy products; Bakery products; Sugar and confectionary products; Beverages; Other food products; Apparel; Household furniture; Leather and leather products; Household appliances; Receiving sets, records and tapes; Motor vehicles and parts; Medical, dental and optical equipment; Personal services; Doctors and dentists; Other health servces; Education; and Other social services. The original estimates had been controlled to NIPA but could not be reconciled with the supply data which were believed to be more accurate than the NIPA estimates which have not been rebenchmarked to a 1977 input-output table. It is believed that the NIPA allocations from the above sectors will be significantly revised when the 1977 benchmarking is completed. The largest adjustment was to increase the NIPA allocation for Other Social Services by 7.8 billion dollars. Several of the other adjustments amounted to several billion dollars.

A few adjustments were made to the original NIPA-controlled allocations to investment and to Federal and State and Local governments. Adjustments were also made to the inventory change estimates and in a few cases, to the original tabulations of imports and exports.

As a result of the above changes to final demand, the total of final demand (GNP) is revised upward from NIPA by approximately 22 billion dollars. It is believed an adjustment of somewhere near this magnitude will be made when NIPA is benchmarked to the 1977 I-O data. The final estimates for the major components of final demand are compared with NIPA in Exhibit 4-2.

Further adjustments to the intermediate consumption estimates were necessary to balance the product rows. Initial adjustments were made to the intra-sector cells when this would improve the balance in the input columns (the intra-sector cells are subject to considerable variation over time, reflecting changes in the extent of vertical integration in an industry). Further adjustments were made by selective changes to large cells, or by scaling, to put the product rows in final balance.

EXHIBIT 4-2:

MRIO AND NIPA FINAL DEMAND, 1977

(Millions of Dollars)

Final Demand	NIPA*	MRIO
Personal Consumption Expenditures	1,205,483	1,226,322
Private Investment	301,296	305,301
Net Inventory Change	20,987	18,437
Exports	183,262	181,463
Imports	(187,486)	(185,587)
Federal Government Expenditures	143,871	143,978
- Defense	93,287	95,512
- Nondefense	50,584	48,466
State & Local Government Expenditures	250,598	250,504
- Capital	38,998	37,901
- Current	211,600	212,603
Total	1,918,011	1,940,418

*National Income and Product Accounts, 1976-79, Survey of Current Business, Special Supplement, July 1981.

Changes in National Value Added by Sector

Value added as originally estimated (controlled to NIPA GPO by major sectors) was revised in a few cases due to the inability to balance the input data with industry output measures. A major change was also made to include all rental receipts by all industries in the value added of the real estate and rental sector, a total of 40 billion dollars. Unfortunately, these receipts have not been removed from the value added in sectors other than mining, construction and manufacturing, thus contributing to an overstatement of value added in those sectors. In total, value added exceeds the overall control (as given by the total of final demand) by 23 billion dollars and this amount is carried as a statistical discrepancy. This imbalance does not affect the calculations of the model, or the model results, but should be noted in interpreting the value added data.

Exhibit 4.3 presents totals for employment and the components of value added in comparison with NIPA totals. Two MRIO files are involved: the Output, Employment and Payroll(OEP) file and the Use matrix (U) file. (The OEP file contains employment and payroll data which are not included in other files. It also contains detail on value added which is repeated in the U file, and on sector output which is included in the Make matrix (M) file.) Certain value added items must be added to the data in the OEP file to derive the value added totals in the U file (sales taxes, duties, rest of world account, and the inventory valuation adjustment). In addition, the OEP file includes a summary adjustment to the payroll and profit-type income totals to account for central administrative offices and auxiliary (CAOs) establishment payroll which was not made in the U file due to lack of a suitable way to make this adjustment by detailed sector. This adjustment is reversed in reconciling to the data in the U file in Exhibit 4.3.

The data in the U file are in turn adjusted in order to compare it with the NIPA totals. Excise taxes are added since they are not included in the U file but instead are included in the Trade Flow file along with transportation charges and wholesale margins. The statistical discrepancy in total MRIO value added represents the net imbalance of sector column totals, representing a net overstatement of value added in the MRIO accounts. (This overstatement is primarily due to failure to take out rental income in the value added for most of the nonmanufacturing sectors which is duplicated in the real estate and rental sector — partially offset by an understatement of value added in the sector detail representing CAO payroll in non-manufacturing establishments. This overstatement could have been eliminated by simply adjusting value added in each

EXHIBIT 4.3: MRIO EMPLOYMENT, PAYROLL AND VALUE ADDED COMPARED WITH NIPA

		Millions of Dollars			
	Employment (000)	Labor Compensation	IBT, BTP and Duties[1]	PTI[2]	Total Value Added
MRIO					
Output Employment and Payroll File Totals	88,065	1,138,384	93,351	642,958	1,874,688
Sales Taxes 39,132			39,132		39,132
PCE 34,616					
Investment 4,516					
Duties			5,467		5,467
Rest of World				23,489	23,489
Inventory Valuation Adjustment				-18,867	-18,867
Central Offices and Auxiliaries Payroll[a]		-41,318		41,318	
Use Matrix File Totals		1,097,066	137,950	688,898	1,923,909
Excise Taxes (Federal and S&L)[b]			39,951		39,951
Statistical discrepancy[c]				-23,505	-23,505
Central Office and Auxiliaries Payroll[a]		41,318		-41,318	
MRIO totals		1,138,386	177,901	624,075	1,940,355
Less Military (U.S. Installations only)	-1,756	-16,280			-16,280
MRIO totals including military	86,309	1,122,106	177,901	624,075	1,924,075[d]
NIPA					
Totals (SCB, Special Supplement July 1981	89,699	1,152,341	174,204		1,918,011
Less military (includes overseas)	-2,937	-25,308			-25,308
Less statistical discrepancy					-4,373
NIPA totals excluding Military	86,762	1,127,033	174,204	587,093[e]	1,888,330[d]

[1] Includes indirect business taxes, business transfer payments, and duties.

[2] Profit type income.

[a] Includes $36,558 (mil) in payroll and $4,760 (mil) in supplements (supplements for manufacturing only) entered in Employment and Payroll file, but incorrectly, not in the Use Matrix file. Does not affect the model structure.

[b] Excise taxes are not in the Use Matrix file and are entered in the Trade Flow file along with transportation and wholesale margins.

[c] Represents net column imbalances purposely left unbalanced. Principally reflects error in not reducing value added for rental receipts in sectors other than manufacturing, mining and construction. Does not affect model structure.

[d] MRIO/NIPA difference reflects primarily $22.0 billion larger Final Demand of MRIO, $9.0 billion difference in military adjustment and NIPA statistical discrepancy.

[e] Calculated by difference.

sector by the imbalance but it was chosen not to do since it would obscure the audit trail and is not important for the model structure — the model results are not distorted as long as the rows in the basic data are in balance.) The CAO adjustment was again reversed as was necessary for comparison with the NIPA data. Finally, employment and payroll for military personnel were subtracted from both the MRIO and NIPA totals for the comparison since the coverage of personnel is different in each account —MRIO covers only personnel based in the U.S. whereas NIPA includes overseas personnel.

The employment and payroll data agree remarkably closely in view of the fact that the MRIO data were developed from establishment data available in state detail and were not reconciled to a central source. The differences in the other components of value added result from the fact that MRIO GNP exceeds NIPA GNP (22 billion in final demand) plus a 9 billion difference in military payroll coverage plus the NIPA statistical discrepancy.

Procedures for State-Level Balancing

Completion of the national balancing procedure above produced the adjusted national-level intermediate use matrix $u^*_{i,j}$ in coefficient form with MRIO rows and BEA columns of detail. As part of the work on Tasks 1 and 2 of this project, BEA-level detail for state industry output was prepared for the development of MRIO output data. The first step for the state-level balancing was to create MRIO-level weighted-average input vectors for all state industries by using the appropriate columns of $u^*_{i,j}$, weighted by the corresponding output of the BEA sector in each state. Following the notation of MRIO Procedures Paper No. 3, the state-level MRIO use matrices are denoted by $U_i^{j,k}$, which indicate the use of commodity j by industry k in state i. We also let $CM_j^{k,m}$ with m ranging over the BEA sectors contained in MRIO sector k, denote the cost of materials for the m^{th} BEA sector in MRIO sector k in state i. Then the state level use matrices were calculated as

$$U_i^{j,k} = \sum_m CM_i^{k,m} \; u^*_{j,m}$$

At this stage specific 1977 state-level input data developed for the agriculture, mining, energy and state and local government enterprises sectors were incorporated into the state-level use matrices by replacing the appropriate elements of $U_i^{j,k}$.

Similarly the state level by-product matrices $B_i^{j,k}$ were computed from the coefficient form of the balanced national level by-product matrix by

$$B_i^{j,k} = \sum_m X_i^{k,m} \; b_{j,m}^*$$

Hence $B_i^{j,k}$ represents the production of commodity j by industry k in state i in producer value.

Since final demand was already developed at the state level as Task 4 of the project, all preliminary versions of the required component matrices of the MRIO model were then ready for entering the state level balancing step, with the exception of the margin portion of the trade-flow and margin matrices, $\underline{T}_{m,i}$, denoting the commodity, margin and service flows from state m to state i (see MRIO Procedures Paper No. 3). Here the elements $T_{m,i}^{j,k}$ denote purchases by the distribution sector for commodity k in state i from producing industry j in state m. The preliminary version of the commodity and service flow and transportation margin portions of the trade-flow and margin matrices were completed as part of the work on Task 8 of this project. The wholesale margin portion of the trade-flow and margin matrices were then calculated using the adjusted national wholesale margin percentages w_j^* by commodity. Appropriate wholesale margin percentages were applied to the sum of intermediate uses plus final demand less retail margins and sales taxes for each commodity row and inserted into the appropriate distribution sector column of the trade-flow and margin matrices in the local wholesale trade sector row. This completed the preparation of the preliminary (unbalanced) component matrices for the state-level MRIO model. Sums were then taken to compare production plus imports to the consumption plus exports for each commodity in each state.

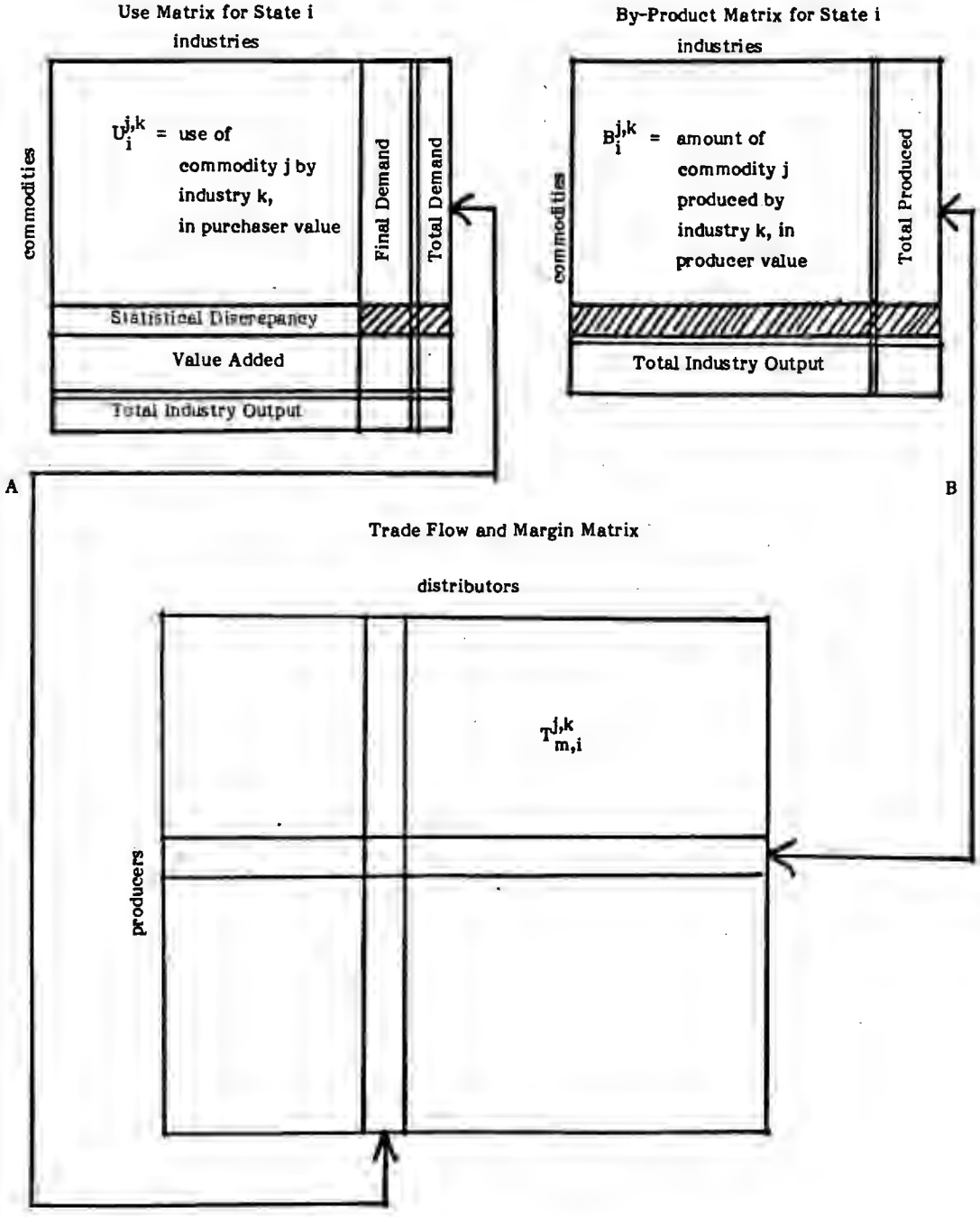
The following summations of the preliminary trade-flow and margin data $T_{m,i}^{j,k}$ will be useful for explaining the state-level balancing procedure (see Exhibit 4-4):

$$\tilde{D}_i^k = \sum_j \sum_m T_{m,i}^{j,k}$$

$$\tilde{B}_m^j = \sum_k \sum_i T_{m,i}^{j,k}$$

where D_i^k denotes the apparent total consumption in purchaser value of commodity k, in state i and B_m^j denotes the producer value of total shipments of commodity j by all

EXHIBIT 4-4:
STATE LEVEL BALANCING



Key:

Comparison A: $\tilde{D}_i^j$ versus D_i^j

Comparison B: $\tilde{B}_i^j$ versus B_i^j

producers in state m. Here the word "commodity" refers to any commodity, margin or service industry column in the $T_{m,i}^{j,k}$ matrix. Also note that the sums labeled "total consumption" and "total shipments" include the intrastate flows of commodities, margins and services. This is true because the sum labeled D_i^k denotes the column sum of the trade flow and margin matrix for the column of inputs to the distribution sector for commodity k in state i, which supplies all consumers of commodity k in that state. Similarly B_m^j denotes the row sum of the shipments to all distribution sectors of commodity j produced either as a primary or secondary product by industries in state m.

Using the state-level use and final demand matrices, we may compute the total demand for commodity j by all users in state i, say D_i^j, as

$$D_i^j = \sum_k U_i^{j,k} + Y_i^j$$

Also from the by-product matrices we may compute total production of commodity j in state i as

$$B_i^j = \sum_k B_i^{j,k}$$

A major problem in the state balancing was the existence of transhipments — shipments into the state that were further shipped to a final destination. This was evident when shipments-out exceeded production plus foreign imports. It occurs in the data for many intermodal shipments that involve separate rail and water movements and in part when shipments on the same mode have a temporary destination and are shipped further on a new bill of lading. Since the CTS data for manufacturing sectors show only the final destination of shipments, the truck, air, and pipeline data for manufacturing shipments were generally free of this problem (this is not the case of rail and water shipments for manufactured products since the rail Waybill and Waterborne Commerce data were used). It is prevalent in shipments of all nonmanufactured products since the CTS does not cover these shipments and individual modal data were used.

The problem arises since the model requires that ultimate origins and destinations be linked in order not to distort the impacts of demand on production in the states of ultimate origin. A technical problem also arises since the model requires that freight charges and wholesale margins be assigned to the delivered values of commodities in the states of final destination. This procedure breaks down when transhipments are

reflected in the data, and it is extremely awkward in the model to deal with cases where shipments-out of a state exceed supply originating in the state (production, imports, and inventory decreases).

In view of the above problem the first step in the balancing procedure was to try to eliminate these transhipments, at least to minimize them to the extent that shipments-out did not exceed supply in the state. Hence, the first step was to scale down shipments-out where they exceeded state supply, scaling down the flows in all modes over all destinations. Since shipments-in must also be reduced, the next step was to scale down shipments-in for the same states in amounts required to balance the state -- i.e., production plus foreign imports plus inventory decreases plus shipments-in equals consumption plus shipments out. In this step, shipments-in were scaled up as needed for balancing, but only from states not subject to the scaling down of shipments-out. This tended to eliminate the flagrant cases of transhipments but left imbalances in each state comprised of the remaining original imbalance augmented by the transhipment flows which need to be linked between ultimate origins and destinations.

Final Balancing Procedure

The final balancing procedure for interstate commodity flows was to link deficit states with surplus states by new flows using a modified gravity procedure. Deficit states were balanced with flows from surplus states in a series of iterations that limited the percentage of surplus in each state that could be drawn upon to satisfy a deficit state in each iteration. The procedure was designed to accord priority to satisfying deficit state requirements from nearby states first in each iteration (each iteration examined surplus supplies in states within a 500 mile radius of the deficit state first, then successively expanded this to a 1000 mile radius, 1500 miles, etc.). The constraints on the percentage of surplus that could be drawn upon in each iteration minimized the occurrence of the "corner" or "box" phenomenon in which deficits in New York, e.g., would have to be satisfied by large shipments from California whereas closer supplies would have been more logical.

After a few iterations, the transportation revenues generated by each flow (link) were calculated and "fixed." This was necessary since transportation revenues comprise part of the delivered value of commodities in each destination state and enter into the balancing of supply value with consumption value in each state. Since this is a

simultaneous process, it was necessary to "fix" these transport charges at a point where remaining state imbalances were minimal. Flows added after this point were assumed to be by private truck (where revenues or delivery costs are not explicitly accounted for) or were assigned to commercial modes with the implicit revenue per-ton mile adjusted to accommodate the added flows.

The final commodity flows data contain tonnage, ton-miles and revenues in addition to the value of shipments. These collateral data are contained on a separate tape since they are not used in the model calculations.

It should be pointed out that many weaknesses have been identified in the commodity flow data in attempting to reconcile it with production and consumption data in this project. Notably, the data from the CTS detailed tapes, when aggregated across all origins and destinations, did not agree with the published totals in the Census of Transportation for each commodity group. It is perplexing in this regard that the ton-mile data often closely agreed with the published totals but the tons and value of shipments data were considerably lower than the published totals. It has not been possible to ascertain whether this way due to error in the aggregation procedure or whether there were inconsistencies in the basic data tapes.

CHAPTER 5

POTENTIAL APPLICATIONS

The MRIO accounts can be used in a number of useful applications. In their simpliest form, the accounts trace the impacts of final demand expenditures on output and employment by industry and state. Moreover, the accounts have been specifically structured to work as a module in the Multiregional Policy Impact Simulation (MRPIS) model and in this role generate the income flows by state that result from changes in output and employment for input into other modules of the MRPIS model. Though many useful applications of the MRIO accounts are possible when they are linked up with the very large and complex MRPIS model, the MRIO also stands alone as a very powerful policy tool.

The following sections provide an overview of potential applications of the MRIO as an independent policy tool. The general types of applications discussed are:

- regional impacts of government programs and expenditures,
- shortage impact analysis,
- energy supply and demand analysis,
- transportation requirements analysis,
- environmental regulation
- labor requirements analysis,
- long-term economic projections,
- defense mobilization planning.

Some of these applications require specific adjustments or refinements of the model which are also discussed below.

5.A REGIONAL IMPACTS OF GOVERNMENT PROGRAMS AND EXPENDITURES

Nearly every governmental action of major importance has direct impacts on receipts and expenditures of people associated with particular economic sectors and states. The MRIO model can provide help in locating those direct impacts, but its primary use is in identifying indirect impacts, which can sometimes be a large fraction of total impacts.

This section shows how geographic impacts can be traced for a wide variety of government actions. It is assumed in this section that the government action creates no shortages of industrial or labor capacity. Shortages are considered in another section.

The types of government action considered here are as follows:[1]

1. Government expenditures for goods and services.
2. Taxes and transfer payments.
3. Regulations that change inputs to producing sectors.
4. Regulations affecting what final consumers can buy.
5. Foreign trade policy.

Government Expenditures for Goods and Services

An input-output model is not necessary to establish that if the Federal or a state or local government buys some commodity or service, output and input in the industry producing that service, and in places where the industry is located, will be stimulated. Government expenditures, however, are ordinarily described by function rather than commodity detail. Although the composition of government expenditures for goods and services in support of some function may change, it can be useful to know the commodity composition of a recent period. The MRIO model has built into it the pattern of commodity and service expenditures for each of defense and non-defense in the case of the Federal government, and for average patterns among state and local governments for each of 20 different state/local governmental functions.

In the case of the Federal government, the state source of supply is specified. Within any state, state and local governments are assumed to distribute their purchases geographically as do private enterprises for the same commodities and services.

The unique feature of the MRIO model is in sectoral and geographic identification of indirect impacts of the government expenditure. Some of the income produced by a purchase in a state — sometimes a great deal of the income — occurs outside the state. For example, an automobile bought in Maryland generates income for a local automobile dealer, his employees, and local suppliers of services to the dealer, but the great

[1] *Each is considered independently although tendencies to take combinations of actions and reactions of monetary authorities could widen the analysis that should be associated with each of the kinds of action considered here. Further comments on this point appear at the end of the section.*

bulk of the money goes to an automobile manufacturer in some other state. In turn, much of the money received by the manufacturer becomes income of suppliers of goods and services from other states. The MRIO provides a unique framework for measuring both the direct and indirect impacts of specified governmental expenditures.

It can often be important to know how much of the income is generated in the state of expenditure, with little importance attached to identification of where other income is generated. For example, a state government may wish to know which kinds of purchases of goods and services in the state have the largest fractions of income generated in the same state. Similarly, if the Federal government is interested in stimulating economies of unusually distressed states, it is useful to identify which kinds of purchases in a state generate the most income per dollar spent within the state. In both cases, it may be useful to undertake research to identify possible direct and indirect objects of expenditure in more detail than provided by the basic MRIO model. Also, the cost of some applications of the model can be reduced by aggregation of states other than the one of interest and by aggregation of commodities that are not of major importance for the problem.

In more complicated problems, there can be concern with identification of where outside the state of original expenditure important impacts on income are generated. For example, states that complain of no benefit from defense expenditures may derive significant benefits as second, third, or later tier suppliers to price contractors. It is likely in such cases, however, that augmentation of the model to cover particular weapon systems would greatly increase its effectiveness. In some cases, it may be possible to establish that some significant part of income generated by government expenditure is generated in foreign countries. This requires no modification of the model to identify income generated by noncompetitive imports associated directly or indirectly with a government purchase. In the case of imports of items that are also produced in the United States, the model must be run in a variant where the imports are not stipulated as a final demand, but rather are generated as accounting for some plausible share of the U.S. market — perhaps the share actually controlled in the base year.

For both of the kinds of government expenditure problems discussed above, a model run may consist of multiplication of the inverted matrix of net output coefficients against a vector of final demands, or several iterations of multiplication of the uninverted matrix

first against the final demands and then against the output requirements generated by the previous multiplication. Each iteration calculates the output required directly to produce the final demands of the first iteration, and then to produce the outputs generated by the previous iteration. A large number of such iterations produces output requirements that sum to the outputs generated by the multiplication of the inverse against the final demands, but the first few iterations may be the only iterations needed for the immediate problem.

Taxes and Transfer Payments

Governments participate in important transactions with the private sectors that do not involve payments for goods and services. Governments levy taxes against particular kinds of economic activity, against incomes, against assets, and against people. They make payments that are unconditional supplements to incomes and that are conditional on performance of various kinds of economic activity (subsidies). These transactions are mixtures of (a) additions to and subtractions from income available for purchases of goods and services and (b) rewards and penalties for certain kinds of activity.

The MRIO model has a place in analysis of the impact of such transactions, but only as a part of a broader analysis that starts — before useability of MRIO — with estimation of how the transactions affect the purchases of goods and services by the private parties to the transactions. For example, a payment to poor families has the effect of adding to the purchases of goods and services by the recipients. Determination of how much more they buy and with what composition requires a different model. The MRIO model can only trace the implications of any incremental purchases that are specified. Similar comments may be made about an income tax. A tax on a commodity or a subsidy for production or purchase of a commodity (e.g., a housing subsidy for renters or an interest rate subsidy for buyers of real estate) cannot have impacts measured through MRIO until the effects of disposable income changes of parties to the transaction and the effects of the subsidies and taxes as incentives to substitute from and to other kinds of economic activity have been estimated. For example, a subsidized interest rate for housing purchases would increase purchases of houses and complementary things such as home furniture and probably decrease purchases of automobiles. These effects would have to be estimated before the MRIO model could be used, but then the MRIO model would be important in tracing the implications for other economic sectors and could provide a state distribution of these "downstream" impacts for any initially determined immediate impacts.

In the case of a tax on an intermediate commodity, the MRIO model could be used to trace the impact on prices to the ultimate bearers of the tax burden. The accuracy of such a tracing would be reduced, though, by any failure of the increased costs to be passed on fully to ultimate consumers. For example, a tax on petroleum would increase the cost of petroleum products. The MRIO model would be able to trace the incidence of that cost increase exactly if the increased cost were reflected exactly in prices charged to users of the refined products, if the users of those products bought just as much as before the price increase, if they reflected their cost increases in exactly offsetting price increases to customers who bought as much as before, and so on, all the way to a final consumer who bought as much of every final product as before. In the real world, there are substitutions against what increases in price — in fact, a tax would be intended to achieve that effect — and a seller may absorb some cost increases. The MRIO model can estimate, however, a maximum impact on particular final consumer classes, and it may provide a reasonable approximation to the correct answer.

Using an input-output model to trace the incidence of cost increases is less common than use to trace income and employment effects of an increment in final demand, but there is no greater technical difficulty. Suppose, for example, that final demand for clothing generates an output of some dollar value of petroleum. A tax of ten percent on the value of petroleum used indirectly in clothing production will raise the price of clothing by ten percent of the amount of petroleum required.

Regulations That Change Inputs to Producing Sectors

Health and safety regulations are likely to involve additions to and substitutions for normal inputs, almost always at higher cost than without the regulations. To the extent that costs rise, the effect is the same as for a tax, and the MRIO model can be used in the same way. The additions to or substitutions for inputs imply a replacement of the previous input coefficients with new ones. Running the model both before and after the replacement of input coefficients will yield sets of income and employment implications of a given final demand with differences for corresponding elements of the two sets that are attributable to the regulation. For example, a change in insulation requirements for new house construction will increase employment and incomes in states producing the new insulation and reduce employment and income in states producing the previously used insulation. A deeper analysis might also consider later changes in the amounts of fuel needed to heat homes and the impacts of those changes on states producing fuel.

Regulations Affecting What Final Consumers Buy

Legislation and regulations prohibiting or requiring purchase of firearms, limiting drinking ages, requiring labels that might discourage purchase of cigarettes, requiring purchase of smoke alarms, requiring purchase of helmets by motorcycle or bicycle riders, prohibiting use of radar detectors, and government publicity about cholesteral dangers in certain food products are similar to indirect taxes on commodities and services in that, after a preliminary analysis to evaluate the direct effects of the government action, the MRIO model can distribute indirect impacts among economic sectors and states.

Foreign Trade Policy

Foreign trade policy affects the distribution of markets between domestic and foreign suppliers and the prices that domestic producers can charge. The initial impacts on inputs to production and prices for the affected production differ in character from those associated with health and safety regulations that change production technology. Although in both cases, there is replacement of domestically produced inputs and associated incomes with other inputs, here the inputs are from abroad and are associated with foreign income changes rather than domestic. Another difference is that the price changes here are associated primarily with changes in wage and profit rates rather than with changes in value of inputs at constant prices. In both cases, however, the sectoral and geographic impacts resulting from the direct effects are estimated with the MRIO model in the same way, and the procedure for identification of who ultimately gain or lose by the cost changes for the products directly affected is the same for both kinds of government action.

Independence of Government Policy Decisions

The preceding discussion has dealt with impacts of government decisions on both total national income and its distribution. The former, however, may represent a partial analysis of total impacts if other offsetting policy decisions are made at the same time. For example, a decision to spend more is ordinarily related to a decision to tax more, and a decision to tax less may bring pressure to spend less. An increase in exports relative to imports will tend to raise total income, but the full impact on total income is not really knowable without knowledge of how monetary authorities will react to the

increase in money supply associated with the increase in net exports. It is unlikely, though, that such offsetting actions with respect to total income will completely offset the original action's impacts on sectoral and geographic distribution of incomes and employment.

5.B SHORTAGE IMPACT ANALYSIS

Many government agencies and corporate planners must consider the vulnerability of the regional economic system to disruption caused by shortages of essential or desired goods and services. Shortages may arise due to a wide variety of situations, including political conflict, natural disaster, labor disputes and business failure or relocation. Due to the regional specialization of the industrial base, shortages which affect one region severely may not be directly significant in a different region. However, when a shortage impacts directly on an industry in one state, other industries in other states which depend on inputs from the directly impacted industry will be affected adversely. These impacts are measured by the so called "forward - effects" version of the MRIO model.

The MRIO model in its current status can be used to trace the interrelationships of the state industries in order to assess the severity and regional extent of the shortage impacts, to identify particularly sensitive industries and regions, and to evaluate possible contingency plans or ameliorative measures. Since the range of plausible shortage scenarios is so broad, a comprehensive model such as the 1977 MRIO can provide the required capability to quickly identify the unique regional characteristics of the shortage situation, to identify the location of alternative sources of supply which may be used to offset the shortage, and to optimize the allocation of available supplies, if necessary.

The advantage of using the state-level MRIO in shortage analysis applications can be enhanced markedly by the addition of data on industrial and transportation capacity constraints and substitution capability of each state industry. When the MRIO model is used in its current form with fixed input and trade coefficients, effects of the shortage which are generated by the model represent an upper bound on actual impacts due to the ability of industry to shift from affected inputs to more readily available complementary inputs and to shift to new supplying states. The capacity for substitution of inputs and sources of supply may be very large for certain inputs such as

energy, or very small as is the case for certain metallurgical additives. Data on substitution of inputs capabilities have been developed by JFA and other researchers for many strategic materials, while little data exist for many other types of inputs. Thus substitution limits may be added to the model only for a select list of goods, depending upon the needs of the application.

While data on the capability of each industry to alter its input requirements is only available for selected materials, a wealth of data exists on industry capacity and current levels of utilization. Industrial capacity data is readily available throughout the mining and manufacturing sectors, and the incorporation of capacity constraints could be accomplished with relatively little further effort. JFA has participated in the development of capacity and capacity utilization time series for the U.S. Department of Labor and the Federal Preparedness Administration (now F.E.M.A.) for the past decade, and has the ability to add required capacity constraints to the model at minimum cost to the user.

The MRIO model has state-level inventory data for all state-industries, and this data provides a basis for examining the mitigating impacts of inventory drawdown. For certain shortages, such as fuels and strategic materials, proper management of regional inventories are an important feature of the shortage response plan. Besides providing information on the regional distribution of stocks of affected materials, the inventory variables in the input-output model can be incorporated in a linear programming solution for optimal stockpiling to prepare for shortages and for analysis of various drawdown policies.

In its current version, the MRIO model has fixed trade coefficients which reflect the patterns of trade which exist in the base year. While these patterns provide a starting point for regional shortage impact analysis, the spatial relationships of trade are extremely flexible within existing transportation capacity constraints. Alterations of the base year trade patterns is best examined via a linear programming version of the MRIO which permits variable trade coefficients. In this version the MRIO can provide answers to questions on optimal adjustment of spatial trade flows within the constraints of capacity, while maintaining required supplies of inputs to state industries which otherwise were not impacted directly by the shortage. In simple terms, the solution of the LP version of the MRIO model represents an adjustment to trade flows which will not induce additional secondary shortages, if such a solution is possible within existing industrial and transportation constraints.

In summary, the addition of substitution capability and industrial and transportation capacity constraints would permit the upgrading of the 1977 MRIO from its current fixed coefficient form to the general LP model. In its LP formulation, the 1977 MRIO would be capable of evaluating optimal strategies for handing shortage emergencies. In its current version, the MRIO can be used to evaluate potential "forward impacts" under the assumptions of fixed trade and technology. When implemented in either version the MRIO can provide a flexible shortage analysis tool which can assist the analyst in examining a wide variety of shortage scenarios. Capacity and substitution data are also important factors if the model is to be used for mobilization planning, energy and transportation analysis, and long-term economic projections, as discussed in other parts of this chapter.

5.C ENERGY SUPPLY AND DEMAND ANALYSES

The MRIO model contains detailed data on energy production, consumption, imports, exports and state-to-state movements by transportation mode. The majority of the figures were derived from data collected by the Bureau of the Census (Sources 03104, 03105, 03106, 03107, 03109 and 03110) and the Department of Energy (Source 03106).

Much of the remaining data was compiled from the National Energy Accounts (Source 23011). At present the MRIO includes the following primary energy producing sectors:

- Coal (MRIO 009)
- Crude petroleum (MRIO 010)
- Natural gas and liquids (MRIO 011).

In addition, primary energy products are consumed, converted or transported, and resold by the following sectors:

- Steel (coke, MRIO 030)
- Petroleum refining and allied products (MRIO 050)
- Electric utilities (MRIO 094)
- Gas transmission and distribution (MRIO 095).

Greater detail on consumption of petroleum by separate products were partially generated during the estimation of total petroleum products. This detail could be completed and readily incorporated into the MRIO model.

In general, input-output modeling is ideally suited to energy analysis. Industries and households not only consume energy directly but also indirectly in the form of energy inputs to goods they consume. The MRIO measures these secondary effects and thus the complete impact of any assumed change.

The regional nature of the MRIO is also extremely important to energy analysis. The U.S. is not homogeneous with respect to energy production and consumption and the MRIO acknowledges this. Each state produces and consumes a different mix of energy products, delivered and received to and from a different mixture of states on a different mixture of transportation modes. In addition, industries within states also consume a different mixture of energy products. The MRIO thus has the capacity to quantify the impact of any change at the state level. Multiplier effects are more correctly measured because they are based on the variance of industries at the state level rather then placing reliance on aggregative national level data. The availability of transportation matrices allows examination of transportation needs by mode and identification of transportation bottlenecks.

It should be noted that utilization of the MRIO for many applications may require the addition of supplementary data sets. These data sets incorporate assumptions on producton and transportation capacities as well as the ability of industries and households to conserve energy, to use substitute fuels and to draw down inventories. The assumptions can be reflected in the model in specific sector detail, using the considerable body of information that is being continuously collected on capacity conservation and fuels-switching potentials by individual industries.

The MRIO can be used to address an array of different types of energy supply and demand applications. Issues that can be addressed include:

- supply disruptions
- demand changes
- price changes
- government expenditures and regulations
- energy forecasting.

Supply Disruptions

The events of the last decade have illustrated the disruptive effects that energy supply emergencies can have on the U.S. economy. Possible supply disruptions include embargoes, labor strikes, natural disasters and political conflicts. The regional nature of the MRIO provides numerous advantages in analyzing impacts of energy emergencies. This is due to several energy characteristics such as the variability in the mix of energy products consumed by different states and regions, the variance in dependence on imported fuels by state, the difference in transportation modes used to receive energy by state, and the differences in the availability of substitute fuels by state. Because the MRIO identifies the interrelationships between industries and states it can be used to assess total impacts as well as identify sensitive industries and regions. These results can be used to evaluate possible contingency plans and ameliorative measures.

The MRIO can predict production that is possible if energy inputs are in short supply due to the disruption. Substitution of inputs can be handled by changing coefficients for each state. Substitution of transportation modes and origin-destination pairs can also be handled in this manner. Several runs are then made with the model, testing the possibilities of achieving specified levels and mixes of final deliveries until an approximate optimal level of output is identified. (A linear programming formulation of the model can be utilized if desired.) The difference between this new level of output, employment, payrolls and GNP and the original levels of outputs, etc. is the impact caused by the supply disruption.

Demand Changes

The MRIO is a very useful tool for predicting how demand changes for energy will impact regions and industries. Demand changes can be caused by rises in demand for energy intensive products, rapid military build-ups, user relocations, an especially cold winter or hot summer, etc. Demand changes may be national or may be confined to certain regional areas. In either case the MRIO can be very useful for determining both primary and secondary effects on industries and states. In cases such as a rapid military build-up the MRIO can identify transportation requirements that may result in bottlenecks and suggest possible alternate transportation modes that could transport the necessary fuel inputs while causing minimum disruption in key industries.

Demand changes can be implemented in the MRIO by changing the levels of final demands for goods or by changing input coefficients in the same manner as suggested in the section on supply disruptions.

Price Changes

The effects of changes in relative prices of energy products can also be measured utilizing the MRIO. For this purpose it is necessary to construct measures of demand elasticities and substitution capabilities as some industries will attempt to diminish use of the relatively more expensive fuel. Capacity constraints on alternative energy products will also be necessary to insure that consumption of alternative energy does not exceed possible production. After these assumptions are in place, row coefficients can be changed and the model run to determine industry and state impacts, to identify sensitive industries and states and to assess problems caused by transportation bottlenecks.

Government Regulations and Expenditures

A great deal of interest has been generated lately on the effect of government actions on supply and demand for energy. Governments can effect energy supply and demand relationships through changes in direct purchases, regulations, import restrictions, taxes and rationing. Each of these government actions is actually a special case of the previously discussed applications. Changes in direct purchases can be handled in the same manner as demand changes. Regulations and import restrictions can cause supply disruptions or changes in relative prices of energy products. Energy taxes cause changes in relative prices of energy products. Rationing leads to changes in demand. The MRIO is especially useful for analyzing rationing plans because the interrelationships of industries can be studied so that proper weight is attached to the importance of industries that supply inputs to essential industries. These important inter-industry impacts may be overlooked using other types of analysis.

Energy Forecasting

The MRIO can also be used to make short- or long-term projections of energy consumption, based on alternative economic growth assumptions, capacity assumptions, conservation assumptions and fuel-switching assumptions. In addition, assumptions can be made on changes in technical coefficients, productivity, population, labor force or

transportation movements. The effect of these changed circumstances can then be evaluated in terms of their effects on industries and states. The MRIO has the advantage of providing consistent forecasts since purchases by both intermediate and final demand are represented for all industries. Forecasts for one industry must be compatible with forecasts for every other industry.

5.D TRANSPORTATION REQUIREMENTS ANALYSIS

The MRIO model links the state economies by way of commodity and service trade flows. The commodity trade flows generate requirements for freight transportation. Thus, the model may be applied to project transportation requirements for a future period, or to analyze the impact on transportation demand of a shift in the state shares of national production or consumption. The model may also be applied to analyze the added transport requirements of large changes in the type and quantities of goods produced associated with national policy changes, e.g., an industrial mobilization for a defense build up.

Transport requirements are generated in the model by mode as a function of specific state origins and destinations for specific commodity shipments. In this way the transport requirements reflect the regional differentials in distance-of-haul and modal split for commodity shipments. This represents a large improvement over national models that depend on averages for both of these parameters.

The model may also be used in analyzing the economic impact of bottlenecks in transport capacity due to labor work stoppages. In its present form, this analyses are done as a feasibility analysis, using the data in the model to test the feasibility of required replenishment rates to maintain production activities in view of inventories available and substitute transportation capacity that is available. The model may be expanded to a linear programming version in which transport capacity and inventory constraints are handled endogenously in the model.

It is realized that the geographic detail (states) now in the model leaves a lot to be desired in transportation analysis. For this purpose it is desirable to have finer area detail that also reflects economic homogeniety in the area definitions. The BEA area definitions, consisting of groups of counties centered around large urban areas, represent a meaningful unit for many types of transportation analysis. Sufficient work has been done to demonstrate the feasibility of developing the MRIO model with detail

for the approximately 175 BEA areas that comprise the total U.S. For example, commodity flows were developed for the year 1972 for bulk commodities, comprising 75 percent of all intercity freight tonnage, and reconciled with production and consumption data in each area.[1] The conversion of the whole model to BEA area detail would represent a major effort but it is feasible in terms of data availability and computational manageability.

The MRIO model framework brings a discipline to commodity flow data development not heretofore available. The data development process involves reconciling the commodity flow data with production and consumption data in each geographic area. Through this process, better estimates of total freight movements, especially for truck shipments, can be made than those currently available from the carrier statistics and from shipper surveys.

5.E ENVIRONMENTAL REGULATION

The MRIO model may be used in several ways in analyzing the economic impact of environmental regulation. Several major uses include:

1. The measurement and projection of pollution emissions associated with specific production activities by geographic area.

2. The measurement and analysis of transitional economic impacts on production and employment resulting from production cost increases associated with pollution abatement.

3. The estimation of the distribution of industry pollution abatement costs among income groups.

Emissions data may be collected for major point sources, and monitored by devices installed for the purpose at major plants. Models such as the MRIO may be used to project the growth in emissions from these plants based on industry and area projections imputed down to the plant level. However, emissions from major plants are only part of the story; the cumulation of emissions from the large number of smaller plants often far outweigh the effect from the major plants. Since it is too costly to measure and

[1] *Jack Faucett Associates, "Freight Commodity Flows, 1972," report to the Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts.*

monitor the emissions from all plants, estimation is required. This can be achieved through an industrial data and projection system such as that provided by the MRIO (albeit finer industry and area detail are desirable and can come in time). Currently, the model has detail for states and for approximately 120 production activities. Imputations must be made to finer industry and area detail; this is possible at the county level in four-digit industrial detail. Projections in emissions growth at the state level can be imputed down assuming a constant product and area mix within the state.[1] In a later version of the model, the area detail could be improved to include detail for the approximately 175 areas of the country as defined by the Bureau of Economic Analysis, U.S. Department of Commerce, comprised by clusters of countries that are relatively homogeneous economic areas. The industry detail could be improved to delineate the more important industries in terms of emissions. This would greatly reduce the inaccuracy associated with the imputations now necessary when the model is used to project future industry and area emissions.

The second major use of the model is to measure transitional impacts of industry output and employment resulting from significant increases in production costs due to emissions abatement, as well as positive impacts on output and employment in the production of emissions control equipment. Increases in production costs for the regulated industries are first estimated; the national model is then used to calculate the effect on prices of all products in the economy, assuming that the initial cost increases in the regulated industries are then passed through to other industries that use the products of the regulated industries. In this way, the cumulative effect on prices of final demand goods is calculated. The impact of these price increases on the demand for final demand goods and services is then calculated using demand price elasticities for this purpose. Demand will be reduced for some products and increased for others as consumption budgets are rearranged due to changes in relative prices among final goods. The demand for investment in pollution abatement equipment will also increase due to the regulation and this impact on final demand will be stipulated. (Important changes in current inputs to the regulated industries as a result of change in the technology to satisfy the regulation will also be reflected by changing the input coefficients to these industries). The changes in national final demand will next be distributed to states for specification to the MRIO model, using base year distributional

[1] *The SEAS data base at EPA can be used for this purpose.*

patterns among states. The MRIO model is then used to calculate the impact of these changes in final demand on specific industry output and employment in each state. These output and employment impacts are transitional and will disappear after industries adjust their technology and capital equipment in view of changes in demand, and after labor skills and training are also adapted to these changed demands. This adjustment period may last up to a decade or more depending on the degree of the change in technology, the life of equipment that is gradually replaced, and the extent of worker retraining that is necessary. These disruptive relatively short-term impacts are usually outweighed by the longer-term changes in costs and benefits resulting from the regulation but they must be given appropriate consideration in assessing the benefits and costs of the regulation.

The third major use of the input-output model in the measurement and analysis of benefits and costs in environmental regulation is in estimating the economic impact of the regulations on different income groups of the population. For this purpose, the national model may be used. The model is applied to calculate the effect on the prices of all final goods and services that result from cost increases in the regulated industries, assuming that initial cost changes are passed through to the prices of final goods and services. Since the price effects are different among these final goods and services, the effect on final consumer budgets depends upon the importance of these goods and services in consumer budgets. The importance may be analyzed by income group to calculate the differing impact on the purchasing power of each income class. The impact on Federal and state and local budgets, and on the costs of investment goods, may similarly be analyzed.

5.F LABOR REQUIREMENTS ANALYSIS

The MRIO provides an excellent basic framework for the conduct of labor requirements analysis. Within the MRIO, state estimates of employment by the 124 MRIO sectors is given. In mining and construction, employment is further specified by supervisory and nonsupervisory categories. By linking these data to a breakdown of occupations by sector, the total labor requirements for any given full or partial bill of goods could be generated by occupational category. These type of analyses would be of significant value to regional planners, defense procurement specialists, non-defense procurement planners in government and private industry as well as to occupational guidance agencies. Two primary sources are available to disaggregate MRIO employment by category: (1) the BLS national occupation matrix and (2) Occupation by Industry data as

developed by the Bureau of Census under the 1980 Census of Population. Details of these sources follow.

BLS National Occupation Matrix

The BLS matrix is based on the periodic establishment-level surveys of a Federal-State Cooperative program of occupational employment statistics (OES). Though the OES program is supported by 43 states, the matrix currently available on computer tape for 1980 includes no state detail.[1] The BLS 1980 matrix identifies approximately 1500 occupations and 350+ industries. By aggregating the BLS tape to the MRIO level (124+ industries), users could estimate the additional labor required, by detailed category, to produce a user-specified bill of goods.

It should be noted that the OES files do not include data on payroll, so that associated changes in payroll by detailed labor category would have to be estimated separately from BLS wage data. Moreover, cross-industry estimates by labor category cannot be developed for most detailed occupations because not all detailed occupations were included on every survey questionnaire. Cross-industry data for major occupational groups, however, is available and can be used to generate total demand of employees by major group.

The primary advantage in utilizing the BLS matrix to estimate employment and payroll by detailed occupational category is that the BLS files are based on establishment-level data, as is the MRIO. The accuracy of responses collected from establishments can be expected to be considerably more reliable than those responses to the same surveys by individuals (as from the Census of Population's surveys).

The disadvantage of the BLS data is that it is not readily available at the state level. The cost of collecting data from individual states would be high and the format and accuracy of data across states could vary considerably. The most cost-effective method of generating state data would be by imputing the matrix to the state level based on MRIO employment by industry and state. While this method would preclude adjustment for differing labor requirements by industries across states, the careful use of state wage rate data could support adjustment for wage rate differentials across states.

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[1] *State detail was last included in 1978 but only for 14 states. State detail for the 43 states currently participating in the program is available only by contacting each individual state office.*

1980 Census of Population

As part of the 1980 Census, various surveys were conducted that are used to characterize the population. When released, Subject Reports: Occupation by Industry will contain two tables of interest in labor requirements analysis. In the 1970 Census, Table 4, "Mean Earnings in 1969 of Employed Person with Earnings in 1969 According to Industry by Occupation: 1970" provided mean earnings for 102 occupations by 55 industries. In 1970, Table 8, "Detailed Occupation of Employed Persons by Detailed Industry and Sex" provided employment for 384 occupations and 227 industries. Since the detailed industry and occupation categories in Table 8 are defined within the broader categories of Table 4, these data provide a means of estimating payroll and employment by 102 occupations and 55 industries. When available for 1980, these data could be disaggregated to the level of MRIO sectors or, alternatively, MRIO sectors could be aggregated to the 55 industry level to match the Census detail. Since BLS has developed a "crosswalk" between their occupational categories and those of Census, the number of employees from Census (when available for 1980, see below) could be compared with the BLS national matrix (discussed above).

The primary advantage of using Census data is the availability of state-level detail. A special tabulation of the 1980 Census covering occupations and earnings for both Table 4 and Table 8 should be available by early 1983. It is expected that, at least for the 55 industry, 102 occupation level, these data would support reliable disaggregation of the MRIO employment and payroll files.

5.G LONG-TERM ECONOMIC PROJECTIONS

The MRIO model can be a key module of a larger model to forecast aspects of the economy ten to twenty years into the future. Other modules could be full or partial bases for predictions of changes in the composition of final demand, changes in the distribution of production capacities, changes in technology, and changes in various market shares. The MRIO model could then calculate the implications of these changes on state and sectoral distribution of economic activity and on employment and incomes. In addition, elaboration of the MRIO model to provide occupational detail, capacity changes through investment activity, and some flexibility of market shares and choice of production processes could increase the relative importance of the MRIO module in the broader forecasting model.

Some illustrations of how the MRIO module might be used follow. They include uses both with and without the kinds of augmentation that are possible. The section ends with a caution on long-term projections.

Major Shifts of Final Demand Among Defense, Consumer Goods, Consumer Services, and Net Exports

The mix of final demands in the economy changes substantially over long periods of time. Defense declined rapidly after Vietnam; a substantial recovery appears to be in process now. There has also been a shift from consumer goods to consumer services such as medical care and transportation. Foreign competition has made large inroads into domestic production of steel, automobiles, and the consumer goods. The MRIO model can be used to trace the impacts of these changes as implied by current technology and market shares. The model can trace impacts to particular industry activity levels in particular states, taking account not only of the industries immediately affected, but also their direct and indirect suppliers. The employment coefficients of the present model could show the impacts of the changed activity levels on employment, and more detailed employment coefficients than the model presently has would allow the user to trace impacts on employment by occupation, race, sex, or other characteristics of interest.

Changes in Key Resource Availabilities

If a key resource is expected to become scarce, the MRIO model could be used to find feasible combinations of final demand that, with no change in technology, might minimize the loss of gross national product. For example, a shortage of petroleum or energy in general could be dealt with by shifting the composition of gross national product toward types of products and services that make comparatively little direct and indirect use of petroleum or other sources of energy. As indicated earlier, the associated change in final demand composition could have its economic impacts traced to sectors and states.

Of course, the shortage would also stimulate changes in technology that might permit lesser change in the composition of gross national product. The present model would need to be modified to permit consideration of technology changes. Technology changes are discussed in the next subsection.

Changes in Technology

Changes in technology can be generated by combinations of changes in the availability of resources, the general advance of science and engineering, government restrictions on technology, and shifts of public tastes (whether in household purchases or government purchases) that change the mix of resource needs.[1]

Within the present form of the MRIO model, a technology change must be dealt with by a replacement of vectors representing old average technology with vectors representing the new. An alternative approach is to let the model retain alternative technology vectors and use computation procedure that lets the model choose the combination of technologies available to the model that maximizes the ability of the economy to meet some desired objective. That is the method of linear programming.

Whether the technological changes are handled by vector replacements or linear programming methods, the model will trace the impacts to sectors, states, and as many categories of employment as the model may include.

Changes in Prices of Key Resources

A change in the supply of key resources operates (in the absence of rationing) by price increases that squeeze some potential buyers out of the market. The previous discussion of changes in key resource availabilities considered the matter from the viewpoint of impacts of failure of some normal buyers to buy. Those who do buy, however, have to pay more, and their direct and indirect customers will have to pay more. The MRIO model can trace these price increases all the way to the most indirect consumers of the resource by sector and by state to the extent that the mix of final demands at constant prices is not affected by the price increases and that the technology for producing intermediate products required for those final demands is not changed.

Populations Shifts and Demographic Changes

The aging of the population and the movement of many retired people to states with warmer climates involves changes in final demands in particular states, changes in the kinds of services that state and local governments must provide, and changes in the kinds of consumer goods that are bought. This is a special case of use of the MRIO model to trace impacts of changes in final demand.

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[1] *Where a change in production mix occurs within an MRIO sector, the input mix that the sector requires may change even if there is no real change in technology. The change in input mix then represents an aggregation error.*

Aging of the population, levels and characteristics of education, and the availability of children's day care services, and other circumstances may affect not only the composition and level of consumer demands, but also the size and characteristics of the labor force. Uses of the MRIO model described earlier can indicate the suitability of the type of labor-force being produced for the kind that is needed.

Cautions for Long-Term Projections

All of the uses of the MRIO model discussed above take the form of implications of specific changes in circumstances. Other changes in circumstances are assumed not to occur to any significant extent for purposes of the problem at hand or to be largely offsetting. In particular, the use of the MRIO model for long-term projections assumes stability both of technology not specified as changing and of market shares of particular states. Of course, we do not know the directions of any significant changes not accounted for in an analysis; and, if the analysis is necessary, the practical way of dealing with unknown changes in circumstances that could either raise or lower some estimate is to assume that they do neither.

Another problem is that the larger model for which the MRIO model is a module, or sub-model, should be capable in principle of dealing with feedback from the MRIO model. For example, some change in final demands determined independently of the MRIO module may generate shortages or surpluses of resources that could ultimately cause population shifts, changes in technology, and changes in resource prices that would affect the "final" demands. The solution generated by the MRIO is incomplete if these changes, which are exogenous to the MRIO, are not translated into further changes in final demand and run through the MRIO accordingly.

5.H DEFENSE MOBILIZATION IMPACT

The model provides a unique capability for measuring the impact of defense build-up procurement on individual industry output and employment in each state. Modifications to the model can provide detail on labor skills requirements in each state. Collateral analysis of the model results together with measures of labor supply and plant capacities can be used to identify industries and geographic areas that may be subjected to inflationary pressures as a result of shortages in productive capacity.

The Defense Economic Impact Modeling System (DEIMS) now provides a translation of D.O.D. budget categories into procurement detail required as input to the model. Finer detail by weapons systems program can be developed from D.O.D. contractor data. This detail in procurement is specified to the model by state of location of the prime contractor and major subcontractors. The requirements for each program may be time-phased by annual periods to reflect different mixes of procurement detail over the Defense Five Year Program. The model will calculate the impact on output and employment for each of 120 industries in each state. Collateral data may be used to break down the employment by labor skills in each industry.

The model is currently limited by lack of specific detail on weapons systems. For example, there is only one aircraft sector for both military and civilian aircraft combined. The model results would be significantly improved by establishing separate industries in the model for each major weapons system. The feasibility of doing this has been demonstrated in earlier work by the Research Analysis Corporation and Jack Faucett Associates.[1]

The interstate trade flows in the model provide the link among the state economies, and quantify the dependence of each industry in each state on other states for materials and subcontracted parts. The trade flows in the model now represent the average trading patterns for each industry, with military and civilian products generally combined in these trade flows. The model results would be significantly improved if weapons systems procurement were separately identified in the model and the subcontracting relationships reflected separately in the trade flows for the major first and second tier subcontractors. The feasibility of this improvement to the model has been demonstrated by the earlier work cited in the footnote above.

Data on industrial capacity may be developed following the methodology established by Jack Faucett Associates in earlier work.[2] These capacity measures may be used to analyze the production requirements for each industry for the defense buildup in terms of current capacity utilization. This analysis will point up potential shortages in industrial capacity and the possibilities for inflationary pressure on prices for selective products and commodities.

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[1] *Research Analysis Corporation, Methodology for Industry Impact Analysis, Technical Paper RAC-TP-190, March 1966; Jack Faucett Associates, "The Regional and Industrial Distribution of Defense Subcontracting and Indirect Procurement," for the U.S. Bureau of Labor Statistics, August 1970.*

[2] *Disaggregate Measurement of Emergency Industrial Capacity, July 1978, and Capacity Substitution During National Emergencies, August 1980, both for the Federal Preparedness Agency (now F.E.M.A.).*

Labor skill requirements may be quantified using detailed employment-by-occupation data for each industry, available from the Bureau of Labor Statistics. These data may be applied (ex poste the model solution) to the specific industry production requirements as calculated in the model to estimate requirements for labor skills by state.

APPENDIX A

April 1982

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Agriculture, forestry and fisheries			
001	Dairy farm products	10100	Dairy farm products	0241, pt. 0191, pt. 0259, pt. 0291
002	Livestock and poultry	10200	Poultry and eggs	025 (excl. pt. 0259), pt. 0191, pt. 0219, pt. 0291
		10301	Meat animals	021 (excl. pt. 0219), pt. 0191, pt. 0259, pt. 0291
		10302	Miscellaneous livestock	027 pt. 0191, pt. 0219, pt. 0259, pt. 0291
003	Cotton, grain and tobacco	20100	Cotton	0131, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20201	Food grains	pt. 011, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20202	Feed grains	pt. 011, pt. 0139, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20203	Grass seeds	pt. 0139, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20300	Tobacco	0132, pt. 0191, pt. 0219, pt. 0259, pt. 0291
004	Fruits, nuts, vegetables, and misc. crops and services	20401	Fruits	pt. 017, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20402	Tree nuts	0173, pt. 0179, pt. 0191, pt. 0219, pt. 0259, pt. 0291

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Agriculture, cont'd			
004	Fruits, nuts, vegetables, and misc. crops and services	20501	Vegetables	0134, 0161, pt. 0119, pt. 0139, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20502	Sugar crops	0133, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20503	Miscellaneous crops	pt. 0119, pt. 0139, pt. 0191, pt. 0219, pt. 0259, pt. 0291
		20600	Oil bearing crops	0116, pt. 0119, pt. 013, pt. 0173, pt. 0219, pt. 0259, pt. 0291
		20701	Forest products	pt. 018, pt. 0191, pt. 0219, pt. 0259, pt. 0291
				pt. 018, pt. 0191, pt. 0219, pt. 0259, pt. 0291,07* (excl. 074)
005	Forestry products			08
006	Commercial fishing and trapping			09
	Mining			
007	Iron and ferroalloy ores	50000	Iron and ferroalloy ores mining	101, 106
008	Nonferrous ores	60100	Copper ore mining	102
		60200	Nonferrous metal ores mining, except copper	103-5, pt. 108, 109
009	Coal	70000	Coal mining	1111, pt. 1112, 1211, pt. 1213

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Mining cont'd			
010	Crude petroleum			pt. 131, pt. 132, pt. 138
011	Natural gas and liquids			pt. 131, pt. 132, pt. 138
012	Stone, clay, sand and gravel	90001	Dimension, crushed and broken stone mining and quarrying	141-2
		90002	Sand and gravel mining	144
		90003	Clay, ceramic, and refractory minerals mining	145
		90004	Nonmetallic mineral services and miscellaneous minerals mining and quarrying	pt. 148, 149
013	Chemical and fertilizer minerals	100000	Chemical and fertilizer mineral mining	147
	Construction			
014	Residential building construction	110101	New residential 1-unit structures, nonfarm	pt. 15, pt. 17
		110102	New residential 2-4 unit structures, nonfarm	pt. 15-17
		110103	New residential garden apartments	pt. 15-17
		110104	New residential high-rise apartments	pt. 15-17
		110105	New residential additions and alterations, nonfarm	pt. 15-17

(cont'd)

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Construction cont'd			
015	Nonresidential building construction	110106	New hotels and motels	pt. 15-17
		110107	New dormitories and other group housing	pt. 15-17
		110201	New industrial buildings	pt. 15-17
		110202	New office buildings	pt. 15-17
		110203	New warehouses	pt. 15-17
		110204	New garages and service stations	pt. 15-17
		110205	New stores and restaurants	pt. 15-17
		110206	New religious buildings	pt. 15-17
		110207	New educational buildings	pt. 15-17
		110231	New hospitals	pt. 15-17
		110232	New residential institutions and other health facilities	pt. 15-17
		110241	New amusement and recreation buildings	pt. 15-17
		110250	Other nonfarm buildings	pt. 15-17
016	Public utility construction	110301	New telephone and telegraph facilities	pt. 16-17
		110302	New railroads	pt. 16-17
		110303	New electric utility facilities	pt. 16-17
		110304	New gas utility facilities	pt. 16-17
		110305	New petroleum pipelines	pt. 16-17
		110306	New water supply facilities	pt. 16-17
		110307	New sewer system facilities	pt. 16-17
		110308	New local transit facilities	pt. 16-17

		110308	New local transit facilities ----------

pt. 16-17

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Construction cont'd			
017	Highways and Streets	110400	New highways and streets ----------	pt. 16-17
018	Other Construction	110501	New farm housing units and additions and alterations ----------	pt. 15, pt. 17
		110502	New farm service facilities ----------	pt. 15, pt. 17
		110601	New petroleum and natural gas well drilling ----------	pt. 138
		110602	New petroleum, natural gas, and solid mineral exploration ---	pt. 108, pt. 1112, pt. 1213, pt. 138, pt. 148
		110603	New access structures for solid mineral development ----------	pt. 108, pt. 1112, pt. 1213, pt. 148
		110701	New military facilities -	pt. 15-17
		110702	New dams and reservoirs -	pt. 15-17
		110703	Other new conservation and development facilities ----------	pt. 15-17
		110704	Other new nonbuilding facilities ----------	pt. 15-17
019	Maintenance construction	120100	Maintenance and repair, residential ----------	pt. 15, pt. 17
		120201	Maintenance and repair of other nonfarm buildings ----------	pt. 15-17
		120202	Maintenance and repair of farm residential buildings ----------	pt. 15, pt. 17

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Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Construction cont'd			
019	Maintenance construction	120203	Maintenance and repair of farm service facilities	pt. 15, pt. 17
		120204	Maintenance and repair of telephone and telegraph facilities	pt. 16-17
		120205	Maintenance and repair of railroads	pt. 16-17
		120206	Maintenance and repair of electric utility facilities	pt. 16-17
		120207	Maintenance and repair of gas utility facilities	pt. 16-17
		120208	Maintenance and repair of petroleum pipelines	pt. 16-17
		120209	Maintenance and repair of water supply facilities	pt. 16-17
		120210	Maintenance and repair of sewer facilities	pt. 16-17
		120211	Maintenance and repair of local transit facilities	pt. 16-17
		120212	Maintenance and repair of military facilities	pt. 15-17
		120213	Maintenance and repair of conservation and development facilities	pt. 15-17
		120214	Maintenance and repair of highways and streets	pt. 16-17

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Construction cont'd			
019	Maintenance construction	120215	Maintenance and repair of petroleum and natural gas wells	pt. 138
		120216	Maintenance and repair of other nonbuilding facilities	pt. 15-17
	Manufacturing			
020	Ordnance	130200	Ammunition, except for small arms, n.e.c.	3483
		130300	Tanks and tank components	3795
		130500	Small arms	3484
		130600	Small arms ammunition	3482
		130700	Other ordnance and accessories	3489
021	Meat products	140101	Meat packing plants	2011
		140102	Sausages and other prepared meats	2013
		140103	Poultry dressing plants	2016
		140104	Poultry and egg processing	2017
022	Dairy products	140200	Creamery butter	2021
		140300	Cheese, natural and processed	2022
		140400	Condensed and evaporated milk	2023
		140500	Ice cream and frozen desserts	2024
		140600	Fluid milk	2026

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing cont'd			
023	Canned and frozen foods	140700	Canned and cured sea foods	2091
		140800	Canned specialties	2032
		140900	Canned fruits and vegetables	2033
		141000	Dehydrated food products	2034
		141100	Pickles, sauces, and salad dressings	2035
		141200	Fresh or frozen packaged fish	2092
		141301	Frozen fruits, fruit juices and vegetables	2037
		141302	Frozen specialties	2038
024	Grain mill products	141401	Flour and other grain mill products	2041
		141402	Cereal breakfast foods	2043
		141403	Blended and prepared flour	2045
		141501	Dog, cat, and other pet food	2047
		141502	Prepared feeds, n.e.c.	2048*
		141600	Rice milling	2044
		141700	Wet corn milling	2046
025	Bakery products	141801	Bread, cake, and related products	2051
		141802	Cookies and crackers	2052
026	Sugar and confectionary products	141900	Sugar	2061-3
		142001	Confectionery products	2065
		142002	Chocolate and cocoa products	2066
		142003	Chewing gum	2067

(cont'd)

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Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing cont'd			
027	Beverages, extracts, and sirups	142101	Malt beverages	2082
		142102	Malt	2083
		142103	Wines, brandy, and brandy spirits	2084
		142104	Distilled liquor, except brandy	2085
		142200	Bottled and canned soft drinks	2086
		142300	Flavoring extracts and sirups, n.e.c.	2087
028	Other food products	142400	Cottonseed oil mills	2074
		142500	Soybean oil mills	2075
		142600	Vegetable oil mills, n.e.c.	2076
		142700	Animal and marine fats and oils	2077
		142800	Roasted coffee	2095
		142900	Shortening and cooking oils	2079
		143000	Manufactured ice	2097
		143100	Macaroni and spaghetti	2098
		143200	Food preparations, n.e.c.	2099
029	Tobacco products	150101	Cigarettes	211
		150102	Cigars	212
		150103	Chewing and smoking tobacco	213
		150200	Tobacco stemming and redrying	214
030	Fabric, yarn and thread mills	160100	Broadwoven fabric mills and fabric finishing plants	221-3, 2261-?
		160200	Narrow fabric mills	224

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC	
	Manufacturing cont'd				
030	Fabric, yarn and thread mills	160300	Yarn mills and finishing of textiles, n.e.c.	2269, 2281-3*	
		160400	Thread mills	2284	
031	Floor coverings and misc. textile products	170100	Floor coverings	227	
		170200	Felt goods, n.e.c.	2291	
		170300	Lace goods	2292	
		170400	Padding and upholstery filling	2293	
		170500	Processed textile waste	2294	
		170600	Coated fabrics, not rubberized	2295	
		170700	Tire cord and fabric	2296	
		170900	Cordage and twine	2298	
		171001	Nonwoven fabrics	2297	
		171002	Textile goods, n.e.c.	2299	
032	Hosiery and knit goods	180101	Women's hosiery, except socks	2251	Revised
		180102	Hosiery, n.e.c.	2252	
		180300	Knit fabric mills	2257-8	
033	Apparel	180400	Apparel made from purchased materials	231-8*, 39996	Revised
		180201	Knit outerwear mills	2253	
		180202	Knit underwear mills	2254	
034	Other fabricated textile products	180203	Knitting mills, n.e.c.	2259	Revised
		190100	Curtains and draperies	2391	
		190200	Housefurnishings, n.e.c.	2392*	
		190301	Textile bags	2393	
		190302	Canvas and related products	2394	

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	1977 BEA I-O Sector Name	1977 SIC
	Manufacturing cont'd			
034	Other fabricated textile products	190303	Pleating and stitching	2395
		190304	Automotive and apparel trimmings	2396
		190305	Schiffli machine embroideries	2397
		190306	Fabricated textile products, n.e.c.	2399
035	Logging and lumber	200100	Logging camps and logging contractors	2411
		200200	Sawmills and planing mills, general	2421
		200300	Hardwood dimension and flooring mills	2426
		200400	Special product sawmills, n.e.c.	2429
036	Wood products	200501	Millwork	2431
		200502	Wood kitchen cabinets	2434
		200600	Veneer and plywood	2435-6
		200701	Structural wood members, n.e.c.	2439
		200800	Wood preserving	2491
		200901	Wood pallets and skids	2448
		200902	Particleboard	2492*
		200903	Wood products, n.e.c.	2499
		210000	Wood containers	2441, 2449
037	Pre-fabricated buildings and mobile homes	200702	Prefabricated wood buildings	2452
		610602	Mobile homes	2451
038	Household furniture	220101	Wood household furniture	2511
		220102	Household furniture, n.e.c.	2519
		220103	Wood TV and radio cabinets	2517

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing cont'd			
038	Household furniture	220200	Upholstered household furniture	2512
		220300	Metal household furniture	2514
		220400	Mattresses and bedsprings	2515
039	Other furniture and fixtures	230100	Wood office furniture	2521
		230200	Metal office furniture	2522
		230300	Public building furniture	2531*
		230400	Wood partitions and fixtures	2541*
		230500	Metal partitions and fixtures	2542
		230600	Drapery hardware and blinds and shades	2591
		230700	Furniture and fixtures, n.e.c.	2599
040	Paper and allied products	240100	Pulp mills	261*
		240200	Paper mills, except building paper	262
		240300	Paperboard mills	263
		240400	Envelopes	2642
		240500	Sanitary paper products	2647
		240602	Building paper and board mills	266*
		240701	Paper coating and glazing	2641
		240702	Bags, except textile	2643
		240703	Die-cut paper and board	2645
		240704	Pressed and molded pulp goods	2646
		240705	Stationery products	2648
		240706	Converted paper products, n.e.c.	2649*
041	Paperboard containers and boxes	250000	Paperboard containers and boxes	265

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing cont'd			
042	Newspapers, periodicals and other printing and publishing	260100	Newspapers	271
		260200	Periodicals	272
		260301	Book publishing	2731
		260302	Book printing	2732
		260400	Miscellaneous publishing	274*
		260501	Commercial printing	2751-2, 2754
		260502	Lithographic plate-making and services	2795
		260601	Manifold business forms	276
		260602	Blankbooks and loose-leaf binders	2782
		260700	Greeting card publishing	277
		260801	Engraving and plate printing	2753
		260802	Bookbinding and related work	2789
		260803	Typesetting	2791
		260804	Photoengraving	2793
		260805	Electrotyping and stereotyping	2794
043	Industrial chemicals	270100	Industrial inorganic and organic chemicals	281* (excl. 28195), 2865, 2869*
044	Agricultural chemicals	270201	Nitrogenous and phosphate fertilizers	2873-4
		270202	Fertilizers, mixing only	2875
		270300	Agricultural chemicals, n.e.c.	2879
045	Other chemical products	270401	Gum and wood chemicals	2861
		270402	Adhesives and sealants	2891
		270403	Explosives	2892

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing cont'd.			
045	Other chemical products	270404	Printing ink	2893
		270405	Carbon black	2895
		270406	Chemical preparations, n.e.c.	2899
046	Plastics and synthetics	280100	Plastics materials and resins	2821
		280200	Synthetic rubber	2822*
		280300	Cellulosic man-made fibers	2823*
		280400	Organic fibers, non-cellulosic	2824*
047	Drugs	290100	Drugs	283*
048	Cosmetics and cleaning products	290201	Soap and other detergents	2841
		290202	Polishes and sanitation goods	2842
		290203	Surface active agents	2843
		290300	Toilet preparations	2844
049	Paint and allied products	300000	Paints and allied products	285
050	Petroleum refining and allied products	310101	Petroleum refining	291
		310102	Lubricating oils and greases	2992
		310103	Products of petroleum and coal, n.e.c.	2999
		310200	Paving mixtures and blocks	2951
		310300	Asphalt felts and coatings	2952
051	Rubber and misc. plastics	320100	Tires and inner tubes	301
		320200	Rubber and plastics footwear	302

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, cont'd			
051	Rubber and miscellaneous plastics	320301	Reclaimed rubber	303
		320302	Fabricated rubber products, n.e.c.	306*
		320400	Miscellaneous plastics products	307
		320500	Rubber and plastics hose and belting	304
052	Leather and leather products	330001	Leather tanning and finishing	311
		340100	Boot and shoe cut stock and findings	313
		340201	Shoes, except rubber	3143-9
		340202	House slippers	3142
		340301	Leather gloves and mittens	315
		340302	Luggage	316
		340303	Women's handbags and purses	3171
		340304	Personal leather goods	3172
		340305	Leather goods, n.e.c.	319
053	Glass and glass products	350100	Glass and glass products, except containers	321, 3229, 323
		350200	Glass containers	3221
054	Stone and clay products	360100	Cement, hydraulic	324
		360200	Brick and structural clay tile	3251
		360300	Ceramic wall and floor tile	3253
		360400	Clay refractories	3255
		360500	Structural clay products, n.e.c.	3259

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC	
	Manufacturing, cont'd				
054	Stone and clay products	360600	Vitreous plumbing fixtures	3261	
		360701	Vitreous china food utensils	3262	
		360702	Fine earthenware food utensils	3263	
		360800	Porcelain electrical supplies	3264	
		360900	Pottery products, n.e.c.	3269	
		360100	Concrete block and brick	3271	
		361100	Concrete products, n.e.c.	3272	
		361200	Ready-mixed concrete	3273	
		361300	Lime	3274	
		361400	Gypsum products	3275	
		361500	Cutstone and stone products	328	
		361600	Abrasive products	3291	
		361700	Asbestos products	3292	
		361800	Gaskets, packing and sealing devices	3293	
		361900	Minerals, ground or treated	3295*	
		362000	Mineral wool	3296	
		362100	Nonclay refractories	3297	
		362200	Nonmetallic mineral products, n.e.c.	3299	
055	Iron and steel mills and forging	370101	Blast furnaces and steel mills	3312	Revised
		370102	Electrometallurgical products	3313*	
		370104	Cold finishing of steel shapes	3316	
		370105	Steel pipe and tubes	3317	

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC	
	Manufacturing, cont'd				
055	Iron and steel mills and forging	370300	Iron and steel forgings	3462*	
		370401	Metal heat treating	3398	
		370402	Primary metal products, n.e.c.	3399	
056	Iron and steel foundries	370200	Iron and steel foundries	332	
057	Primary nonferrous metals and products	380100	Primary copper	3331	
		380200	Primary lead	3332	
		380300	Primary zinc	3333	
		380400	Primary aluminum	3334, 28195	
		380500	Primary nonferrous metals, n.e.c.	3339	
		380600	Secondary nonferrous metals	334	
		380700	Copper rolling and drawing	3351	
		380800	Aluminum rolling and drawing	3353-5	
		380900	Nonferrous rolling and drawing, n.e.c.	3356	
		381000	Nonferrous wire drawing and insulating	3357	
		381100	Aluminum castings	3361	
		381200	Brass, bronze, and copper castings	3362	
		381300	Nonferrous castings, n.e.c.	3369	
		381400	Nonferrous forgings	3463*	
058	Metal containers and misc. metal products	370103	Steel wire and related products	3315	Revised
		390100	Metal cans	3411	
		390200	Metal barrels, drums, and pails	3412	

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, cont'd			
058	Metal containers and misc. metal products	420100	Cutlery	3421
		420201	Hand and edge tools, n.e.c.	3423
		420202	Hand saws and saw blades	3425
		420300	Hardware, n.e.c.	3429
		420401	Plating and polishing	3471
		420402	Metal coating and allied services	3479
		420500	Miscellaneous fabricated wire products	3495-6
		420700	Steel springs, except wire	3493
		420800	Pipe, valves, and pipe fittings	3494, 3498
		421000	Metal foil and leaf	3497
		421100	Fabricated metal products, n.e.c.	3499
059	Structural metal products	400100	Metal sanitary ware	3431
		400200	Plumbing fixture fittings and trim	3432
		400300	Heating equipment, except electric	3433
		400400	Fabricated structural metal	3441
		400500	Metal doors, sash, and trim	3442
		400600	Fabricated plate work (boiler shops)	3443
		400700	Sheet metal work	3444
		400800	Architectural metal work	3446
		400901	Prefabricated metal buildings	3448
		400902	Miscellaneous metal work	3449

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, cont'd			
060	Screw machine products and metal stampings	410100	Screw machine products and bolts, nuts, rivets and washers	345
		410201	Automotive stampings	3465
		410202	Crowns and closures	3466
		410203	Metal stampings, n.e.c.	3469*
061	Engines and turbines	430100	Turbines and turbine generator sets	3511
		430200	Internal combustion engines, n.e.c.	3519
062	Farm and lawn equipment	440001	Farm machinery and equipment	3523*
		440002	Lawn and garden equipment	3524
063	Construction and mining equipment	450100	Construction machinery and equipment	3531*
		450200	Mining machinery, except oil field	3532
		450300	Oil field machinery	3533
064	Materials handling equipment	460100	Elevators and moving stairways	3534
		460200	Conveyors and conveying equipment	3535
		460300	Hoists, cranes, and monorails	3536*
		460400	Industrial trucks and tractors	3537*
065	Metalworking equipment	470100	Machine tools, metal cutting types	3541
		470200	Machine tools, metal forming types	3542

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, cont'd			
065	Metalworking equipment	470300	Special dies and tools and machine tool accessories	3544.5*
		470401	Power driven hand tools	3546
		470402	Rolling mill machinery	3547
		470403	Metalworking machinery, n.e.c.	3549
066	Special industry machinery and equipment	480100	Food products machinery	3551
		480200	Textile machinery	3552
		480300	Woodworking machinery	3553
		480400	Paper industries machinery	3554
		480500	Printing trades machinery	3555
		480600	Special industry machinery, n.e.c.	3559*
067	General industrial and other non-electrical machinery and equipment	490100	Pumps and compressors	3561, 3563
		490200	Ball and roller bearings	3562
		490300	Blowers and fans	3564*
		490400	Industrial patterns	3565
		490500	Power transmission equipment	3566*, 3568*
		490600	Industrial furnaces and ovens	3567
		490700	General industrial machinery, n.e.c.	3569
		500001	Carburetors, pistons, rings, valves	3592
		500002	Machinery, except electrical, n.e.c.	3599
068	Office and computing equipment	510101	Electronic computing equipment	3573
		510102	Calculating and accounting machines	3574

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, cont'd			
068	Office and computing equipment	510200	Typewriters	3572
		510300	Scales and balances	3576
		510400	Office machines, n.e.c.	3579
069	Service industry machinery and equipment	520100	Automatic merchandising machines	3581
		520200	Commercial laundry equipment	3582
		520300	Refrigeration and heating equipment	3585
		520400	Measuring and dispensing pumps	3586
		520500	Service industry machines, n.e.c.	3589*
070	Electric transmission and electrical industrial equipment	530100	Instruments to measure electricity	3825
		530200	Transformers	3612
		530300	Switchgear and switchboard apparatus	3613
		530400	Motors and generators	3621
		530500	Industrial controls	3622
		530600	Welding apparatus, electric	3623
		530700	Carbon and graphite products	3624
		530800	Electrical industrial apparatus, n.e.c.	3629
071	Household appliances	540100	Household cooking equipment	3631*
		540200	Household refrigerators and freezers	3632
		540300	Household laundry equipment	3633

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, Cont'd			
671	Household appliances	540400	Electric housewares and fans	3634*
		540500	Household vacuum cleaners	3635
		540600	Sewing machines	3636
		540700	Household appliances, n.e.c.	3639
672	Electric lighting and wiring equipment	550100	Electric lamps	3641
		550200	Lighting fixtures and equipment	3645-8
		550300	Wiring devices	3643-4
673	Receiving sets, records and tapes	560100	Radio and TV receiving sets	3651
		560200	Phonograph records and tapes	3652
674	Communications equipment	560300	Telephone and telegraph apparatus	3661
		560400	Radio and TV communication equipment	3662
675	Electronic components	570100	Electron tubes	3671-3
		570200	Semiconductors and related devices	3674
		570300	Electronic components, n.e.c.	3675-9
676	Other electrical equipment	580100	Storage batteries	3691
		580200	Primary batteries, dry and wet	3692
		580300	X-ray apparatus and tubes	3693
		580400	Engine electrical equipment	3694
		580500	Electrical equipment and supplies, n.e.c.	3699*

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, Cont'd			
077	Motor vehicles and parts	590100	Truck and bus bodies	3713*
		590200	Truck trailers	3715
		590301	Motor vehicles and car bodies	3711
		590302	Motor vehicle parts and accessories	3714
078	Aircraft and parts			3721, 3728
079	Missiles, spacecraft and parts			3761, 3769
080	Aircraft, missile and spacecraft propulsion units			3724, 3764
081	Other transportation equipment	610100	Ship building and repairing	3731
		610200	Boat building and repairing	3732
		610300	Railroad equipment	374
		610500	Motorcycles, bicycles, and parts	375
		610601	Travel trailers and campers	3792*
		610603	Motor homes (made from purchased materials)	3716
		610700	Transportation equipment, n.e.c.	3799
082	Scientific and photographic equipment, watches and clocks	620100	Engineering and scientific instruments	3811
		620200	Mechanical measuring devices	3823-4, 3829

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, Cont'd			
082	Scientific and photographic equipment, watches and clocks	620300	Environmental controls	3822
		620700	Watches, clocks, and parts	387
		630300	Photographic equipment and supplies	386
083	Medical, Dental and Optical equipment	620400	Surgical and medical instruments	3841
		620500	Surgical appliances and supplies	3842
		620600	Dental equipment and supplies	3843
		630100	Optical instruments and lenses	383
		630200	Ophthalmic goods	385
084	Other manufactured products	640101	Jewelry, precious metal	3911
		640102	Jewelers' materials and lapidary work	3915
		640104	Silverware and plated ware	3914
		640105	Costume jewelry	3961
		640200	Musical instruments	393
		640301	Games, toys, and children's vehicles	3944
		640302	Dolls	3942
		640400	Sporting and athletic goods, n.e.c.	3949
		640501	Pens and mechanical pencils	3951
		640502	Lead pencils and art goods	3952
		640503	Marking devices	3953
		640504	Carbon paper and inked ribbons	3955
			(cont'd)	

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Manufacturing, Cont'd			
084	Other manufactured products	640600	Artificial trees and flowers	3962
		640701	Buttons	3963
		640702	Needles, pins, and fasteners	3964
		640800	Brooms and brushes	3991
		640900	Hard surface floor coverings	3996
		641000	Burial caskets and vaults	3995
		641100	Signs and advertising displays	3993
		641200	Manufacturing industries, n.e.c.	3999 (excl. 39996)
	Transportation			
085	Railroads	650100	Railroads and related services	40*, 474, pt. 4789
086	Local passenger transportation and inter-city bus	650200	Local and suburban transit and interurban highways passenger transportation	41
		790100	Local government passenger transit	pt. 41
087	Motor freight	650300	Motor freight transportation and warehousing	42*, pt. 4789
088	Water transportation	650400	Water transportation	44
089	Air transportation	650500	Air transportation	45
090	Pipelines, except natural gas	650600	Pipe lines, except natural gas	46
091	Transportation services	650701	Freight forwarders and other transportation services	471, 4723, pt. 478
		650702	Arrangement of passenger transportation	4722

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Communications			
092	Communications, except radio and TV	660000	Communications, except radio and TV	48 (excl. 483)
093	Radio and TV broadcasting	670000	Radio and TV broadcasting	483
	Electric, gas, and sanitary services			
094	Electric utilities (private and public)	680100	Electric services (utilities)	pt. 491, pt. 493
		780200	Federal electric utilities	pt. 491
		790200	State and local electric utilities	pt. 491
095	Gas transmission and distribution (private and public)	680200	Gas production and distribution (utilities)	492*, pt. 493
		(Includes pt. 790300 Other state and local government enterprises)		
096	Water and sanitary services (private and public)	680301	Water supply and sewerage systems	494, 4952
		680302	Sanitary services, steam supply, and irrigation systems	495 (excl. 4952), 496-7, pt. 493
		(Includes pt. 790300 Other state and local government enterprises)		
	Trade and services			
097	Wholesale trade	690100	Wholesale trade	50*, 51* (excl. manufactures' sales offices)

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	I-O Code	Sector Name	1977 SIC
	Trade and services, cont'd			
098	Eating and drinking places	740000	Eating and drinking places	58, pt.
099	General merchandise and apparel stores	690200	Retail trade (MRIO code 100 also includes liquor stores, pt. BEA code 790300, Other state and local government enterprises)	53, 56
100	Food, drug and liquor stores (includes state and local government liquor stores)			54, 591, 592
101	Automotive dealers and gasoline service stations			55
102	Other retail stores			52, 57, 593-599, 7396
103	Banking, credit agencies and investment brokers	700100	Banking	60
		700200	Credit agencies	61* (excl. pt. 613), 67*
		700300	Security and commodity brokers	62

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Trade and services, cont'd			
104	Insurance	700400	Insurance carriers	63*
		700500	Insurance agents, brokers, and services	64*
105	Real estate and rental	710100	Owner-occupied dwellings	not applicable
		710200	Real estate	65-6[illegible], pt. 1531
106	Hotels and lodging place	720100	Hotels and lodging places	70[4] (excl. dining)
107	Personal and repair services, except auto	720201	Laundry, cleaning, garment services and shoe repair	721, 725
		720202	Funeral service and crematories	726
		720203	Portrait, photographic studios, and miscellaneous personal services	722, 72**
		720204	Electrical repair shops	762
		720205	Watch, clock, jewelry and furniture repair	763-4
		720300	Beauty and barber shops	723-4*
108	Misc. services and advertising	730101	Miscellaneous repair shops	769
		730102	Services to dwellings and other buildings	734

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Trade and services, cont'd			
108	Misc. services and advertising	730103	Personnel supply services	736
		730104	Computer and data processing services	737
		730105	Management and consulting services, testing and research labs	7391-2, 7397
		730106	Protective services	7393
		730107	Equipment rental and leasing	7394
		730108	Photofinishing labs, photocopy, and commercial photography	7332-3, 7395
		730109	Other business services	732, 7331, 7339, 735, 7399*
		730200	Advertising	731
109	Misc. professional services	730301	Legal services	811
		730302	Engineering, architectural, and surveying services	8911
		730303	Accounting, auditing and bookkeeping, and miscellaneous services, n.e.c.	893*, 899
110	Auto rental, repair and maintenance	750001	Automotive rental and leasing, without drivers	751
		750002	Automotive repair shops and services	753, 7549
		750003	Automobile parking and car washes	752, 7542

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Trade and Services cont'd			
111	Amusements	760100	Motion pictures	78
		760201	Theatrical producers (except motion pictures), bands, and entertainers	792
		760202	Bowling alleys, billiard and pool establishments	793
		760203	Commercial sports except racing	7941
		760204	Racing (including track operation)	7948*
		760205	Membership sports and recreation clubs	7997
		760206	Other amusement and recreation services	791, 799* (excl. 7997)
112	Doctors and dentists, inc. outpatient care facilities			801-3,808, pt 1
113	Hospitals and nursing	770200	Hospitals	806
		770301	Nursing and personal care facilities	805
114	Other medical and health services			074, 804 except 8041, 807, 80
115	Educational services	770401	Elementary and secondary schools	821
		770402	Colleges, universities, and professional schools	822
		770403	Libraries, correspondence and vocational schools, and educational services, n.e.c.	823-9

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name	1977 SIC
	Trade and Services cont'd			
116	Nonprofit organizations	770501	Business associations and professional membership organizations	861-2
		770502	Labor organizations and civic, social, and fraternal associations	863-4
		770503	Religious organizations	866
		770504	Other membership organizations	84, 865, 869, 8922
117	Other social services	770600	Job training and related services	8331
		770700	Child day care services	8351
		770800	Residential care	8361
		770900	Social services, n.e.c.	8321*, 8399
	Government enterprises			
118	Federal government enterprises, except utilities and local transit	780100	U.S. Postal Service	4311
		780300	Commodity Credit Corporation	pt. 613
		780400	Other Federal Government enterprises	several
119	State and local government enterprises, except utilities and local transit	790300	Other State and local government enterprises	several
	Special industries			
120	Directly allocated imports	800000	Noncomparable imports	
121	Scrap	810001	Scrap	

(cont'd)

Concordance of MRIO, BEA I-O and SIC Codes

MRIO Code	Sector Name	1977 BEA I-O Code	Sector Name
	Special industries cont'd		
122	Government industry	820000	Government industry ---
123	Household industry	840000	Household industry ----
Added 124	Rest of World		
125	Inventory Valuation Adjustment		
	Final Demand		
	Personal consumption expenditures		
	Gross private fixed capital formation		
	Net inventory change		
	Gross exports		
	Federal gov't capital expenditures, (except defense)		
	State and local gov't capital expenditures		
	Federal defense expenditures (current and capital)		
	Federal gov't current expenditures (except defense)		
	State and local gov't current expenditures		
	Foreign imports		

•Indicates those industries in which there was a change in composition between the 1972 and 1977 SIC's.

APPENDIX B

MRIO PROCEDURES PAPERS

APPENDIX B.1

MRIO Procedures: No. 1
November 4, 1981

TRADE AND TRANSPORTATION MARGINS IN THE MRIO MODEL

The treatment of trade and transportation margins in input-output tables has always posed special problems. In the national input-output tables these margins are allocated to consuming industries in association with the flow of inputs to which they apply. Thus the flow of steel to automobiles carries with it the cost of transporting the steel from the steel production plant to the automobile plant. In practice it is calculated as the revenue collected by each transportation mode for hauling steel prorated over the consumers of steel. In lieu of data on the specific modal mix and distance-of-haul for each consumer, each consumer is allocated a portion of the revenues from each mode proportionate to its value of steel consumed, reflecting the national average modal-mix and distance-of-haul.

When these allocations are completed for the flows of all commodities, each consuming industry has been assigned transportation costs for each of its inputs. This set of allocations, one for each transportation mode, is referred to as a transportation margin matrix; each column records the transportation costs (for a specific mode) on each of the inputs to a specific industry. The sum of each column represents the total transportation costs to the industry for a transportation mode. These totals are then entered as a row in the main I-O table, representing the allocation of transportation freight costs (revenues) for each mode to each industry. The commodity flows are expressed in producers' values and the transportation margin inputs (together with wholesale trade and other margins) account for the difference between producers and delivered values.

In the national table this procedure can be simplified by allocating the transportation margins to the producing industries. As long as transportation costs are allocated to consuming industries proportionate to transactions values, the exact same results will be obtained in model solutions by allocating the margins as a total to producing industries. The commodity flows then represent producers' values plus the cost of transportation.

Wholesale trade margins are handled in an identical fashion to transportation margins in the national I-O table. These margins also can be allocated to producing industries, eliminating the need for the wholesale trade margin matrix. In this case, the transactions flows in the main I-O table would be expressed in producers' values plus transportation and wholesale trade margins. Thus the intermediate transactions data could be expressed in values very close to delivered or purchasers' values, the exceptions being retail trade margins, of which 90% are allocated to final demand, and minor margins for insurance. (Excise and sales taxes are now allocated in the national I-O table either to producing industries or to wholesale or retail trade as a total for each type of tax -- the effect is the same as that suggested for transportation and wholesale trade above.)

Note: It is not contended that transportation and trade margins are always allocated to consuming industries proportionate to transactions in the national I-O table; rather this is the case in an overwhelming majority of the flows and an assumption of proportionality is a close approximation of what is now the case. This follows from the simple fact that information on how these margins apply to specific consuming industries is simply not available.

The assignment of transportation and wholesale trade margins to producing sectors eliminates two arduous procedures which are cumbersome and frustrating in both the development and updating of I-O tables, and lead to considerable complexity in exposition and interpretation of the tables:

1. The margin matrix procedure explained above. This procedure is cumbersome to perform, subject to tedious revision in every case of revision to transactions in the course of balancing the table, and equally tedious in updating the table.

2. The "unpeeling" of margins from purchasers' value to obtain the producers' values in which the transactions data are finally stated. Much of the data on materials and services purchased by each industry is available only in purchasers' or delivered values; adjusting these values to producers' values is a tedious task, subject to much error, adjustments that must be revised continually to be consistent with changes as they are made to the

transactions data. These adjustments are voluminous and are difficult to track, making it extremely difficult to maintain an audit trail from the original data. In the end, much time and effort is spent on maintaining specious detail which provides no additional information over a less elaborate procedure.

Transportation and Wholesale Margins at the Regional Level

The difficulties in allocating margins to consuming industries are compounded at the state level because of the manyfold increase in the volume of the data. Instead, it is proposed to allocate the transportation freight margins and wholesale trade margins to special distribution sectors established for this purpose. A further special treatment of retail trade margins will be employed.

There are a number of complications due to the existence of inter-state trade. Thus the transportation freight margins should be associated with the movement of interstate freight, as well as intra-state shipments. It is also difficult to identify the specific state impacts or incidence of inter-state transportation: How much for the originating state? How much for the terminating state? How much for the states that are traversed?

There is a further complication with the assignment of wholesale margins by state to producing industries. The best presumption is that wholesale trade activity is associated with consumption in each state which does not generally agree with amounts produced by each industry. If wholesale trade margins were allocated to producing industries in each state, shipments out of the state would implicitly be assigned wholesale trade activity that should properly be assigned by the receiving state. This kind of distortion on the wholesale trade imputs generated by the model must be avoided.

Fortunately, the solution to these complications is rather straightforward. The procedure requires the establishment of a separate distribution sector for each industry in each state, for each sector producing commodities (or services) subject to either transportation margins or wholesale trade margins. This presents no problem and requires no additional information; the work required is simply to segregate certain flows in the accounting conventions in the model. With current computer capacities for computation and data storage, no computational constraints need be a concern.

The flows are illustrated in matrix form in Figure 1. Production in each state is represented in the diagonal matrices; the off-diagonal matrices represent the trade flows (in the diagonal cells). Production sectors are labelled P and "sell" only to a state distribution sector, P', to distribution sectors in other states and to foreign exports (see for example, line A). The distribution sector, P', sells only to consuming industries and final demand within the state. All production inputs appear in the P column. State wholesale trade margins, for each commodity (MRIO group) are allocated wholly to the state distribution sectors, P's (lines B & E). In this way wholesale trade margins are allocated only to consumption within the state.

Transportation margin assignments are slightly more complex. Freight revenues will first be calculated for each commodity for each state-to-state link for each freight mode. There will be a large number of data items but they will be calculated by computer and stored for use, based on national revenue per ton-mile (converted to flows in dollar values), using a formula for each mode which reflects fixed terminal costs at origins and destinations and line-haul costs as a function of distance between state centroids (nodes). Intra-state freight revenues per dollar of flow for each commodity will also be calculated as an integral part of the inter-state flow procedure.

These revenues by origin-destination (O-D) link will be assigned, by a formula to be worked out, partly to the originating state and partly to the terminating state (revenues for intra-state shipments are allocated to the one state).[1] It is assumed that freight costs are paid for by consumers in the receiving state. Thus freight revenues will be allocated along with the trade flows to the distribution sector in the receiving state. For example, in Figure 1, railroad freight in state 1 is allocated to the shipment of glass products to state 2 (line C), in the column for P' in state 2. (Some railroad freight in state 1 is also allocated to P' in state 1 -- for intra-state shipments of glass products.) Some railroad freight from state 2 is allocated to this shipment also (line F), also in the column for P' in state 2. Thus freight costs become part of the value in state 2's distribution sector which is allocated to consuming industries and final demand in state 2. Thus the appropriate rail freight costs are always allocated to the customers in the receiving state, costs that reflect the distance of haul and the specific mode by which transported. (Other modal freight costs are allocated in similar rows, one for each mode -- to the same P' vectors as appropriate).

[1] *The assignment of freight transportation activity by state is necessarily a somewhat arbitrary procedure. These assignments must be calibrated with the mechanism that generates the demand for freight transportation in the model. Thus, the base-year output measures for freight transportation by state, will be developed as a fallout from the revenue assignment procedure.*

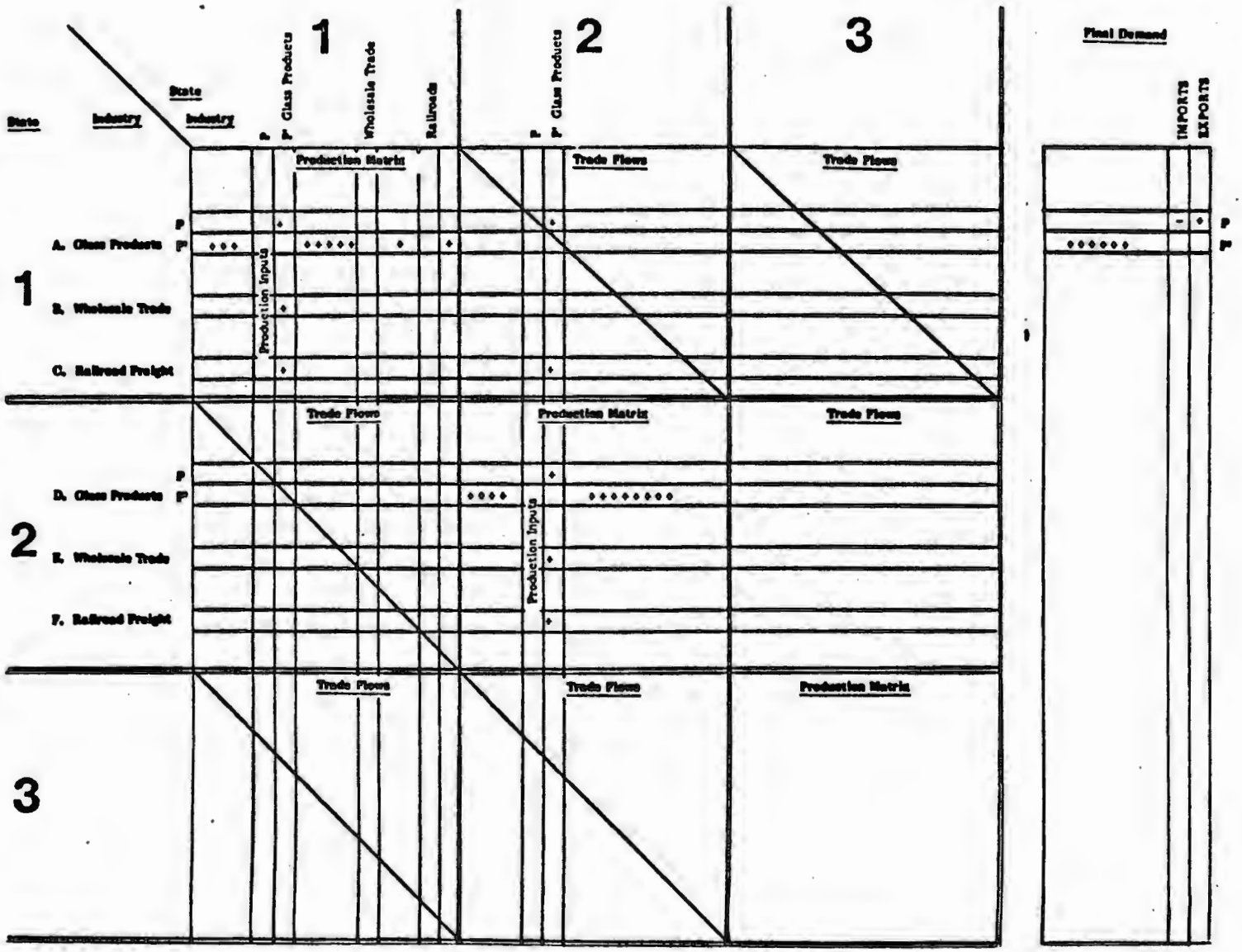


FIGURE 1: ALLOCATION OF TRANSPORTATION AND WHOLESALE TRADE MARGINS

Fortunately this procedure for handling transportation and wholesale margins is not as complex as it sounds -- it is simple straightforward accounting. It insures that margins in the correct amounts are assigned to the appropriate consumers within each state -- thus insuring that requirements for transportation and wholesale trade activity are "driven" by the appropriate demand wherever located by state. Updating is relatively simple since the margins are identified with specific flows and are shown as explicit data cells in the matrix.

Retail Trade Margins and Excise and Sales Taxes

Retail trade margins and excise and sales taxes also account for part of the difference between producers' values and purchasers' values of transactions. Since retail trade margins apply only selectively to consumers of each commodity, it is not appropriate to assign these to producing sectors (P), or to state distribution sectors (P'). Since they are allocated about 90% to personal consumption expenditures (PCE), they can be handled with few exceptions as extra detail carried in PCE, stipulated in final demand. For this purpose, several columns would be set up in final demand to record the margins on each commodity as illustrated in Figure 2. This will facilitate keeping track of the margins and taxes in stipulating final demand in model applications. Purchasers' values will be stipulated in each state and retail trade margins and excise taxes "pulled off" to derive producers' value including wholesale and transportation margins. This procedure will also facilitate the introduction of changes in excise taxes (in model applications), a topic of timely interest.

Retail margins to intermediate industries and other final demand account for only about 10% of total retail margins. These will be treated in the traditional way, i.e., allocated to sectors that consume the commodities to which the margins apply. However, the appropriate coefficients for this purpose will be estimated based on national coefficients without any precise tracking of such margins via a margin matrix.

Manufacturers' excise taxes will be allocated to the state distribution sectors discussed earlier, the P's, to avoid allocating these taxes to foreign exports. Wholesales excise taxes, either state or federal, will be allocated to these distribution sectors; this procedure allows state wholesale excise taxes to be allocated in a state-specific manner. Retail excise taxes will be handled exactly as retail margins are handled.

I-O Codes	Personal Consumption Expenditures				
	Producers' Value including Wholesale and Trade Margins	Retail Trade Margin	Retail Excise Taxes	Retail Sales Taxes	Purchasers' Value
	-				=
Totals		+	+	+	

FIGURE 2: RETAIL TRADE MARGINS AND RETAIL TAXES IN PCE

APPENDIX B.2

MRIO Procedures: No. 2
November 18, 1981

REDEFINITIONS AND SECONDARY PRODUCTS IN THE MRIO MODEL

Redefinitions in input-output tables are generally made to adjust for secondary products made in establishments, products that are principally made in other industries. It is necessary to assimilate the total output of each product into a single row for distribution to consuming industries since the industry of origin is not distinguished in the consumption data.

In a few cases it is desirable to separate data for products that have been grouped together in a single Standard Industrial Classification industry that are not in fact made in the same establishment, e.g., aluminum combined with other chemicals, -- this is not strictly a redefinition of establishment data but a separation of the statistics. The distinction is important since the first involves separating data for the basic reporting unit, the establishment, whereas the latter is simply a function of the establishment classification system. In many such cases, separate data are available for the activities involved. For example, in government enterprises certain activities are redefined to their private sector counterparts: electric and gas utilities and transit systems, among others; in these cases the data are simply compiled under the appropriate sector classification code and no separation of reported data is generally necessary. Thus, redefinitions of establishments within SIC codes are covered by the sector classification system and are not dealt with in this paper. The concern here is with redefinitions of products or services within the basic reporting unit, i.e., the establishment -- to adjust the establishment data to move these products to other establishment industry classifications.

In addition to redefinitions, other adjustments to industry data as collected are necessary due to undercoverage of the activities for whatever reason.

For purposes of discussion it is convenient to group redefinitions and adjustments in the MRIO model as follows:

1. Adjustments to establishment data to redefine the production process to a product or activity basis, eliminating the production of secondary products in each industry.

2. Adjustments to output measures (and transactions) to augment the observed measures for undercoverage due to:

   a. Work done on a contract basis for which contract fees are reported, understating the full value of the product flow. Examples: ores mined or refined on a contract basis, stumpage cut and logged on a contract basis, fabrics finished on a contract basis.

   b. Services rendered for which explicit payments are not made: banking services in lieu of interest payments, implicit rental services to owner-occupied homes. Most of these cases represent implicit economic flows recognized in the National Income and Product (NIPA) accounts as imputations.

3. Adjustments to establishment data for products that are primary to more than one SIC industry -- to redefine this production to the SIC in which it is primarily produced. These cases to some extent involve products that are produced as joint products or by-products in industries other than the principal industry of production. Examples: natural gas liquids produced as joint products in natural gas processing plants, produced as primary products in petroleum refining; processed and bottled milk produced on the farm, a primary product of the processed milk industry in manufacturing; wire rope and strand produced in wire drawing mills, a primary product of the wire product industry that makes its products from purchased wire. This category is a special case of category 1 above. Products in this latter category reflect integrated operations in which the raw materials for the products are made in the same industry and, to an extent the products are either by-products or joint products of producing the basic materials.

Categories 1 and 3 above involve the conflict between the classification of production activities on an establishment basis and on a product base. The conflict arises because input data on materials, fuels and labor are generally available for establish-

ments -- and not for products, whereas consumption data are available on a product basis and the specific industries of production are not distinguished. Thus, it is convenient to have the I-O table defined on an establishment basis for input definition (the columns) and on a product basis for the distribution of output (the rows).

ESTABLISHMENT/PRODUCT CLASSIFICATION BRIDGES

There are at least three ways to bridge the establishment/product classification problem.

Method 1

In the first input-output tables produced by BLS and BEA, the secondary products of an industry were transferred to the industry to which they are primary via a synthetic flow. In this case, demand for the product is always satisfied by production from the primary industry and from other industries in fixed proportions. This is mathematically convenient, but it is hard to find any plausible combination of circumstances that would require such stability of market shares.

In conjunction with this method, certain industries were also defined on a product basis, principally agriculture and construction. In the case of agriculture, the redefinition was limited to the agricultural industries -- sectors were simply defined by product groupings, and agricultural activity in other industries, which was of a limited nature in any event, was ignored. In the case of construction, a large amount of construction carried on in other industries, referred to as force-account construction, was redefined to the construction industries, defined on a product basis.

In addition to these two major redefinitions, a few other activities were redefined. These included manufacturing performed in trade and service establishments, retail trade carried on in service industries, services carried on in the trade industries, and selected services were redefined among the services industries. These redefinitions required appropriate adjustments to the establishment output measures and input data for these industries.

Method 2

The second method is to redefine all activities to a product basis by adjusting their establishment-based output to include all production of products primary to the industry and to exclude all secondary production; inputs are adjusted similarly to reflect primary product production only. This method avoids the "clumsy" transfer procedure of Method 1 but results in the distortion of the establishment based data beyond recognition. The inability to "track" the model results with establishment-based data is a serious drawback in interpreting model results and in updating the data in the model. This method is extremely tedious to implement even at the national level since information on the separation of inputs between primary and secondary production is lacking. Inevitably most of the input adjustments are made by "scaling" the inputs of the industry of primary production by the ratio between outputs as secondary and primary production. This is a dubious procedure in many cases. The problems of adjustment are compounded at the regional level; thousands of "scalings" would be necessary without substantial justification.

Method 3

This method is designed to maintain the input data on an establishment basis as far as possible while distributing each product, regardless of where made, in a single row. This assumes that outputs of the same product in different industries are substitutable to a large extent and requires no stability of market shares. It avoids the general adjustment of the establishment input data of Method 2. It also avoids the introduction of synthetic transfers and the augmentation (duplication) of establishment output of Method 1.

The basic approach is to treat secondary products as joint products of the industries producing them, with the output flows of these secondary products shown as negative inputs from the industry row to which they are primary. In this way primary products are always distributed in a single row, with negative offsets in the row for the amounts produced as secondary products in other industries. It assumes that, if two products are produced in the same establishment, it is usually because producing more of one of the products tends to reduce the input increments needed to produce more of the other. This tends to control output proportions.

The mechanics of this treatment in the matrix are illustrated in Figure 1. The flows for several products produced in some amounts as a secondary product in another industry are illustrated. The first example is milk, processed and bottled on the farm, and sold to final consumers (via wholesale and/or retail trade). This product is primary to milk processing, a manufacturing industry. A negative flow is shown in the Milk processing row, Agriculture column, to account for this production. The other entries in the Milk processing row account for the consumption of all processed milk produced, including that produced and sold from the farm. The sum of the product output is obtained by adding all the postive numbers and ignoring the negative number. The industry output for Milk processing (the control total for its column) is the alegbraic sum of its row (including the negative number). If it produced any secondary products, the value of these secondary products would be included in deriving its column sum. Thus, in the case of Agriculture, its output is obtained as the algebraic sum of its row plus the value of processed milk shown in its column.

The next example is that of natural gas liquids produced in gas processing plants which consist of gasoline and other products that are the same as products produced in Petroleum refining, the principal producing industry. (This is a case where the Standard Industrial Classification recognizes products as primary to more than one industry -- they are a joint product, in a truer sense a by-product, of gas extraction and processing). The flow is shown as a negative amount in the Petroleum refining row, in the column for Natural gas wells and processing plants.

The two other examples involve the Wholesale trade and the Meat processing industries. These examples are typical of a large number of cases in which wholesale trade has some manufacturing operations and, conversely, manufacturing plants perform their own distribution and sales functions. In the first example, cattle slaughtering, a primary function of the Meat processing industry, is performed in wholesale trade establishments. In the second example, Meat processing plants sell and distribute their products to retailers, a function of the Wholesale trade industry.

These examples illustrate the general case in which secondary products are treated as negative allocations in the row that distributes these products, in the column of the industry that produces them. The algebraic sums of each row and corresponding column

Producing Industry \ Consuming Industry	Agriculture	Milk Processing	Natural Gas Wells and Processing Plants	Petroleum Refining	Meat Processing	Wholesale Trade	Other Industries	Final Demand	Total Product Output
Agriculture (agriculture products)		40			60			200	300
Milk Processing (processed milk)	-10							120	120
Natural Gas Wells and Processing Plants (natural gas)	5	5		10	5	5	45	50	125
Petroleum Refining (petroleum products)	10	5	-10		5	10	60	40	130
Meat Processing (meat products)						-20		140	140
Wholesale Trade (wholesale trade margins)	10	5		10	-5		40	55	120
Other Industries (other products)	50	5	95	20	5	50		150	375
Value Added	235	50	40	80	50	70	230	735	
Total Industry Output Including Secondary Products	310	110	135	120	125	135	375		1,310

FIGURE 1: TREATMENT OF SECONDARY PRODUCTS IN THE MRIO MATRIX (ILLUSTRATIVE)

are equal; the sums of the product distributions and the inputs to the industry (the sums of the positive numbers in the row and in the corresponding column) differ by the amount of product output and industry output. Thus, the control total for the column is establishment output and all the inputs are establishment-based; the control total for the row is product output whereever produced. Thus the accounting system provides an easy transition from the establishment-based input data to the product output data.

This treatment of secondary products assumes that the secondary products are always produced in fixed proportions to the primary product. Although this assumption is certainly not completely true, it is believed to be acceptable in view of the limitations of the alternative methods of handling secondary products in the model. These limitations were discussed above under Methods 1 and 2.

PLANS FOR THE MRIO MODEL

It is planned to adopt Method 3 as described above wherever feasible in handling secondary products (and products primary to more than one industry) in the MRIO model. Several redefinitions will made, principally in force account construction (in a redefinition both output and inputs are adjusted in moving the activity from one sector to another). Finally, a number of adjustments will be made to coverage where the Census data understate the full value of output of specified activities.

There are a number of adjustments that affect a large number of industries. These will be discussed first below and then, the specific industry adjustments will be discussed.

Force-Account Construction

New and maintenance construction performed by employees of the establishment (rather than contracted for from the construction industry) is important in a number of industries. Adjustments will be made to specific industries that account for about 80 percent of this activity (in the 1972 BEA table) as listed in Appendix A. The initial data file records the data on an establishment basis but does not include the capitalized value of new construction in the output measures (maintenance construction is a cost that would not be included in the output measure in any event). The cost of materials control, value added, employment and payroll data will be adjusted in a special

Redefinition File that will permit these adjustments to be tracked back to the Initial Data File. The adjustments will be based on input patterns developed in the construction analysis. The Redefinition File will serve also to add these data to the appropriate construction sector file. Data for specific material inputs from central sources, e.g., fuels consumed, will also be adjusted for in the Redefinition File; other inputs will simply be developed to exclude any inputs for construction activity.

Manufacturers Resales

Goods bought and sold in the same form constitute a wholesale trade function. Some sales of this nature occur in most all manufacturing industries but is generally of minor significance. It is not appropriate to treat these receipts as secondary products and accord them the Method 3 treatment since the purchase value of the goods is not relevant to the wholesale trade industry (only the markup or margin on such sales is relevant). Thus to make the adjustment it is necessary to eliminate the value of the sales from output and the cost of the goods from cost of materials, and then compute the component costs of the margin (materials and labor) and move it to the wholesale trade sector. When this is completed, minor adjustments have been made to many data items without having added much to essential information provided by the model (wholesale trade is augmented in a relatively small way by an activity that is somewhat extraneous to it and the establishment data are distorted).

In view of all this, it is deemed more appropriate to keep the establishment data intact and to simply make a "wash" transaction to account for these sales that are included in the output measure for each industry. This is accomplished by allocating these sales to the industry itself on the main diagonal, i.e., an intra-sector transaction. This procedure maintains the integrity of the establishment data while "immunizing" the flow in terms of balancing output and input in the matrix.

Rental Receipts

All rental receipts, real or imputed will be redefined into the Real estate and rental sector, following the BEA convention. Since this is only a financial flow to property type income, no signficant inputs are associated with it and therefore no adjustment will be made to establishment-based input data. Rental receipts have been excluded

from the output data (they are not included in the Census output measures and have been excluded in developing the data for other sectors). The development of the data on real and imputed rents is described in the chapter for the Real estate and rental sector in the report on output, employment and payrolls.

Electric Energy Sales

Sales of electric energy by non-utility plants will be handled by Method 3 for secondary products, as described in this paper, to the extent they can be identified by industry and state.

Specific Adjustments, Redefinitions and Secondary Products

The specific treatment of coverage adjustments and redefinitions made by BEA in 1972 national input-output table are noted in the reproduced pages from Definitions and Conventions of the 1972 Input-Output Study, BEA Staff Paper, July 1980, attached as Appendix B. Only items of $200 million or greater value in 1972 have been considered. The planned treatement of each is noted by the following symbols:

- R - redefine; move output and inputs to appropriate industry. This is for cases where the input requirements for primary and secondary outputs are independent.
- A - adjust; generally made to increase Census flows for undercoverage.
- B - treatment of secondary products by Method 3 procedures. This is for cases where cost complementarities between primary and secondary products tend to fix the output proportions.
- I - no adjustment to output; allocate flow as intra-sector.
- X - no adjustment; either not deemed significant, it affects an intermediate flow not of interest, or a reclassification does not seem appropriate
- ? - not yet resolved.

Other Secondary Products

It is planned to make only a few adjustments for other secondary products. Generally, establishment output will be considered to be product output. In cases where the difference between industry output (establishment-based) and product output in the

national totals is minor (at the MRIO level of industry aggregation), no adjustments will be made. In cases where the difference is significant, secondary product flows will be introduced in appropriate rows to approximately balance out these differences. These flows will be introduced in accordance with the Method 3 treatment of secondary products.

APPENDIX B.3

MRIO Procedures: No. 3
January 11, 1982

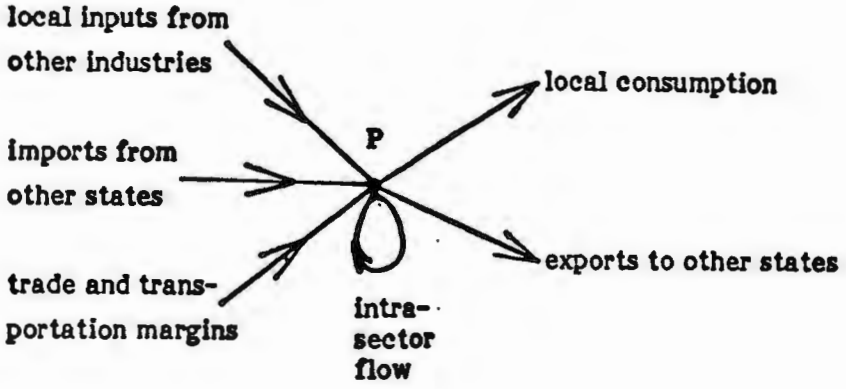
MRIO's MATHEMATICAL FORMULATION

In this paper the matrix formulation of the base year (1977) MRIO accounts is developed. Several new procedures have been introduced in the formulation of the accounts, including the use of separate activities in each state to serve as the distribution sectors for commodities consumed in the state (see MRIO Procedures No. 1), treatment of secondary products using a by-product approach (see MRIO Procedures No. 2), and the use of national and regional "clearinghouse" sectors to account for interstate service flows. Unlike previous regional models, trade flows and trade and transportation margins are incorporated explicitly into the table, an approach which will considerably simplify future updates and user applications of the model.

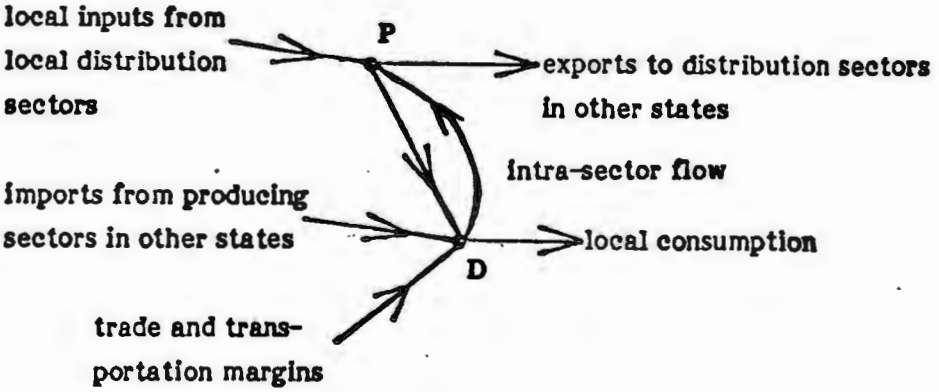
A comparison of the input/output link structure of the new margin and trade flow approach is compared to the traditional approach in Exhibit 1, with producing industries represented by a "P" and distribution activities by a "D". In the new formulation output of the producing industries (expressed in 1977 producer prices) is sold only to distributors while consumption (valued at 1977 purchaser prices) is supplied by the distributors to all users, including exports. In this paper distribution activities will be introduced for both commodity and service sectors, except for service sectors which have national clearinghouses. The distribution activities for the service industries are the only "dummy" sectors, since purchaser price is defined to equal producer price in these sectors. Hence no margins are charged and these "dummy" sectors serve only as a place holder in the matrix structure of the problem. The fundamental variables of the model are the primary product output of each industry in each state and the total consumption of each product in each state by both intermediate and final users. All other quantities of interest may be derived from the fundamental variables by a relatively simple post-solution calculation. An example of such a quantity would be the total output of a particular industry. Under the assumption of Procedures Paper No. 2, by-product production is assumed proportional to primary product production. Hence total output of the industry is a constant times primary output. If the percent change of total output is desired, this percent will be equal simply to the percent change in primary product output.

EXHIBIT 1

OLD



NEW



(output of P in producer price;
output of D in purchaser price)

The following notation will be used for the case of N industries and S states. It will be assumed that the industries are ordered such that the last n industries are service industries with associated national clearinghouses. All margin industries are assumed to have associated national or regional clearinghouse activities. For notational convenience we let n' = N-n+1 denote the index of the first industry in the ordering which has a clearinghouse. Unless otherwise noted indices extend over the full range of states and industries.

P_i^k : identifier for producing industry k in state i.

D_i^k : identifier for the distribution sector for product k (k = 1, . . ., N-n) in state i.

H^k : identifier for the national clearinghouse for service from industry k (k = n', . . ., N).

X_i^k = production (output) of primary product k by industry k in state i, in 1977 producer prices (i = H may also indicate the national clearinghouse for k = n', . . ., N).

C_i^k = consumption (both intermediate and final) of the product k (k = 1, . . ., N-n) in state i, in 1977 purchaser prices.

E_i^k = international exports of product k from state i, in freight-alongside-ship prices.

I_i^k = international imports of product k to state i, in domestic port prices.

Y_i^k = final demand for product k in state i, in purchaser prices.

$U_i^{k,l}$ = intermediate use (input) of product k (k = 1, . . ., N-n) by industry l in state i, in purchaser prices.

$B_i^{k,l}$ = by-products of type k (k = 1, . . ., N-n) produced by industry l in state i ($B_i^{k,k} = 0$), in producer prices.

$T_{i,j}^k$ = interstate (or intrastate) trade flow of product k (k = 1, . . ., N-n) moving from state i to state j, in producer prices.

$M_{i,j}^{k,l}$ = margin or interstate service flow purchased from sector k (k = n', . . ., N) in state i by the distribution sector l (l = 1, . . ., N-n) in state j, in producer prices (i may also identify the national clearinghouse).

G_i^k = allocation of national clearinghouse revenues to the producer for mode k (k = n', . . ., N) in state i, in producer prices.

It should be noted that clearinghouse and margin sectors, which have no associated local distribution sector, are treated uniquely in the above definitions. In particular, careful attention to the subscripting will show that no secondary production of a clearinghouse and margin service is defined, nor are margins paid by clearinghouse sectors. In addition, all distribution sectors purchase margins directly from the appropriate producing sector or national clearinghouse.

To aid in understanding the interrelationships of the quantities defined above, consider the particularly simple example of two industrial sectors (S = steel and F = foundries) and one transportation sector (R = railroads) in a two-state model. Exhibit 2 displays the appropriate MRIO table for this example, which utilizes a national-level rail clearinghouse to distribute the portion of interstate transportation margins which cannot meaningfully be assigned to the originating or destinating state. In this example, the steel and foundry industry in each state are represented by a producing and a distributing sector. The rail industry has no local distribution sector but has a national clearinghouse. Hence, in the notation introduced above, S = 2, n =1 and n' =N=3. Note that since the rail industry has no local distribution sector, final demand for rail transportation is satisfied directly by the producing sector for the rail industry. (Although in the two (or three) state example the clearinghouse approach may appear somewhat superfluous, its usefulness in the many state problem is immediately obvious.) In Exhibit 2, the sectors are arranged by state with adjacent producing and distributing sectors for each commodity. In Exhibit 3 the ordering of sectors has been sorted within states to group all producing sectors together, revealing the block matrix structure of the table. Reading across the first row of Exhibit 3, we obtain the following equation:

$$-X_1^S - B_1^{S,F} - B_1^{S,R} + T_{1,1}^S + T_{1,2}^S = 0$$

or,

$$X_1^S = T_{1,1}^S + T_{1,2}^S - B_1^{S,F} - B_1^{S,R} \qquad (1)$$

			REGION I					REGION II					NATIONAL RAILROAD CLEARING HOUSE	FOREIGN EXPORTS & FINAL DEMAND
			STEEL		FOUNDRY		RAIL	STEEL		FOUNDRY		RAIL		
			P_1^S	D_1^S	P_1^F	D_1^F	P_1^R	P_2^S	D_2^S	P_2^F	D_2^F	P_2^R		
REGION I	STEEL	P_1^S	$-X_1^S$	$T_{1,1}^S$	$-B_1^{S,F}$		$-B_1^{S,R}$		$T_{1,2}^S$					0
		D_1^S	$U_1^{S,S}$	$-C_1^S$	$U_1^{S,F}$,		$U_1^{S,R}$							$Y_1^S + E_1^S$
	FDY	P_1^F	$-B_1^{F,S}$		$-X_1^F$	$T_{1,1}^F$	$-B_1^{F,R}$				$T_{1,2}^F$			0
		D_1^F	$U_1^{F,S}$		$U_1^{F,F}$	$-C_1^F$	$U_1^{F,R}$							$Y_1^F + E_1^F$
	RL	P_1^R		$M_{1,1}^{R,S}$		$M_{1,1}^{R,F}$	$-X_1^R$		$M_{1,2}^{R,S}$		$M_{1,2}^{R,F}$		G_1^R	$Y_1^R + E_1^R$
REGION II	STEEL	P_2^S		$T_{2,1}^S$				$-X_2^S$	$T_{2,2}^S$	$-B_2^{S,F}$		$-B_2^{S,R}$		0
		D_2^S						$U_2^{S,S}$	$-C_2^S$	$U_2^{S,F}$		$U_2^{S,R}$		$Y_2^S + E_2^S$
	FDY	P_2^F				$T_{2,1}^F$		$-B_2^{F,S}$		$-X_2^F$	$T_{2,2}^F$	$-B_2^{F,R}$		0
		D_2^F						$U_2^{F,S}$		$U_2^{F,F}$	$-C_2^F$	$U_2^{F,R}$		$Y_2^F + E_2^F$
	RL	P_2^R		$M_{2,1}^{R,S}$		$M_{2,1}^{R,F}$			$M_{2,2}^{R,S}$		$M_{2,2}^{R,F}$	$-X_2^R$	G_2^R	$Y_2^R + E_2^R$
NAT. RAIL CLEARING-HOUSE				$M_{H,1}^{R,S}$		$M_{H,1}^{R,F}$			$M_{H,2}^{R,S}$		$M_{H,2}^{R,F}$		$-X_H^R$	0

S = STEEL
F = FOUNDRY
R = RAIL

EXHIBIT 2

			REGION I					REGION II					NATIONAL RAILROAD CLEARING-HOUSE	FOREIGN EXPORTS & FINAL DEMAND
			PRODUCERS			DISTRIBUTORS		PRODUCERS			DISTRIBUTORS			
			P_1^S	P_1^F	P_1^R	D_1^S	D_1^F	P_2^S	P_2^F	P_2^R	D_2^S	D_2^F		
REGION I	PRODUCERS	P_1^S	$-X_1^S$	$-B_1^{S,F}$	$-B_1^{S,R}$	$T_{1,1}^S$					$T_{1,2}^S$			0
		P_1^F	$-B_1^{F,S}$	$-X_1^F$	$-B_1^{F,R}$		$T_{1,1}^F$					$T_{1,2}^F$		0
		P_1^R			$-X_1^R$	$M_{1,1}^{R,S}$	$M_{1,1}^{R,F}$				$M_{1,2}^{R,S}$	$M_{1,2}^{R,F}$	G_1^R	$Y_1^R + E_1^R$
	DIST	D_1^S	$U_1^{S,S}$	$U_1^{S,F}$	$U_1^{S,R}$	$-C_1^S$								$Y_1^S + E_1^S$
		D_1^F	$U_1^{F,S}$	$U_1^{F,F}$	$U_1^{F,R}$		$-C_1^F$							$Y_1^F + E_1^F$
REGION II	PRODUCERS	P_2^S				$T_{2,1}^S$		$-X_2^S$	$-B_2^{S,F}$	$-B_2^{S,R}$	$T_{2,2}^S$			0
		P_2^F					$T_{2,1}^F$	$-B_2^{F,S}$	$-X_2^F$	$-B_2^{F,R}$		$T_{2,2}^F$		0
		P_2^R				$M_{2,1}^{R,S}$	$M_{2,1}^{R,F}$			$-X_2^R$	$M_{2,2}^{R,S}$	$M_{2,2}^{R,F}$	G_2^R	$Y_2^R + E_2^R$
	DIST	D_2^S						$U_2^{S,S}$	$U_2^{S,F}$	$U_2^{S,R}$	$-C_2^S$			$Y_2^S + E_2^S$
		D_2^F						$U_2^{F,S}$	$U_2^{F,F}$	$U_2^{F,R}$		$-C_2^F$		$Y_2^F + E_2^F$
NAT. RAIL CLEARING-HOUSE						$M_{H,1}^{R,S}$	$M_{H,1}^{R,F}$				$M_{H,2}^{R,S}$	$M_{H,2}^{R,F}$	$-X_H^R$	0
			PRODUCTION			CONSUMPTION		PRODUCTION			CONSUMPTION			

S = STEEL
F = FOUNDRY
R = RAIL

EXHIBIT 3

Equation (1) may be interpreted as stating that (in 1977 producer price) the steel industry in state 1 (P_1^S) must produce an amount of steel equal to the trade flows demanded by the steel distributors in states 1 and 2 (D_1^S and D_2^S) less the amount of steel produced as by-product by the foundry and rail producing sectors in state 1 (P_1^F and P_1^R). Similarly, the fourth row in Exhibit 3 (second row in Exhibit 2) yields

$$C_1^S = U_1^{S,S} + U_1^{S,F} + U_1^{S,R} + Y_1^S + E_1^S \qquad (2)$$

indicating that D_1^S must supply an amount of steel equal to the sum of the intermediate uses of steel by the steel, foundry and rail industries in state 1 plus the exports and final demand for steel in that state. To satisfy this demand, the fourth column of Exhibit 3 shows that D_1^S must purchase amounts $T_{1,1}^S$ and $T_{2,1}^S$ of steel plus the transportation margins $M_{1,1}^{R,S}$, $M_{2,1}^{R,S}$ and $M_{H,1}^{R,S}$ which are paid to the rail producing sectors in states 1 and 2 and to the national clearinghouse, respectively. Since the distribution sectors are assigned no value-added, a column equation

$$C_1^S = T_{1,1}^S + T_{2,1}^S + M_{1,1}^{R,S} + M_{2,1}^{R,S} + M_{H,1}^{R,S} \qquad (3)$$

may be written to show that the total output of D_1^S equals the producer value of steel consumed in state 1 plus margins. A similar column interpretation may be given to a producing sector column, except that for these sectors value-added, which is not shown in the sample table, is no longer zero. Using V_1^S to denote the value-added by the steel industry in state 1, column 1 of Exhibit 3 yields the equation

$$V_1^S + U_1^{S,S} + U_1^{F,S} = X_1^S + B_1^{F,S} \qquad (4)$$

indicating that the inputs on the left hand side of equation (4) are the amounts necessary to produce <u>both</u> the primary and secondary products of the steel industry.

The block matrix structure evident in Exhibit 3 may be exploited to express concisely the many-state table using a block matrix representation. We will use the following notation:

$$\underline{Y}_i = \begin{pmatrix} 0 \\ \vdots \\ 0 \\ Y_i^{n'} + E_i^{n'} \\ \vdots \\ Y_i^{N} + E_i^{N} \\ Y_i^{1} + E_i^{1} \\ \vdots \\ Y_i^{N-n} + E_i^{N-n} \end{pmatrix} \qquad (i = 1, \ldots, S)$$

$$\underline{U}_i = \begin{pmatrix} U_i^{1,1} & \cdots & U_i^{1,N} \\ \vdots & & \vdots \\ U_i^{N-n,1} & \cdots & U_i^{N-n,N} \end{pmatrix} \qquad (i = 1, \ldots, S)$$

$$\underline{B}_i = \begin{pmatrix} X_i^{1} & B_i^{1,2} & \cdots & B_i^{1,N} \\ B_i^{2,1} & X_i^{2} & \cdots & B_i^{2,N} \\ \vdots & \vdots & & \vdots \\ B_i^{N-n,1} & B_i^{N-n,2} & \cdots & B_i^{N-n,N} \\ 0 & 0 & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & X_i^{N} \end{pmatrix} \qquad (i = 1, \ldots, S)$$

$$\underline{T}_{i,j} = \begin{bmatrix} T_{i,j}^{1} & 0 & \cdots & 0 \\ 0 & T_{i,j}^{2} & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & & T_{i,j}^{N-n} \\ M_{i,j}^{n',1} & M_{i,j}^{n',2} & \cdots & M_{i,j}^{n',N-n} \\ \vdots & \vdots & & \vdots \\ M_{i,j}^{N,1} & M_{i,j}^{N,2} & \cdots & M_{i,j}^{N,N-n} \end{bmatrix} \qquad (i, j = 1, \ldots, S)$$

$$\underline{T}_{H,i} = \begin{bmatrix} M_{H,i}^{n',1} & \cdots & M_{H,i}^{n',N-n} \\ \vdots & & \vdots \\ M_{H,i}^{N,1} & \cdots & M_{H,i}^{N,N-n} \end{bmatrix} \qquad (i = 1, \ldots, S)$$

$$\underline{C}_{i} = \begin{bmatrix} C_{i}^{1} & 0 & \cdots & 0 \\ 0 & C_{i}^{2} & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & C_{i}^{N-n} \end{bmatrix} \qquad (i = 1, \ldots, S)$$

$$\underline{G}_{i} = \begin{bmatrix} 0 & 0 & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & 0 \\ G_{i}^{n'} & 0 & \cdots & 0 \\ 0 & G_{i}^{n'+1} & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & G_{i}^{N} \end{bmatrix} \qquad (i = 1, \ldots, S)$$

$$\underline{X}_H = \begin{bmatrix} X_H^{n'} & 0 & \cdots & 0 \\ 0 & X_H^{n'+1} & \cdots & 0 \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ 0 & 0 & \cdots & X_H^{N} \end{bmatrix}$$

where $$X_H^k = \sum_{i=1}^{S} G_{i,H}^k \qquad (k = n', \ldots, N)$$

Here $\underline{Y}_i$ refers to the final demand (plus exports) vector for state i, $\underline{U}_i$ and $\underline{B}_i$ refer to the use matrix and make matrix for state i, and $\underline{T}_{i,j}$ consists of an upper part which is a diagonal matrix containing trade flows of all commodities moving from state i to state j along its diagonal, with the clearinghouse and margin payments in the lower rows. $\underline{T}_{H,i}$ contains the payments to the national clearinghouse. The diagonal matrix, $\underline{C}_i$, has the state consumption of products along the diagonal. The matrices $\underline{G}_i$ contain the allocations from each clearinghouse to the local producers, while $\underline{X}_H$ contains on its diagonal the total output of each national clearinghouse. These diagonal entries, along with the diagonals of the $\underline{B}_i$ and $\underline{C}_i$ matrices contain the fundamental variables of the model.

The above definitions allows the use of a single block-partitioned account matrix, A, to represent the many-state model as follows. We define:

$$
A = \begin{array}{c|cccccccc|l}
 & \overbrace{\text{STATE 1}}^{} & & \overbrace{\text{STATE 2}}^{} & & & \overbrace{\text{STATE S}}^{} & & \overbrace{\text{NATIONAL CLEARING-HOUSES}}^{} & \\
\hline
 & -\underline{B}_1 & \underline{T}_{1,1} & \underline{0} & \underline{T}_{1,2} & \cdots & \underline{0} & \underline{T}_{1,S} & \underline{G}_1 & \\
 & \underline{U}_1 & -\underline{C}_1 & \underline{0} & \underline{0} & \cdots & \underline{0} & \underline{0} & \underline{0} & \text{STATE 1} \\
\hline
 & \underline{0} & \underline{T}_{2,1} & -\underline{B}_2 & \underline{T}_{2,2} & \cdots & \underline{0} & \underline{T}_{2,S} & \underline{G}_2 & \\
 & \underline{0} & \underline{0} & \underline{U}_2 & -\underline{C}_2 & \cdots & \underline{0} & \underline{0} & \underline{0} & \text{STATE 2} \\
\hline
 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \\
 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \\
 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \\
\hline
 & \underline{0} & \underline{T}_{S,1} & \underline{0} & \underline{T}_{S,2} & \cdots & -\underline{B}_S & \underline{T}_{S,S} & \underline{G}_S & \\
 & \underline{0} & \underline{0} & \underline{0} & \underline{0} & \cdots & \underline{U}_S & -\underline{C}_S & \underline{0} & \text{STATE S} \\
\hline
 & \underline{0} & \underline{T}_{H,1} & \underline{0} & \underline{T}_{H,2} & \cdots & \underline{0} & \underline{T}_{H,S} & -\underline{X}_H & \text{NATIONAL CLEARING-HOUSES}
\end{array}
$$

$$W = \begin{bmatrix} \underline{Y}_1 \\ \underline{Y}_2 \\ \cdot \\ \cdot \\ \cdot \\ \underline{Y}_S \\ \underline{O} \end{bmatrix} \qquad Z = \begin{bmatrix} \underline{X}_1 \\ \underline{C}_1 \\ \underline{X}_2 \\ \underline{C}_2 \\ \cdot \\ \cdot \\ \cdot \\ \underline{X}_S \\ \underline{C}_S \\ \underline{X}_H \end{bmatrix}$$

Here A is a square accounts matrix of dimension $q = S(2N-n)+n$ and W is the final demand (plus exports) vector of dimension q by 1. The column vector Z is of the same dimension as W and contains as its elements the entire set of fundamental variables, including the primary product output and the total consumption of the product for each industry in each state, plus the output of each national clearinghouse activity. In forecasting applications it will be necessary to solve for Z, hence this vector will be defined as the solution vector.

To convert the base year accounts matrix to a coefficient matrix suitable for forecasting applications, each column of A must be divided by the negative of the corresponding element of the solution vector. In other words, each column of A is to be divided by the element in that column which lies along the diagonal. The resulting coefficient matrix will then contain the number 1 along its diagonal. Using "a" to represent the coefficient matrix, we have

$$a_{i,j} = \frac{A_{i,j}}{A_{j,j}} \qquad (i,j = 1, \ldots, q)$$

The MRIO model may then be represented as a set of linear equations. The solution vector for a future year may then be obtained as a linear function of the exogeneously stipulated final demand vector for that year. The base year equation is

$$a Z^{77} = W^{77} \tag{5}$$

Assuming for now the invertability of the coefficient matrix, a, we may write the solution for the forecast year, represented by an asterisk, as

$$Z^{*} = a^{-1} W^{*} \tag{6}$$

Since the coefficient matrix is quite large (q approximately 12,000), actual inversion of the matrix may not be the most efficient method of obtaining solutions. An alternative method is to expand the inverse in a series expansion. We note that since the matrix a contains ones along its diagonal the required inverse may be written formally as

$$a^{-1} = (I - L)^{-1} = I + L + L^{2} + \ldots \tag{7}$$

where the matrix L = I-a contains zeroes on the diagonal. Existence and convergence properties of the series expansion in equation (7) remain to be investigated. Determination of such properties is complicated by the fact that L contains both negative and positive values, hence convergence will not be monotonic.

APPENDIX C

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