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Constructing and Implementing Multiregional Models for the Study of Distributional Impacts

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CONSTRUCTING AND IMPLEMENTING MULTIREGIONAL MODELS FOR THE STUDY OF DISTRIBUTIONAL IMPACTS

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by

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Preface

This is one in a series of reports being written by the multiregional planning (MRP) staff on the theoretical, accounting, and empirical issues related to the structuring of the business sector and product market of the multiregional policy impact simulation (MRPIS) model for the Social Welfare Research Institute, Boston College. The section of this report on multiregional models is revised from the "MRPIS: Literature Review for the Partial Response Version of the Multiregional Policy Impact Simulation Model." An initial version of the remainder of the report was completed in August 1981 for the Seventeenth General Conference of the International Association for Research in Income and Wealth in Gouvieux, France. At the time the present version of the report was completed (May 1982), funding of the MRP staff for the MRPIS project had been terminated. The discussion in the report, however, reflects the directions the research will take if additional funds are made available.

In the first part of the report, the interrelationships among economic theory, accounts, and models are discussed to highlight some of the basic issues that were being reviewed by the MRP staff during the MRPIS research. The two issues of industrial classification and secondary products are discussed in the last sections of the report. This version of the report will be published in a volume of papers being edited by Reiner Stäglin from the conference on the International Use of Input-Output Analysis, which was held in Dortmund, Germany, May 27-28, 1982. The reference is: <u>International Use of Input-Output</u>

Analysis, Proceedings of an International Conference on Input-Output. Dortmund, May 1982, Sonderhefte zum Allgemeinen Statistischen Archiv, Nr. 19, Verlag Vandenhoeck & Ruprecht, Göttingen, 1982.

Constructive criticism of the material presented in the report would be appreciated.

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TABLE OF CONTENTS

Constructing and Implementing Multiregional Models for the Study of Distributional Impacts

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The purpose of this paper is twofold. First, some of the general factors influencing the construction of multiregional economic accounts and models will be discussed; then, the issues that arise in regard to specifying industrial classifications and methods of treating joint products in accounts and models will be set forth. Although these are only two of the many issues that emerge in structuring multiregional economic accounts and models, both have significant implications for the design of an overall framework of analysis and illustrate the interrelationships that exist among theories, accounts, and models.

Several points will be emphasized throughout the paper. First, underlying all current multiregional economic models is a set of economic theories, data, techniques, assumptions, and so on. In order to make an appropriate comparison and evaluation of such models, it is important to specify the interrelationships explicitly. Second, data from the economic accounts form important inputs when economic models are empirically tested. The structuring of those accounts, therefore, must form a significant part of the work in developing a multiregional model. Multiregional accounts may be structured differently from corresponding national accounts because of the particular types of policy issues involved and the types of interrelationships that need to be taken into account. Third, even an

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*Professor of Regional Political Economy and Planning, Department of Urban Studies and Planning, Massachusetts Institute of Technology. Members of the multiregional planning staff who helped to structure the 1977 multiregional input-output accounts discussed in this paper include Ramon Bueno, Randall Crane, William Crown, Peter Jordan, and Lorris Mizrahi. An earlier version of the paper was presented at the Seventeenth General Conference of the International Association for Research in Income and Wealth, Chateau de Montvillargene, Gouvieux, France, August 17-22, 1981. The research reported in this paper was funded through subcontract No. PO 52836, 482-1 with the Social Welfare Research Institute, Boston College, under a grant from the office of the Assistant Secretary of Policy and Evaluation, U.S. Department of Health and Human Services.

accounting framework and a model that on the surface appear to be simple and straightforward have a vast number of interrelationships that must be considered simultaneously. Fourth, of the many different multiregional models being constructed, input-output models are the ones that include the most direct interface with the construction of economic accounting frameworks. Yet, all multiregional models use accounting information to some degree. Although the accounting consistency requirements are not always directly imposed on these alternative models, they should be considered as the models are designed and implemented. Fifth, analysts are becoming more sophisticated in terms of trying to link multiregional models. One example is the attempt by Kort and Cartwright (1981) to connect the National-Regional Impact Evaluation System (NRIES) and the Regional Impact Evaluation System II (RIMS II) models to provide a link between an econometric model and an input-output model. Another example is the combining by the Social Welfare Research Institute et al. (1981) of the multiregional input-output (MRIO) and the microsimulation transfer income maintenance (TRIM) models into a comprehensive analytical system to study distributional impacts of government policies to form the multiregional policy impact simulation (MRPIS) model. As different types of models are combined, it is becoming increasingly important that the nature of the interrelationships between theories and accounts and models be made as explicit as possible to assure that the models being used are structured appropriately. Sixth, and final, the successful development of a multiregional model requires knowledge of the potentials and limitations of economic theory, economic data, mathematics, computer techniques, and the interfaces between economic policy and theory. Research on income generation and distribution must also take into account the historical context and institutional structure within which certain economic policies are being proposed and also the political, economic, social, and physical ramifications of these policies. To the extent possible, examples of these points will be provided in the paper.

I. Interrelationships Among Accounts, Theories, and Models

The current literature on multiregional analysis deals with many different factors, such as economic theory, regional accounts, estimation techniques, economic models, mathematical structures, statistical analyses, computer programs, and so on. These factors are usually discussed in abstract from their interrelationships with one another. As a comprehensive multiregional economic model and accounting framework are developed, it is important to consider the interrelationships among these many different factors. The author's experience with two multiregional models and accounting systems will be used here to illustrate the types of issues that come under consideration. The first is the 1963 MRIO accounts and model. The second is the 1977 MRIO accounts and the MRPIS model with which the 1977 accounts will be used. In addition, other multiregional models will be used to illustrate some specific issues.

The 1963 MRIO accounts provide an extensive multiregional accounting framework that includes state interindustry accounts for each of the 51 regions of the United States (50 states plus the District of Columbia) and 79 industries. These are linked to a set of interregional trade accounts for each of the 51 regions and 79 industries. The MRIO model is a comprehensive, multipurpose tool that can be used for systematic studies of many regional economic policies. It provides a consistent framework for describing and analyzing not only the sales and purchases of all industries in every region of the economy, but also the shipments to and from all regions. The dual version of the model can be used for analyses of regional wages and prices. Some of the assumptions, such as fixed input and trade coefficients, that at times constrain the usefulness of the primal and dual versions of the model are discussed later. Because both industries and regions are strongly interdependent, the MRIO model provides a useful way of measuring the direct and indirect effects of variations in economic activities throughout the country. For example, it can be used to show how a purchase in one region generates a chain of transactions affecting industries in many regions. If the MRIO framework has been correctly specified, the outputs required from each region to fulfill the given demand and the resulting interregional shipments of all goods needed for the production of those outputs can be accurately measured. Additional details on the accounts and model are provided in the book by Polenske (1980).

The 1977 MRIO accounts are similar to the 1963 MRIO accounts, but are for 120, rather than 79, industries, and provide greatly expanded detail in the value added and final demand components of the accounts. Because the overall accounting structure and data assembly will not be completed until the fall of 1982, only a few of its features will be discussed in this paper. Funds to assemble the MRIO data were made available in 1980 specifically to obtain 1977 data for use in the MRPIS model, but the data will also be useful as inputs in many of the other U.S. multiregional models. The MRPIS model is eclectic in nature in that it combines aggregate Keynesian demand, input-output, neoclassical, and institutional economic theories. It is composed of a business sector, a household sector, a product market, and a labor market. Thus, the full circular flow of activity can be traced.

By incorporating institutional analyses into the overall framework, various imperfections in the product, labor, and capital markets (such as structural unemployment and discrimination on the basis of sex, race, and ethnicity) can be explicitly addressed. The use of an eclectic set of theories is a departure from most currently available U.S. multiregional models, which use only one theoretical structure, as in the RIMS II model by Cartwright, Beemiller, and Gustely (1981), or link two structures, as in the Kort and Cartwright (1981) model. An initial version of the MRPIS model was based upon the REgional, Sectoral, and INcome Distribution (RESIND) model developed by Golladay and Haveman (1977) to analyze impacts of federal tax-transfer policies. An important attribute of the MRIO portion of the MRPIS and RESIND models is the detail provided on state-to-state gross shipments of all goods and services. None of the other available U.S. multiregional models are structured to incorporate state-to-state detail on interregional trade. Additional details on the MRPIS six-year research strategy are available in a report prepared for the Department of Health and Human Services by the Social Welfare Research Institute, Boston College; the multiregional planning (MRP) staff, Massachusetts Institute of Technology; and Sistemas, Inc., Washington, D.C. (1981).

Figure 1 illustrates some of the linkages that may occur among the different factors that are used for economic accounting and modeling studies. To structure a multiregional accounting and modeling framework, all major dimensions of economic theory must ultimately be considered. Thus, choices must be made as to the relevant production, consumption, investment, trade, fiscal, monetary, and other theories to use. (One choice, of course, is not to deal explicitly with the theory.) For the MRPIS model, for example, the fixed-input-coefficient (input-output) production function, which has constant returns to scale and zero elasticity of substitution, was selected instead of, say, a Cobb-Douglas production function. The model also is based upon Stone's (1954) linear consumption expenditure system, but there is no explicit theory of interregional trade, such as the comparative cost, Heckscher-Ohlin,

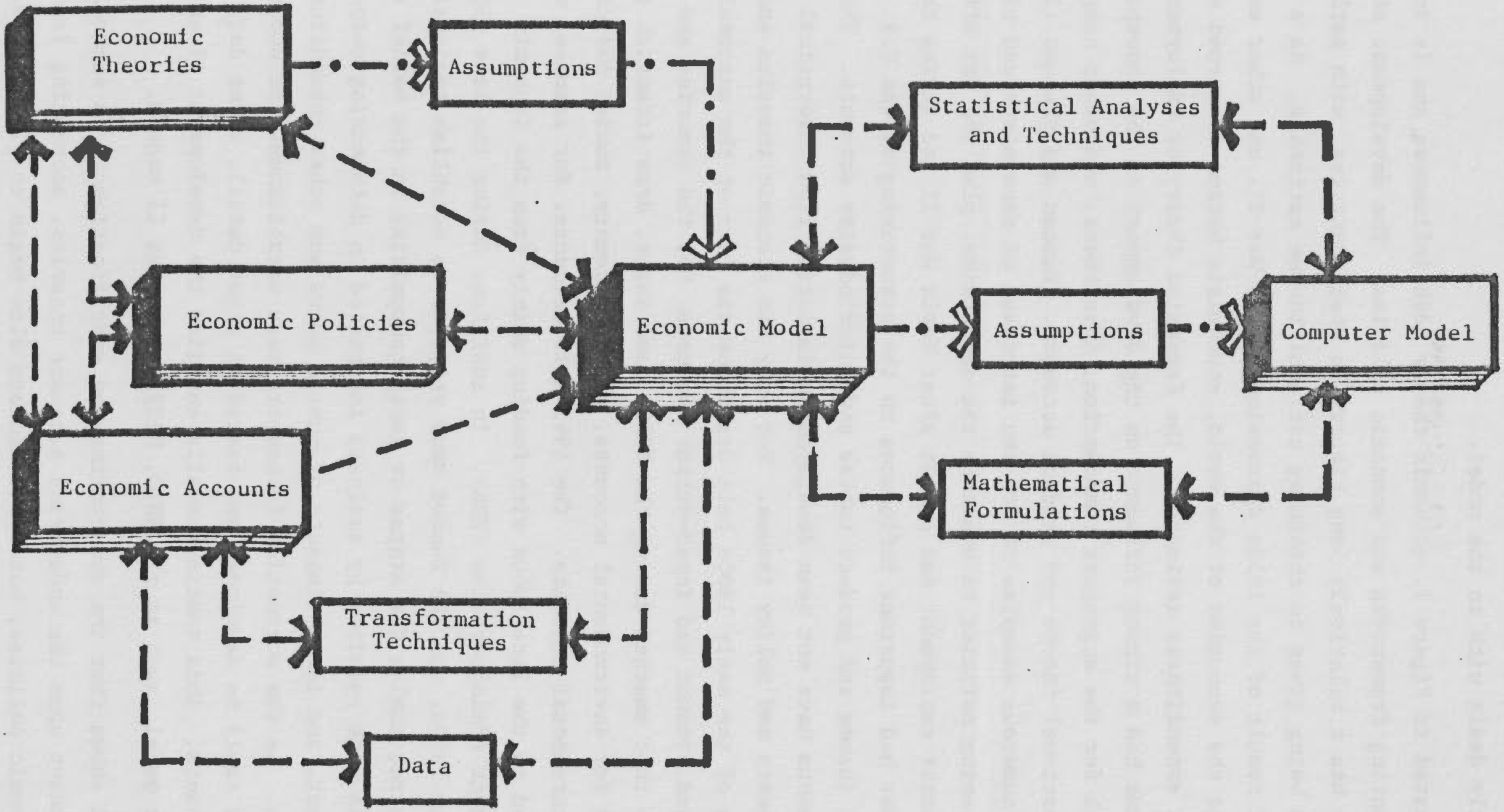

Figure 1. Components of Constructing and Testing an Economic Model

or monopoly and discrimination theories. Also, monetary theory is not explicitly dealt with in the model.

As indicated in Figure 1, economic theory both influences and is influenced by accounting frameworks and economic policies. The development of national accounts has a relatively long history in most countries, with early emphasis being given to obtaining national income estimates. As a combined result of the 1930s depression, World War II, and other events affecting the economies of the world, economists became concerned with national expenditures estimates. The Keynesian theory of employment and income had a strong influence on the development of the conceptual framework for the aggregate consumption, investment, and other components of the national income and product accounts. Duncan and Shelton (1978) provide numerous examples of how the interests of economists and planners in developing policies to overcome the depression, plan the war effort, and forecast employment and output after World War II and during the Korean War had important influences on the structuring of the U.S. national income and product tables and interindustry accounts. Thus, the accounts have not been developed in isolation from theoretical developments and policy issues. Not only did economic theories and policies of the early 1900s help determine the form of the national income and product and input-output accounts, but the theories and policies that emerged during the 1950s, and later, drew attention to the need for environmental accounts, energy accounts, social indicators, and multiregional accounts. The 1963 MRIO accounts, for example, were assembled in the late 1960s with funding mainly from the Economic Development Administration (EDA). In addition, during the late 1960s and early 1970s, the EDA funded many projects to establish regional input-output tables for states or local communities in the belief that such data were required by analysts interested in determining output, employment, and income impacts of public works and other expenditures programs. As the accounting frameworks were established, the economic theories could be developed and tested in great detail, using data from the accounts. This testing usually entailed the development of an economic model, such as the MRIO, NRIES, and RIMS II models.

Figure 1 shows that the structuring and specification of an economic model is dependent upon the underlying economic theories, accounting frameworks, and economic policies, but other factors also begin to play a role. The transformation of an economic theory into a form useful for structuring an economic model generally requires the application of certain assumptions pertaining to the production, consumption, trade, or some other theory. Throughout their book, Deaton and Muellbauer (1980) discuss the many interactions that occur among theories, policies, data, and the assumptions. They discuss Stone's linear expenditures system, for example, and state that ". . .Stone consistently uses the theory to define and modify the equations to be applied to the data" (Deaton and Muellbauer, 1980, p. 61). Stone applied the homogeneity restriction to the logarithmic functional form of the expenditures system to reduce the number of parameters to be estimated. Earlier, Leontief had applied the assumption of fixed technical coefficients to the interindustry relations in the input-output model for the same reason, that is, to reduce the number of parameters in the economic model. Thus, some data may be used directly without reference to an accounting structure, or sometimes the data from the accounting structure must be transformed through the application of certain techniques.

The economic model is often very fully detailed, usually through the use of equations, but to implement and test it, certain assumptions and techniques must be applied as it is formulated into a computer model. As Moses (1955), for example, implemented his multiregional model, he had to assume that Interstate Commerce Commission rail waybill data were representative of state-to-state shipments for all modes of transportation. Thus, his computer model was implemented using rail data, rather than the total transportation data implied in his economic model. The computer version of the economic model may therefore be far less complete than the original economic model. In order to implement and test the economic model, the economic analyst should be fully aware of the mathematical structures of the system, such as linear versus nonlinear relations, and of the statistical procedures, such as regression, analysis of variance, and logit models, that are available for use. Far from being a simple endeavor, the construction and implementation of a multiregional model cover many areas of economics, mathematics, statistics, and computer science, as well as ideally including consideration of the political, social, and physical environments.

As just noted, in economic models, the theoretical structure will vary as the accounting structure varies, and vice versa. A short discussion of national accounts and theories will help to illustrate this statement. The comprehensive production concept used in Western economies attributes value to inputs of all services, whereas the limited material production accounting concept used in economies oriented toward socialist economics does not place a value on the inputs of these services. Thus, the definition of the production function, while mathematically expressed in the same notational form, has a different meaning in terms of what inputs are included in the determination of the final set of outputs in value terms. In fact, the definition of value itself differs. The accounting framework, therefore, in a Western economy will reflect different theoretical valuations of goods and services than will an accounting framework developed for a socialist economy. Stone (1970) compares the System of National Accounts (SNA) and Material Products System (MPS), showing the differences and similarities between the two accounting frameworks. When economic models of income distribution are developed using the alternative accounting structures, the theoretical meaning of the model and the data used for the testing of the model will be different.

The theoretical approach for determining the employment and income impacts of government policies in the MRPIS model requires that the MRIO accounting structure be developed in an expanded form. In the formulation of the MRPIS model, stress is placed on the behavior of the individual household in determining the aggregate consumption behavior. The household sector is therefore treated in considerable detail, using microdata sets, the treatment of which requires that the detailed components of the value added and final demand portions of the MRIO structure be thoroughly specified. In the 1963 accounts, value added was treated as a single item; for the 1977 accounts, it is separated into three components (compensation of employees, indirect business taxes and business transfer payments, and property-type income), reflecting the payments to the various factors of production. In addition, the 1963 MRIO final demand portion of the accounts was fully specified only for the six major components of gross regional product. Personal consumption expenditures were assembled by 32 income distribution categories, state and local government expenditures were determined for 15 functions, federal government expenditures were constructed for military and nonmilitary components, and private investment was estimated in terms of state capital-flow matrices (showing producing and purchasing industry for plant and equipment). Even so, the accounting structure and definitions were never fully specified for this amount of detail, and the final estimates were provided to the public only for totals of each final demand category. The 1977 accounts contain considerable detail for each of the six major components.

As the accounting framework is more fully detailed for the 1977 than for the 1963 MRIO accounts, the theoretical issues that have long plagued the accounting community begin to take much more explicit forms: What is the relevant concept of an income flow? What is the theoretical base for making various imputations? Is the theory of investment for government capital formation different from that for private capital formation? How can the incomes accruing to different factors of production be represented in the accounts in order to test various theories of income distribution and in order to determine how the effects of different government policies on corporations and individuals can be analyzed? What is the potential usefulness of microaccounts in multiregional models? The work by Richard and Nancy Ruggles on microaccounts (1981) may be of particular relevance if extended to the multiregional level.

The spatial dimension augments the number of interactions among all aspects of the model-development work that must be considered, as well as increasing the number of techniques, statistical tests, and mathematical procedures available for use. Location quotients, gravity models, shift-share techniques, and transportation versions of linear programming models are a few of the many tools that a regional analyst may use in the process of transforming economic theories and accounts into a computer model for the analysis of income distribution and other policy issues. Complications arise in the use of these tools when the structure of the data and the behavioral relations employed at the regional level vary from those employed at the national level. Although the RAS procedure, for example, has been used successfully to adjust data in national input-output tables (Paelinck and Waelbroeck, 1963), its application to the adjustment of U.S. interregional trade data creates instances where the iterations do not converge because of the structural characteristics of the trade data (Möhr, 1975). Another example is data that may be readily available for national accounts, such as purchases of goods and services by the federal government, may be far more difficult to assemble on a consistent basis for a set of multiregional accounts. As noted earlier, however, it is important for the regional analyst to be as fully aware as possible of the advantages and limitations of each of the major aspects of the work involved in constructing economic accounts and models.

The stress in this portion of the paper has been on the interrelationships that exist between economic theories, accounts, policies, models, and other factors that play a role in the development of multiregional models. Only a limited number of illustrations have been given related to a few of the current U.S. multiregional accounts and models. Many more could be provided. At the national level, the recognition of these interrelationships is implicitly evident in the significant contributions to economic theory, accounts, and models made by Leontief (1951b), Stone (1961), and Ruggles and Ruggles (1970). The work on social accounting matrices at the World Bank by Pyatt and others (1977) should also be emphasized, in that they have tried to help to establish viable accounting frameworks and economic models for developing countries to use for income distribution analyses.

II. U.S. Multiregional Models

The similarities and differences in the theoretical and accounting structures of the various U.S. multiregional models are initially less obvious than those related to capitalist and socialist economic theories and accounts, but an understanding of them is nevertheless important for determining the advantages and limitations of particular multiregional economic models for use in distributional or other studies. Some of these similarities and differences are covered in this section.

As indicated in the previous section, the underlying theoretical and accounting structures of the MRIO and MRPIS models involve production, consumption, and interregional trade relationships. In both models, at present, the production theory being used is one of an input-output form with fixed input coefficients; production is assumed to be a function of all the material and primary inputs used in producing the output. The fixed input-coefficient production function can be used with a wide variety of accounting structures and economic models. Although its appropriateness is frequently challenged, extensive empirical tests at the national level by Carter (1966, 1967, 1970), Vaccara (1970), and Vaccara and Simon (1968) tend to support its continued use. All of these national studies indicated that during the 1940s and 1950s changes in the technology in the United States occurred slowly for most industries, exceptions being the aircraft, instruments, and coal-mining industries. The dominant feature of the change in input requirements was an across-the-board decrease in labor inputs. Similar tests at the regional level are not available for the United States.

While the MRIO and the initial version of the MRPIS models use identical production functions, they vary considerably in terms of the method of determining income and employment impacts. The MRIO model has already been used to generate income impacts. For the determination of the level and distribution of income in different regions and industries, the MRIO model is partially closed with respect to households by making the personal consumption expenditures column and the wage and salary row for each respective state input-output table part of the endogenous portion of the model. An example of this methodology is provided in the paper by DiPasquale and Polenske (1980). In the initial runs of the MRIO model, average consumption expenditures were used.

A theoretical alternative to this version of the MRIO model was developed by Shalizi (1980), based upon Miyazawa's (1976) concept of a partitioned matrix multiplier. Miyazawa's formulation utilizes disposable personal income (rather than wages), marginal consumption coefficients (rather than average consumption coefficients), and an aggregate marginal propensity to consume of less than one (rather than the equality between the supply and demand of the household sector). These conditions are required in order to embed the Leontief form of structural interdependence in production into the broader Keynesian framework. Shalizi adapted Miyazawa's methodology to the MRIO model. He introduced the Keynesian consumption function on a disaggregated level and, consequently, began to deal with the structure of income distribution by determining the additional income that is generated in the process of producing an extra dollar of final demand through the inducement of further consumption, more production, and hence more income. By explicitly incorporating the income formation and distribution process into an augmented version of the MRIO model, Shalizi was able to evaluate the overall income effect of exogenous changes to the regional system.

Until the formulation of the RESIND (Golladay and Haveman, 1977) and the MRPIS (Social Welfare Research Institute et al., 1981) models, induced income effects were either neglected in multiregional models or were calculated, as indicated above, by closing the input-output model with respect to households. The direct, indirect, and induced impacts are determined sequentially in the RESIND and MRPIS models. The reduced form of the open MRIO model is used in each case to determine the direct and indirect effects. To determine the induced impacts, the direct and indirect effects are traced sequentially as they impact first upon the number of laborers demanded and supplied in each region, then (through use of a microsimulator) upon the income generated by each individual household in the region, and then upon the demands made by those households for consumer goods. Several iterations can be used to trace the circular flow. In most cases, the results from the computer model will only approximate the "true" circular flow represented by the economic model. The fixed technology assumptions may pose a problem in all static input-output models; in the MRIO, MRPIS, and RESIND models, the assumption of fixed trade coefficients is also made. These assumptions can be relaxed only if a dynamic multiregional economic model were formulated and then only if sufficient data were available to implement the model. Empirical testing is required to determine how critical these fixed-coefficient assumptions are for various regional policy analyses. It should be noted that for the MRIO and MRPIS models, technical coefficients are determined from actual state data, rather than being adjusted from national coefficients. The multipliers in the models are determined not only with the use of state-differentiated technologies, but also the interregional trade effects among the industries in all regions are explicitly accounted for by using the trade-flow tables constructed from state data on interregional flows of commodities and services. A comprehensive analysis of the interregional linkage effects in the MRIO model is contained in two publications by Crown (1981, 1982).

Other U.S. multiregional models that are based on an input-output theoretical structure for the determination of multiplier effects include the Income Determination Input-Output Model (IDIOM), developed by Dresch (1980); the RIMS II model, developed by Cartwright, Beemiller, and Gustely (1981) at the Bureau of Economic Analysis, U.S. Department of Commerce; and a model developed by Stevens, Treyz, and others at the Regional Economic Models, Inc. (REMI). One of the basic differences between these three models and the MRIO model is in the way the direct and indirect component of the multiplier is structured. Only the MRIO model contains explicit information on interregional linkages as expressed by state-to-state shipments.

In the IDIOM model, interregional trade is treated on a net basis, the technical input coefficients for each region are based upon national coefficients. It is structured along the lines of the Leontief intranational model. In 1953, Leontief proposed one of the first multiregional models, extending the concepts of the economic-base model into an input-output format (Leontief, 1953). Industries in the IDIOM model are separated into basic (national) and nonbasic (local) types, with the specification depending upon the origin of demand for the output of the industry.

The multipliers provided by IDIOM are considerably more detailed than the early single-region, economic-base models, and in contrast to the econometric models, the multipliers can be easily determined. The structural characteristics of this model make it relatively easy to obtain the required regional data, and the computations are easily performed. The analyst, on the other hand, is confronted with a model that contains many unrealistic elements. As an example, the model is usually implemented using national technologies for each region, in which case the interindustry structure of the multipliers only reflect the national linkages between industries. Outputs for the basic (national) industries are allocated to regions using regional proportions of output in the base period; therefore, only the level, not the percentage distribution, of the output for these industries can vary for different policy analyses. In addition, and most important, only net, not gross, interregional trade flows are determined; there are no interregional feedbacks in the model. It was, in fact, these and many other disadvantages of the intranational model, which was being used at the Harvard Economic Research Project in the 1960s, that led to the development of the MRIO model.

The RIMS II and REMI models are similar in structure. For both models, multipliers are calculated with the use of detailed national (presently 1972) input-output coefficients that have been adjusted to reflect regional variations in technology and trade structures. Location quotients are used in RIMS II and regional purchase coefficients are used in REMI to make the adjustments. The industry detail is extensive, about 500 industries in each case. In neither model are the interregional trade effects directly incorporated into the structure of the multiplier. The REMI multipliers only take account of the intraregional (shipments within the region) trade effects, and even that intraregional trade component is not calculated within a consistent multiregional accounting frameowrk and therefore may not reflect properties consistent with the other regional data used to calculate the multipliers. The REMI regional-purchase coefficient is based upon the assumption that intraregional purchases are systematically related to comparative delivered costs. A regression equation is then used to estimate the comparative delivered costs as a function of relative production costs, industrial concentration, weight-to-value ratios, and the spatial density of suppliers. Proxies for each measure are developed from published data. The induced effects in the RIMS II model are calculated in the same way as for the MRIO model, that is, by partially closing the model with respect to households. The regional wage and salary row is based upon value-added-to-gross-output ratios from the national 496-industry input-output table, and the regional personal consumption expenditures column is based upon national consumption and savings-rate data and national and regional tax-rate data. Both the RIMS II and REMI models can be used for impact analyses at the county level. Two major problems exist with either the RIMS II or the REMI multipliers. First, they rely upon adjustment of national coefficients for the determination of regional technologies. Second, the interregional linkage effects are either only indirectly accounted for (RIMS II) or partially accounted for (REMI).

Econometric multiregional models are also available in the United States for the determination of multiplier impacts. The structure of the multipliers in these models is difficult, if not impossible, to determine in the explicit detail that is possible in input-output models, because the structure of the econometric model itself can so easily vary. Macroeconometric models are used to determine multiplier impacts by statistically fitting cross-section and/or time-series data to particular functional equation forms. As the number and type of variables included in or excluded from the model change and as the structure of the equation system changes, the structure and size of the multipliers will vary. Because of the tremendous flexibility in structuring the economic relationships, the econometric models are very appealing to many policy analysts. Glickman (1977, pp. 71-77) differentiates three types of multipliers that can be determined with econometric models, depending upon the linearity of the system and upon whether static or dynamic analyses are desired. He calls them "impact multipliers," "interim multipliers," and "dynamic multipliers."

The many statistical problems associated with regional econometric models are reviewed in detail in publications by Glickman (1977), Pleeter (1980b), and Czamanski (1972). The three major problems that arise are the scarcity of time-series data even for single regions, let alone for many regions; the difficulties of specifying the true relationships among the economic parameters; and the total dependence of the regional variables upon national variables, rather than showing relationships to other regional variables (Polenske, 1981, p. 26). According to Glickman, Czamanski, and others, one of the major problems with econometric models is that it is difficult to determine the "best" system, given the current state-of-the-art in regional econometrics. Thus, the flexibility of these models must be traded off against the difficulties associated with specifying the structure of the multipliers and assessing their accuracy.

One of the best-documented multiregional econometric models is the National-Regional Impact Evaluation System (NRIES), developed by Ballard and Wendling (1978) at the Bureau of Economic Analysis (BEA). It comes from the long tradition of econometric modeling at the Wharton School, University of Pennsylvania, starting with the pioneering work of Klein (1969) and Glickman (1974) on econometric models for single, rather than multiple, regions. A gravity-model approach is used by Ballard and Wendling for estimating the interregional linkages in NRIES. In the present version of the NRIES model, there are already approximately 14,000 equations, of which 3,500 are behavioral. The relationships are specified for 51 regions, but only for 12 sectors. NRIES is designed to project a variety of demographic and economic variables over a 6- to 10-year time span. The demographic variables include five age classifications of population, the total labor force, and total and uninsured unemployment. The major economic categories include industrial output, retail sales, employment, wages, nonwage income, state and local government revenues and expenditures, retail sales, and personal tax and nontax payments.

In a review of multiregional models, Bolton (1980b) points out several potential difficulties with NRIES. One of these difficulties was the assumption of a uniform elasticity of -1 in the gravity model to represent distance. In reality, the elasticities will vary by industry, transportation mode, and region. Although widely used, particularly in the transportation field during the 1950s and 1960s to calculate transportation flows, gravity models were not found to perform particularly well. Research performed by Trainer and Howland (1979) found that econometric estimation of trade flows using the gravity model formulation was unsatisfactory. In fact, Ballard, Gustely, and Wendling (1980a, p. 118) state that

> the unavailability of trade flow data necessitated the use of gravity models as the basic interregional element in NRIES. If adequate trade data were available, the effects of economic changes in one State or adjacent States could be much more effectively modeled.

The latest version of this model is discussed in a paper prepared by Kort and Cartwright (1981) in which a proposed linking of the NRIES model with the Regional Input-Output Modeling System (RIMS II) model is set forth. One of the major difficulties of this new model may be the inconsistency between the location-quotient relationships used in the RIMS II model and the gravity relationships used in the NRIES model. The other econometric models being developed at the University of Pennsylvania include one by Milne, Adams, and Glickman (1980) and one by Fromm, Loxley, and McCarthy (1980), which is being developed for the Electric Power Research Institute.

Other major multiregional econometric models currently in use for policy analyses include one called MULTIREGION, developed by Richard Olsen (1976), and one called MRMI, developed by Curtis Harris (1970). In each case, the latest version of these models is described and/or evaluated in the book by Adams and Glickman (1980). Bolton provides a critique of the models in his article in the same volume. The Harris model, which was the first U.S. multiregional econometric model developed, is directly linked to the Almon Interindustry Forecasting at the University of Maryland (INFORUM) model. The interindustry relationships are therefore modeled at the national level. A linear programming model is incorporated within the overall framework. In the MRMI model, transportation rates for shipping goods between regions are calculated according to the minimum cost by mode of transport, aggregated over all weight classifications. A linear programming algorithm converts the transportation-rate data into marginal transportation costs associated with each shipment into and out of each region. These are important in helping to determine industrial location, and thus are an important element in the MRMI model. However, the linear programming formulation in the MRMI model has several defects. First, truck and rail are apparently the only transportation modes considered, and it is assumed that industry location will be influenced primarily by these modes. This may not be the case for all commodities. For example, in the case of oil, natural gas, and even coal, pipelines may be the major transportation mode influencing industrial location. Another difficulty with the linear programming formulation is the network over which the transportation costs are minimized. Even though the linear program uses mode-specific cost data (for rail and truck), distances between demand and supply areas are found from the 473 transportation zones of the Department of Transportation. These zones reflect nodes on the U.S. highway system and may not accurately reflect distances between demand and supply areas on the U.S. rail network. Finally, the assumption that firms locate so as to minimize transportation costs is highly questionable. The use of minimum transportation cost criteria to explain industrial location has not generally been found to be effective. Nevertheless, Harris is unique in attempting to model industrial location within a general multiregional model, and it is unclear what other readily available data would provide a better measure.

In this section, emphasis has been given to the input-output, economic base, econometric, and eclectic (MRPIS and RESIND) multiregional economic models used to determine economic impacts. Some of the different structural characteristics of each of the models was reviewed to help illustrate in a more concrete form how different theories, data, assumptions, and so on are used in economic models. Many of these multiregional models are described in the useful book by Adams and Glickman (1980).

In the final two sections of this paper, the emphasis will shift to two of the types of considerations that have influenced the development of the MRIO and MRPIS models. First, the level of industrial detail will be discussed; then, alternative methods of handling secondary products will be reviewed.

III. Level of Industrial Classification

The level of industrial detail to use is a difficult, but very important, decision to make, regardless of whether national or multiregional accounts and models are being constructed. Although relevant levels of detail for the value added and final demand components of the accounts are also critical decisions, the issues are different and will not be covered here. A number of factors influence the level of industrial classification that will be maintained as data are assembled for use in a multiregional accounting system. These include the availability of data from secondary data sources (assuming that no surveys are to be undertaken); the degree of accuracy of alternative types of data; the costs of assembling data for different levels of industrial classification; and the amount of estimation bias that will occur when models are implemented if particular industries are aggregated or disaggregated.

During the initial work on the 1977 MRIO accounts and the MRPIS model, some government officials questioned why data should be assembled for 100 rather than for 50 or fewer industries given that the MRPIS model might be implemented for only a small number of industries, say, 20 to 40. Is there a significant increase in cost and reduction in accuracy if the data are assembled for the larger number of industries and for 51 regions? The 1963 MRIO accounts, it should be noted, were assembled according to the same 80-order industrial classification as that used for the national input-output accounts. The 1977 MRIO accounts are being assembled for 120 industries. The industries were selected on the basis of the needs of the regional analyses for which the accounts were to be used, with cost, accuracy, and other factors also being taken into account.

In this section, the discussion will focus primarily on the issues relevant for consideration in assembling data, rather than on the issues of level of industrial classification to be used for model implementation. First, a brief history is provided of some of the considerations that have been given to industrial classification by U.S. input-output analysts. Second, a discussion is provided of the most critical issues considered as decisions were made concerning the level of industrial classification to maintain for the 1977 MRIO accounts.

1. History of Industrial Classifications

The appropriate level of industrial classification to be used for accounts and models has altered over time, partly as a result of the computer revolution. Thus, in 1950, it did not seem remarkable for Leontief to refer to a system containing only ninety linear equations as a large-scale system (Leontief, 1951b, p. ix). Today, systems containing thousands of equations are used. As a consequence of the computer revolution and related developments in the collection of data and in data-management systems, the size of industrial classifications can be larger than those used thirty years ago. Even so, adding a spatial dimension to the data system means that the question is one of whether 30 or 200 industries should be selected, not one of whether 300 or 1000 industries should be selected. It appears that the accuracy of data begins to decrease significantly if data for 51 regions are assembled for more than 200 industries. As Leontief noted, the classification selected is always a compromise between ". . . a theoretical ideal and practical necessity" (Leontief, 1951a, p. 20). The rationale for selection of a particular level of industrial detail for U.S. national input-output tables is discussed in the literature only in vague terms. Two factors appear to have played a role in determining the level of industrial detail to use: technological differences and standard industrial classification (SIC) codes. The main rationale cited is consideration of differences in technology, but analysts have not provided specifics on the methods used to determine whether or not the technology is different.

For the 1939 U.S. input-output table, "Leontief had hoped for 95 sectors, but 15 of them were blank and several others were deficient in various ways" (Battelle, p. 8-7). About 15 percent of the economic activity in the U.S. 1939 economy was not accounted for in the table because of the lack of data, according to a Battelle report (p. 8-8). The specific rationale for the selection of the 95 sectors is not provided in the available literature.

For the 1947 U.S. input-output table, data were assembled for 450 industries. It appears that the analysts looked for the most detailed data available for each sector. Evans and Hoffenberg stated that

> The most important reason for carrying through an input-output study in the greatest degree of industry detail possible is the fact that this approach actually makes the work easier and improves the quality of the results. (Evans and Hoffenberg, 1952, p. 114)

According to Evans and Hoffenberg, the reasons for assembling data from information at the four-digit SIC detail (or even in more detail) were that materials-consumed data were available on a very detailed basis; input costs could be more easily determined; better checks on reasonableness of the results were possible; fewer index number problems arose when data from other time periods had to be used; it would be easier to revise and maintain detailed tabulations; and the detailed tabulated data could be used in a very flexible manner for different applications (Evans and Hoffenberg, 1952, p. 114).

Jack Alterman and Morris Goldman stated that the main criterion in selecting the industrial classification for the 1947 manufacturing sector was to use no more detail than that used for the Census of Manufactures (National Bureau of Economic Research, 1954, p. 6-20). When manufacturing industries were combined, four factors were taken into account: (1) Problems of estimating input requirements; (2) Problems of estimating requirements for the output of the industries; (3) Overlapping of primary and secondary products; and (4) Small industries. They noted that

> an advantage of an extremely detailed classification system is that it permits considerable latitude for aggregating, depending on the specific problem to be studied. (National Bureau of Economic Research, 1954, p. 6-21)

With the exception of a few industries for the 1947 manufacturing industries, each four-digit SIC industry was maintained as a separate category for the 450-industry table (U.S. Department of Labor, 1953). Less detail was maintained for the service sector.

Some of the rationale for not maintaining detail in several of the service industries is indicated in the chapter on Services and Financial Intermediaries in the 1954 Technical Supplement (National Bureau of Economic Research, 1954). The chapter on Trade provides the following explicit details on problems with the wholesale and retail trade and service industries:

> The three Census of Business divisions covered retail trade, wholesale trade, and the services. Each used different commodity classification systems.
>
> With regard to retail trade, one cannot point to one commodity classification system covering this area. Rather, there were 22 such systems, each designed to fit the characteristics of specific kinds of business. The degree of detail in each of these systems varied from three or four specific items (for grocery and liquor stores) to 56 items (for department stores).
>
> Although the 22 classification systems contained about 260 items (excluding "Other Sales"), repetition of the same general commodity category in the various systems cut down severely the real amount of useful detail. For example, 43 items of the 260 applied to apparel. (National Bureau of Economic Research, 1954, p. 10-7)

Criteria for the determination of the level of industrial detail to use for the overall set of accounts are not provided in the available documentation. Given the emphasis in early input-output analyses on changes in technology, industry capacity, and investment, it is not surprising that considerable detail was maintained for the manufacturing industries. Another reason for the particular selection of industries seems to be that more data were available for manufacturing industries than for the nonmanufacturing industries.

The rationale for the aggregation from the 450-industry to the 192-industry level of detail for the 1947 study is also lacking in the literature. The 192-industry classification represents a combination of three-digit and four-digit SIC detail (U.S. Department of Labor, 1953). The fact that the 192-industry table was to be used for employment impact and other analyses related to the Korean War probably helped to determine which industries were to be aggregated. (The 192-industry model is referred to in the literature as the Emergency Model, or just as the EM.)

For the more current (1958, 1963, 1967, and 1972) U.S. input-output tables, again very little information is provided in the literature as to the reasons for selecting the industries included in the 80-order, 370-order, or 500-order industrial classification schemes presently used by the Bureau of Economic Analysis, U.S. Department of Commerce.[1] The 80-order industry classification first appeared for use with the 1958 national input-output table, which was published in September 1965 (U.S. Department of Commerce, 1965).[2] The 1963, 1967, and 1972 tables were prepared for the three different levels of classification mentioned above, while the 1958 table has been made available to the public only at the 80-order level. The changes from 478 industries for the 1963 table to 484 industries for the 1967 table and to 496 industries for the 1972 table appear to have been related to the changes that occurred in SIC codes rather than to any major decisions on new industry groupings.

As far as can be determined through discussions with government officials, a similarity in technological structure was the primary motivation for combining certain industries. Duncan and Shelton in a review of input-output (IO) work state that the ". . . grouping of industries in an IO table should be selected with considerable regard to similarity of input pattern" (Duncan and Shelton, p. 113). In addition, the Census of Manufactures for 1954 and for 1958 seem to have provided a significant expansion of information over earlier censuses, which probably contributed to some of the changes in industry detail. Duncan and Shelton note that those two publications included as changes "much more detail on inputs and the separation of industries which had markedly different input

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[1]The term "order" refers to the approximate number of endogenous industries in the tables.

[2]A revised 1947 table was published in March 1970 for 80 industries (U.S. Department of Commerce, 1970).

patterns" (Duncan and Shelton, p. 112). It would appear, however, that at least the sizes of output and employment in the industries should also have been taken into consideration, but they were not.

For 1958, the 80-order industrial classification resulted in levels of output that ranged from $408 million for IO-21, Wooden containers, to $92,203 million for IO-69, Wholesale & retail trade, out of a total output for the nation of $882,573 million. Employment ranged from 20,556 employees for IO-10, Chemical, fertilizer, & mineral mining, to 10,708,422 employees for IO-69, Wholesale & retail trade, out of a total of 56,974,311 employees (U.S. Department of Commerce, 1965). By 1972, the value of output was only $466 million for IO-21, while the value of output for IO-69 had increased to $216,384 million, yet each industry was listed as one of approximately 80 industries (U.S. Department of Commerce, 1979).

These extremes in industry size do not appear to be just accidents in an otherwise rational classification system. In 1967, total employment in the United States was 75,331 thousand, of which 14,694 thousand were employed in the public sector, leaving a total private employment of 60,637 thousand. Of the 79 industries included in the smallest input-output table, 12 had fewer than 100,000 employees, and 24 had more than 500,000 employees. Total output also showed wide ranges (Coughlin, 1978). Although technology may have been the determining criterion for selection of the specific industries to include, it appears doubtful that an industry that employs only a few thousand employees or has only a very small relative size of output should be treated as a separate industry even if its technology is significantly different from the technology of other industries.

Not only are the reasons for choosing the 80-order industry categories unclear, but the lack of balance among industries appears to be even greater when the 370-order industry detail is considered. One of the 367 industries, IO-14.26 (Vegetable oil mills, not elsewhere classified) has fewer than 2 thousand employees, while IO-69.01 (Retail trade) is also maintained as a single industry with 10,137 thousand employees (Coughlin, 1978). The first industry is comprised of one four-digit SIC industry, while the latter industry is comprised of eight two-digit

SIC industries. The apparent reason for these types of imbalances is that almost all four-digit manufacturing industries were maintained as single industries, regardless of size. The food subindustry IO-14.26 is comprised of one four-digit code--SIC 2093. On the other hand, detailed information for retail trade is not readily available, as was indicated by the earlier quote relating to the 1947 input-output study. In the United States, the marginal cost of assembling data for one more manufacturing industry is relatively small, because almost all of the data are available on computer tapes. In fact, it probably would cost more to aggregate those manufacturing industries with small employment or output than to leave them separate if all other manufacturing industries are to be maintained at the four-digit level. If many industries are to be combined, the question then arises as to what criteria should be used to determine the appropriate combination to make. The treatment of this at the multiregional level is covered in the next section.

2. Industrial Classifications for Multiregional Accounts

For the 1963 MRIO accounts, primary emphasis was placed upon keeping a system of accounts that was comparable in terms of industrial classification with that used for the 1963 national input-output table. The 80-order national industrial classification was used, and no consideration was given to adopting a different classification scheme.[3] For the 1977 MRIO accounts, considerable attention was given to determining the level of industrial detail that should be established, partly because of pressure from government officials to reduce the number of industries to 20-40 from the proposed 120. The assumption made by the officials was that significant cost savings could be realized if data were collected for fewer industries. The stress in theoretical literature is on the technological homogeneity of the industries being considered for aggregation. As will be shown below, this is too narrow a focus for empirical analyses, especially for multiregional studies.

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[3]The so-called "dummy" industries were treated differently from the way they were treated in the national table. Details of the methodology used are provided in the documentation of the 1963 MRIO accounts (Polenske et al., 1974).

It is anticipated that the 1977 MRIO data will be used in the MRPIS model for a number of years. Because not all of the many policies for which the MRIO and MRPIS models will be used were known at the time the data assembly was begun, it seemed important to maintain a reasonable amount of industrial and regional detail in the accounts even though present uses indicated that less information might be required initially. Three factors were considered as the MRIO accounts were assembled. One related to the level of accuracy of the data assembled compared with the costs of assembling data for more (or fewer) industries and regions. This information is difficult to obtain and assess, and the literature contains very few guidelines, partly because of the problems in determining relative costs and accuracy of using alternative data sources and levels of detail. The second factor related to the amount of estimation bias that would occur in implementing the MRIO model if industries and/or regions were aggregated. Errors in the determination of outputs and employment may occur as a result of technology, interregional trade, or other factors that are not specified in sufficient detail to account for structural differences among industries and regions. The third factor was the spatial distribution of the industry. Although a firm may be insignificant for the nation as a whole, it may dominate in one or more local economies. Tobacco processing is a case in point. It comprises less than one percent of national output, but amounted to 10 percent of the output of North Carolina in 1967. Separate data for different industries may therefore be desirable for planning purposes at the regional level and may save money at later stages of analysis. Agggregation of data is generally a far less expensive procedure than disaggregation.

To determine the level of industry detail to maintain in the 1977 MRIO accounts, the 80-order industry classification was used as the starting point. A very careful review of the industries was conducted, including an attempt to determine the cause of some of the apparent ambiguities that exist in that classification scheme.

The following criteria were used to establish the industrial classifications for the 1977 MRIO data assembly:

1. <u>Size of output, employment, payroll, and tonnage figures</u>.
   Industries with fewer than 100,000 employees, less than $1 billion of output, less than $500 million in payrolls, or less than 1 million tons shipped should be considered as potential candidates for aggregation, based upon their small size. Industries with more than 500,000 employees, $5 billion of output, $5 billion in payrolls, or 10 million tons shipped should be considered as potential candidates for disaggregation, based upon their large size.

2. <u>Standard industrial classification (SIC) categories</u>.
   Industries that fall into the same three-digit SIC category should be examined for possible aggregation. An industry should not be considered for disaggregation into subindustries if four-digit SIC data are required for a particular subindustry.

3. <u>Industry structure</u>.
   Each industry or group of industries identified through the above set of reviews should be compared with industries with which the industry or group of industries would be aggregated (for small industries) or in terms of the subindustries within the industry (for large industries), based upon the following structural characteristics:
   (a) employment-to-output ratios
   (b) payroll-to-output ratios, compensation-to-output ratios, or value added-to-output ratios (whichever are available for the particular industry)
   (c) structure of demand (final demand versus intermediate demand, consumption demand versus investment demand, private sector demand versus public sector demand)
   (d) technology structure
   (e) interregional trade structure
   (f) secondary products

4. <u>Data availability</u>.
   In a few cases, the possible unavailability of data may require keeping industries in a more aggregated form than desired even if their structural characteristics are vastly different.

The data contained in Table A-1 were the primary basis upon which the final industrial classification was determined. The main concern was to establish an industrial classification that would provide accurate measurements of employment and income regional impacts and that would simultaneously maintain flexibility for future analyses. Employment-to-output and compensation-to-output ratios were used to determine differences in technological structure because time limitations prevented an analysis of the entire industrial input structure. A comprehensive discussion of how the data in Table A-1 were used to help determine the final industrial classification for the 1977 MRIO accounts is contained in the report by Crane and Mizrahi (1981).

Two additional considerations should also be noted. First, even if errors of estimation are not evident when two or more industries are combined, the emphasis on employment and income generation and distribution in the MRPIS research required that attention be given to the structure of employment in each of the industries that will be used in the labor-market module. Thus, the combining of two industries that have similar technologies, interregional trade, and demand structures, but completely different occupational structures, for example, was not considered to be desirable.

Second, an attempt was made to take into account changes in nomenclature that occur for goods and services as technological change varies the nature of commodities and services provided. This is a factor that has not received very much attention in the United States, but one that is obviously becoming increasingly important. Some of the experience of French analysts may become more and more relevant in this respect. All classification systems impose certain restrictions on analyses that may hinder accuracy. Even with relatively detailed input-output tables, problems arise as products and services change due to technological innovation. A major revolution, for example, is occurring in the products of IO-51, Office & computing machines. As early as 1963, 78 percent of the output of IO-51 was attributed to computing and accounting machines, and only 9 percent to typewriters (U.S. Department of Commerce, 1969). For the 1972 input-output table, the first subindustry was separated into electronic computer equipment and calculating and accounting machines.

Together, these comprise 84 percent of the total output of the industry, with typewriters now representing less than 6 percent of total output. One of the members of the staff of a major distributor of word processors predicted recently that typewriters would not be sold in the United States in five years from now. An analyst interested in studying the phasing-out of the clerical worker and the impact of this on income distribution should have access to information on the types of capital equipment that have "replaced" the worker.

Aujac's explanation of how the French during the 1960s solved some of the problems of changing nomenclatures goes as follows (Aujac, 1972). First, detail was maintained within industries that formed production chains. This was done with account being taken of production and marketing data related to current inventories, labor skills, investment, and raw materials required to sustain the new product. As Aujac indicates, because industries in the input-output tables have "ceased to be representative," it is important to "anticipate the new description" and to study "for example, the possible consequences on the textiles and clothes chain of innovations made in chemicals, automation, computer sciences, etc." (Aujac, 1972, p. 416).

The second factor, referred to earlier, concerning estimation bias in implementing the MRIO and MRPIS models at different levels of industrial and regional detail, will be tested as additional research is undertaken. One of the concerns in establishing the industrial classification was to maintain sufficient detail for later testing of estimation errors that may occur as a result of differences in technological, interregional trade, and demand structures. In the current literature on multiregional models, the available tests are not sufficiently comprehensive to assist in this assessment. Studies of technological and interregional linkage and feedback effects at the regional level are very limited. Miernyk et al. (1970) have been conducting single-region studies of technology, and the study by Harrigan, McGilvray, and McNicoll (1980) covers only two regions: Scotland and the rest of the United Kingdom. At present, no study of regional technologies has been made that is comparable to Carter's (1970) extensive national study of technology in the U.S. economy.

Although several articles, such as those by Greytak (1970), Miller (1969), Miller and Blair (1980), and Stevens and Trainer (1978), have been published concerning interregional feedback effects, all of the studies are extremely limited in scope. The studies of trade stability are also very restricted. Suzuki's (1971) study is the only one that concludes that interregional trade flows are stable. The studies by Isard (1953), Moses (1955), and Riefler and Tiebout (1970) all indicate that varying degrees of instability exist. An important extension of the studies on feedback effects and stability conditions has been completed by Crown (1981, 1982). Even so, it is not possible to obtain much information from any of the available technology or trade studies to assist in determining the potential estimation errors when multiregional models are implemented. An attempt, however, is under way by the multiregional planning staff to design a comprehensive interregional linkage and feedback analysis.

Given that funds are extremely restricted, the design of industrial classification schemes for multiregional analyses in the United States is very important in terms of the data to be assembled in the accounts and the types of analyses for which multiregional models can be used. It is obvious that many interesting implications arise from the industry selection made for an accounting framework and model. The methods of handling secondary products are also important; these will be the focus of the next section.

IV. Treatment of Secondary Products.

The existence of secondary products is an excellent case of how work on economic theory and economic accounts should become more interrelated than it is at present. Almost all theories of production contain the assumption that a firm produces a homogeneous product. But as data are collected for the accounts, it becomes evident that most firms produce more than one product and that the products are probably not homogeneous. The secondary production of U.S. firms was greater than 10 percent for 20 of the 79 industries in the 1963 80-order input-output table (U.S. Department of Commerce, 1969). Thus, many establishments in the United States produce more than one product; yet, the Census data upon which the input-output accounts are built provide input data for the entire establishment, rather than input data for each separate product. Each establishment is classified in an industry based upon the principal commodity produced. All the output of that establishment, primary or secondary, is considered to be output of the industry in the census data.

Authors who discuss alternative treatments of secondary products in input-output accounts include Almon (1970), Edmonston (1952), Evans and Hoffenberg (1952), Koenig and Ritz (1967), Kok (1971), Rijcheghem (1967), Stone and Stone (1977, pp. 39-41), Strout (1963), and United Nations (1973, pp. 23-33; 1975, pp. 47-48). An important addition to this literature in terms of input-output analyses is the thesis by Mizrahi (1982). For his thesis, Mizrahi reviews the four major secondary product methodologies. These include the Office of Business Economics (OBE) methodology used by the OBE in its U.S. input-output tables prior to and including the 1967 table (U.S. Department of Commerce, 1974, pp. 12-14); the MRIO methodology used in the 1963 MRIO study (Polenske, 1974, pp. 13-29); the Bureau of Economic Analysis (BEA) methodology used in the 1972 U.S. input-output table (U.S. Department of Commerce, 1980, pp. 37-42), which is also being used in substantially the same way for the 1977 U.S. input-output table; and the United Nations (UN) methodology, which is specified in the System of National Accounts (United Nations, 1968, pp. 35-51). Most countries other than the United States use the UN methodology for the construction of input-output tables. The four methodologies are briefly summarized here; the detailed equation specification of each is given in Mizrahi's thesis.

In the OBE tables, some secondary products were redefined, while others were recorded in a separate secondary-product matrix. The flows in the secondary-product matrix were then added cell by cell to the corresponding flows in the so-called primary matrix. Only the combined set of flows was published by the OBE. This treatment of secondary products created problems when the input data from the published tables were analyzed. For example, double counting occurs with this method. More important, the input requirements are distorted when technical coefficients are calculated. In order to undertake appropriate analyses, computer tapes that contained the two sets of tables had to be obtained from the OBE. Even then, the method of handling secondary products became cumbersome whenever industrial aggregations were made, because any secondary products that occurred as part of an intraindustry transaction had to be eliminated. All interindustry secondary products created distortions in the detailed output multipliers. Specifics on the OBE method are given in the volume State Estimates of Technology, 1963 (Polenske et al., 1974, pp. 13-38).

The MRIO methodology was developed for the 1963 MRIO accounts in an attempt to side-step some of the problems created by the OBE methodology at the same time that consistency was maintained with the final output estimates obtained from the national input-output table. For each state secondary matrix, the elements were summed to obtain a single aggregate row and column. Each state input-output table was then augmented to include the secondary transfers-in (sums of elements in the secondary matrix columns) and secondary transfers-out (sums of the elements in the secondary matrix rows). This treatment resulted in double counting secondary production in the output data when the MRIO model was implemented, but did not create the serious biases in the technical coefficients that had occurred with the use of the OBE methodology.

For both the BEA and the UN methodologies, either commodity-by-commodity or industry-by-industry flow tables can be obtained. The inputs and outputs of the secondary products are transferred from the industry in which they are produced to the industry of which they are a primary product. The difference between the two methodologies is in whether a market-shares or a product-mix assumption is used. The BEA uses the industry-technology or market-shares assumption in which it is assumed that the technology of a secondary product is identical to that of its producing industry. The methodology has the strong advantage that the product detail of industries can be maintained through use of the so-called Use and Make matrices in rectangular form. In addition, the inputs taken away from the industry producing the secondary products can never exceed the inputs used by the industry, thus creating a definite advantage of this methodology over the UN methodology.

The UN methodology is based upon the use of a commodity-technology or product-mix assumption. As Mizrahi (1982, p. 12) states

> . . . [this assumption] means that all similar commodities have identical technologies no matter which industry produces them. This is not the same as saying that the technology of the secondary product is identical with its primary industry because the latter contains its own secondary production of other commodities and hence is "polluted".

The main problem with this methodology is the negatives that occur in the inverse matrix. Their appearance means either that the assumption of uniform input patterns for similar commodities is invalid at the particular level of aggregation selected or that the data are inaccurate.

Mizrahi (1982) compared the inverse matrices and outputs obtained from the four methodologies. He concluded that at the 19-industry level, the choice of methodology was not important in terms of results calculated, while at the 78-industry level, significant differences occurred. None of the methodologies is ideal. Given that secondary products represent a large percentage of total output for some industries, additional attention should be directed to this issue as multiregional accounts and models are constructed.

V. Conclusion.

One purpose of this paper has been to try to show some of the interrelationships that exist among various aspects of work on economic accounts and models. An analyst interested in building an economic model should have a thorough understanding of economic theories, accounts, and policies and of the mathematical and statistical techniques that are involved in constructing and using the model. Selected features of four types of existing multiregional economic models (input-output, economic base, econometric, and eclectic) were briefly examined in terms of how the structure of the multiplier was treated in each type of model. Another purpose of the paper has been to examine some of the issues that should be considered in specifying industrial classifications and methods of treating secondary products. These are only two of the many issues that arise in structuring multiregional economic accounts and models.

APPENDIX

Table A-1
1967 Output, Employment, Compensation, Investment, and Final Demand Relationships

Industry Number												
Short List	Long List	BEA Input-Output	Industry Title	Output (mill. $)	Employee Comp. (mill. $)	Employ-ment (thous.)	Comp.-to-Output Ratio	Employ.-to-Output Ratio	Investment (mill. $)	Final Demand (mill. $)	Invest.-to-F. Demand Ratio	F. Demand-to-Output Ratio
S01	L01	1.01	Dairy farm prdts.	6,559	626	204	.095	.031	0	155	.000	.024
	L02	1.02-1.03	Livestock, other livestock prdts.	24,079	674	245	.030	.010	0	1,863	.000	.077
S02	L03	2.00, excl.L04	Cotton, grains, other agri. prdts.	22,626	906	375	.040	.017	0	3,617	.000	.160
	L04	2.04-2.05	Fruits, nuts, veg., misc. crops	5,915	1,425	463	.241	.078	0	3,232	.000	.546
S03	L05	3.00, 4.00	Fores., fish. prdts., agri. serv.	4,615	1,081	266	.234	.058	0	434	.000	.094
S04	L06	5.00	Iron, ferro. ores mining	1,744	228	24	.131	.014	0	82	.000	.047
	L07	6.00	Nonferrous ores mining	1,640	352	41	.215	.025	0	173	.000	.105
	L08	7.00	Coal mining	3,163	1,215	130	.384	.041	0	622	.000	.197
S05	L10	9.00	Stone, clay mining & quarrying	2,355	686	95	.291	.040	0	51	.000	.022
	L11	10.00	Chem., fert. mineral mining	1,027	199	23	.194	.022	0	189	.000	.184
S06	L09	8.00	Crude petro., natural gas	15,031	882	95	.059	.006	0	339	.000	.023
	L12	11.01	New resid. bldg. constr.	26,385	7,173	935	.272	.035	25,125	26,385	.952	1.000
	L13	11.02	New nonresid. bldg. constr.	26,888	8,620	952	.321	.035	17,574	26,888	.654	1.000
S07	L14	11.03	New publ. util. constr.	10,919	3,556	383	.326	.035	7,603	10,919	.696	1.000
	L15	11.04	New highways, streets constr.	8,371	2,841	312	.339	.037	0	8,371	.000	1.000
	L16	11.05-11.07	New constr., all other	7,326	2,872	344	.392	.047	4,036	7,326	.551	1.000
S08	L17	12.01	Maint. resid. constr.	6,265	2,408	358	.384	.057	0	176	.000	.028
	L18	12.02	Maint. constr., all other	17,126	9,439	1,160	.551	.068	0	5,519	.000	.322
S09	L19	13.00	Ordnance, accessories	10,733	4,079	406	.380	.038	25	9,076	.003	.846
	L20	14.01-14.06	Meat, dairy prdts.	36,924	4,257	587	.115	.016	0	28,000	.000	.758
	L21	14.07-14.13	Canned, frozen food	9,940	1,593	283	.160	.028	0	8,042	.000	.809
	L22	14.14-14.18	Grain prdts.	17,342	3,454	463	.199	.027	0	9,807	.000	.566
S10	L23	14.19-14.20	Sugar, confectionary prdts.	6,086	811	123	.133	.020	0	3,151	.000	.518
	L24	14.21-14.23	Beverages, extracts, sirups	12,588	1,915	238	.152	.019	0	9,959	.000	.791
	L25	14.24-14.32	Other food prdts.	10,889	1,104	153	.101	.014	0	5,957	.000	.547
	L26	15.00	Tobacco mfr.	7,940	642	95	.081	.012	0	6,059	.000	.763
	L27	16.00	Fabrics, yarn & thread mills	15,966	3,398	622	.213	.039	0	1,058	.000	.066
S11	L28	17.00	Misc. textile, floor coverings	4,668	777	124	.166	.027	107	1,711	.063	.367
	L31	19.00	Misc. fabr. textile prdts.	4,283	899	176	.210	.041	0	2,459	.000	.574
S12	L29	18.01-18.03	Hoisery, knit apparel	4,519	1,176	246	.260	.054	0	1,112	.000	.246
	L30	18.04	Other apparel	19,586	5,606	1,232	.286	.063	0	15,755	.000	.804
S13	L32	20.00, 21.00	Lumber, wood prdts.	13,448	3,227	568	.240	.042	7	817	.009	.061
S14	L33	22.00	Household furniture	5,122	1,668	304	.326	.059	205	4,183	.049	.817
	L34	23.00	Other furniture & fixtures	2,822	922	131	.327	.046	1,632	2,251	.725	.798
S15	L35	24.00	Paper, allied prdts.	16,733	3,863	456	.230	.027	0	2,674	.000	.160
	L36	25.00	Paperboard cont. & boxes	6,031	1,626	226	.270	.037	0	191	.000	.032
S16	L37	26.01-26.02	Newsp., period., print. & publ.	8,873	3,277	428	.369	.048	0	2,304	.000	.259
	L38	26.03-26.08	Print. & publ., all other	14,447	4,925	642	.341	.044	0	3,456	.000	.239
	L39	27.01	Ind. inorg. & org. chem.	17,041	2,971	297	.174	.017	0	2,677	.000	.157
S17	L40	27.02-27.04	Agri. & misc. chem. prdts.	6,776	1,226	155	.181	.023	0	1,708	.000	.252
	L41	28.00	Plastics, synthetics	8,424	2,063	217	.245	.026	0	774	.000	.092
	L43	30.00	Paint, allied prdts.	2,914	622	73	.213	.025	0	160	.000	.055

Table A-1 (continued)
1967 Output, Employment, Compensation, Investment, and Final Demand Relationships

Industry Number: Short List	Long List	BEA Input-Output	Industry Title	Output (mill. $)	Employee Comp. (mill. $)	Employment (thous.)	Comp.-to-Output Ratio	Employ.-to-Output Ratio	Investment (mill. $)	Final Demand (mill. $)	Invest.-to-F. Demand Ratio	F. Demand-to-Output Ratio
S18	L42	29.00	Drugs, cosmetics	12,582	2,420	265	.192	.021	0	8,665	.000	.689
S19	L44	31.00	Petro. refn., related inds.	26,915	2,591	208	.096	.007	0	12,755	.000	.474
S20	L45	32.00	Rubber, misc. plastics	13,809	3,991	539	.289	.039	31	3,330	.009	.241
S21	L46	33.00, 34.00	Leather	5,330	1,707	341	.320	.064	0	3,761	.000	.706
S22	L47	35.00	Glass, glass prdts.	3,801	1,410	181	.371	.048	0	571	.000	.150
S23	L48	36.00	Stone, clay prdts.	11,026	3,367	452	.305	.041	0	588	.000	.053
	L49	37.01	Blast furn., basic steel prdts.	25,156	6,473	658	.257	.026	0	1,151	.000	.046
S24	L50	37.02	Iron, steel foundries	4,657	1,999	241	.429	.052	0	62	.000	.013
	L51	37.03-37.04	Iron, steel forg., prim. met. prdts.	2,391	648	70	.271	.029	0	115	.000	.048
S25	L52	38.00	Prim. nonferrous met. mfr.	23,098	3,438	399	.149	.017	34	1,115	.030	.048
S26	L53	39.00, 42.00	Met. cont., other fab. met. prdts.	15,874	4,407	570	.278	.036	348	2,138	.163	.135
S27	L54	40.00	Fabr. met. prdts.	12,510	3,469	445	.277	.035	933	1,632	.572	.130
S28	L55	41.00	Screw mach. prdts., etc.	9,293	2,970	348	.320	.037	0	885	.000	.095
	L56	43.00	Engines, turbines	3,825	1,004	106	.262	.028	732	1,751	.418	.458
	L57	44.00	Farm mach., equip	4,826	1,276	152	.264	.031	2,942	3,866	.761	.801
	L58	45.00	Constr. & mining mach., equip.	5,974	1,701	197	.285	.033	2,428	4,115	.590	.689
	L59	46.00	Materials handling mach., equip.	2,538	780	89	.307	.035	1,108	1,376	.805	.542
S29	L60	47.00	Metalworking mach., equip.	8,676	3,273	345	.377	.040	3,461	4,375	.791	.504
	L61	48.00	Special ind. mach., equip.	5,681	1,879	218	.331	.038	3,205	4,163	.770	.733
	L62	49.00	General ind. mach., equip.	7,800	2,531	289	.324	.037	1,888	2,954	.639	.379
	L63	50.00	Misc. machinery, exc. electr.	3,940	1,624	206	.412	.052	5	336	.015	.085
	L65	52.00	Service ind. machines	5,279	1,139	146	.216	.028	1,729	2,847	.607	.539
S30	L64	51.00	Office, computing & account. mach.	6,166	1,952	216	.317	.035	2,841	4,507	.630	.731
S31	L66	53.00	Electr. transmiss. & distr. equip.	9,903	3,484	426	.352	.043	2,886	4,472	.645	.452
	L73	58.00	Misc. electrical mach., equip.	3,136	884	114	.282	.036	210	1,281	.164	.408
S32	L67	54.00	Household appliances	5,450	1,352	178	.248	.033	588	3,956	.149	.726
S33	L68	55.00	Electr. lighting & wiring equip.	4,118	1,183	168	.287	.041	67	965	.069	.234
S34	L69	56.01-56.02	Receiving sets, records, & tapes	4,831	1,091	152	.226	.031	115	4,040	.028	.836
	L70	56.03	Telephone, telegraph apparatus	2,776	980	119	.353	.043	1,456	1,786	.815	.643
	L71	56.04	Radio, TV communication equip.	9,900	4,116	420	.416	.042	1,367	7,896	.173	.798
S35	L72	57.00	Electronic components, acces.	8,147	3,131	439	.384	.054	18	1,435	.013	.176
S36	L74	59.01-59.02	Truck & bus bodies, trailers	1,654	419	58	.253	.035	1,086	1,240	.876	.750
	L75	59.03	Motor vehicles, parts, acces.	42,317	8,045	791	.190	.019	7,968	27,053	.295	.639
	L76	60.01	Aircraft	11,264	4,174	398	.371	.035	2,311	9,251	.250	.821
S37	L77	60.02	Aircraft & missile eng., parts	5,637	2,116	203	.375	.036	56	3,270	.017	.580
	L78	60.03-60.04	Other aircraft & missile equip.	6,964	2,201	228	.316	.033	0	2,273	.000	.326

Table A-1 (continued)
1967 Output, Employment, Compensation, Investment, and Final Demand Relationships

Industry Number: Short List	Industry Number: Long List	Industry Number: BEA Input-Output	Industry Title	Output (mill. $)	Employee Comp. (mill. $)	Employment (thous.)	Comp.-to-Output Ratio	Employ.-to-Output Ratio	Investment (mill. $)	Final Demand (mill. $)	Invest.-to-F. Demand Ratio	F. Demand-to-Output Ratio
S38	L79	61.00	Other transportation equip.	7,726	2,469	311	.320	.040	3,430	6,390	.537	.827
S39	L80	62.00	Profess., scien., control. instru.	6,191	1,953	259	.315	.042	1,132	3,281	.345	.530
	L81	63.00	Optical, medical, photo. equip.	4,779	1,412	153	.295	.032	920	2,926	.314	.612
S40	L82	64.00	Misc. manufacturing	9,357	2,711	443	.290	.047	533	5,692	.094	.608
	L83	65.01	Railroads, related serv.	12,782	5,564	611	.435	.048	314	3,771	.083	.295
	L84	65.02	Highway passenger transport.	4,501	1,721	283	.382	.063	0	3,177	.000	.706
S41	L86	65.04	Water transport	7,160	2,054	240	.287	.034	23	3,592	.006	.502
	L87	65.05	Air transport	8,164	2,925	297	.358	.036	39	4,121	.009	.505
	L88	65.06	Pipelines, exc. nat. gas	1,205	118	12	.098	.010	0	322	.000	.267
	L89	65.07	Transportation serv.	1,018	696	94	.684	.092	0	115	.000	.113
S42	L85	65.03	Motor freight transp. & warehous.	18,341	7,883	1,079	.430	.056	453	5,555	.082	.303
S43	L90	66.00	Communications, exc. radio & TV	19,328	6,820	826	.353	.043	1,096	10,084	.109	.522
S44	L91	67.00	Radio & TV broadcasting	3,183	1,060	119	.333	.037	0	7	.000	.002
	L110	76.00	Amusements	9,644	3,053	563	.317	.058	0	6,057	.000	.628
	L92	68.01	Electric utilities	19,698	2,717	290	.138	.015	0	9,146	.000	.464
S45	L93	68.02	Gas production, distribution	14,076	1,837	220	.131	.016	0	4,907	.000	.349
	L94	68.03	Water supply, sanitary serv.	3,563	346	31	.097	.009	0	1,899	.000	.533
S46	L95	69.01	Wholesale trade	64,759	26,071	3,131	.403	.048	3,638	35,523	.102	.549
S47	L108	74.00	Eating & drinking places									
	L96	69.02a	Retail trade, general merchandise	98,607	44,215	10,137	.448	.103	2,906	85,292	.034	.865
S48	L97	69.02b	Retail trade, food & misc.									
	L98	69.02c	Retail trade, auto. & gas serv.									
	L99	69.02d	Retail trade, other									
	L100	70.01	Banking	14,865	5,920	869	.398	.058	0	8,489	.000	.571
S49	L101	70.02-70.03	Credit agen., sec. & com. brokers	8,357	4,596	535	.550	.064	0	5,307	.000	.635
	L102	70.04-70.05	Insurance car., agen. & brokers	24,836	8,862	1,210	.356	.049	4	12,023	.000	.483
S50	L103	71.00	Real estate, rental	112,363	1,715	443	.015	.004	2,100	75,245	.028	.700
S51	L104	72.01	Hotels, lodging places	5,415	1,462	431	.270	.080	0	3,517	.000	.649
	L105	72.02-72.03	Personal & repair serv., exc. auto.	15,390	5,466	1,226	.355	.080	0	12,648	.000	.822
S52	L106	73.01-73.02	Misc. business serv., advertising	40,385	11,059	1,746	.274	.043	0	4,691	.000	.116
	L107	73.03	Misc. profess. serv.	16,958	5,040	640	.297	.038	0	4,597	.000	.271
S53	L109	75.00	Auto. repair & serv.	14,756	3,804	722	.258	.049	0	8,220	.000	.557
	L111	77.01	Doctors, dentists	13,734	2,110	445	.154	.032	0	13,501	.000	.983
S54	L112	77.02	Hospitals	10,814	7,025	1,415	.650	.131	0	10,794	.000	.998
	L113	77.03	Other medical & health serv.	4,378	1,522	385	.348	.088	0	3,534	.000	.807
S55	L114	77.04	Educational serv.	7,977	4,812	1,030	.603	.129	0	7,957	.000	.997
S56	L115	77.05	Nonprofit organizations	11,692	7,824	1,750	.669	.150	0	10,032	.000	.858
	L116	77.06-77.09	Other social services									
		1.00-77.00	Total, intermediate industries	1,409,441	377,075	55,913	.268	.040	112,715	728,066	.155	.517

Table A-1, continued

ABBREVIATIONS:

Comp.	Compensation
Employ.	Employment
F. Demand	Final Demand

NOTE: For full industry titles refer to the 1967 detailed industry report of the U.S. Department of Commerce, referenced below.

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NOTE: The table on the preceding pages is reproduced from the report by Randall Crane and Lorris Mizrahi, 1981, "Industrial and Regional Classification for Multiregional Economic Accounts," Report No. 26, Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology (September).

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