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Utah State and Local Government Fiscal Impact Model
Working Paper Series: 94-1

The Base Period 1992 Utah Multiregional Input-Output (UMRIO-92) Model: Overview, Data Sources, and Methods
June 1994

The Fiscal Impact Model (FIM) Working Paper Series is the product of a continuing research project within the Demographic and Economic Analysis Section of the Utah Governor's Office of Planning and Budget. The Office has a primary function of evaluating state budgetary and planning issues. The Utah State and Local Government Fiscal Impact Model is an analytical process used to evaluate many of these issues. The model was originally developed in 1990 through the collaborative efforts of the Office's research staff and university faculty. Although the basic structure of the model is at this point institutionalized, refinements occur with practically each application. This working paper series documents the ongoing research associated with the development of this model.

Working Paper 94-1 has been partially funded with a grant from the Economic Development Administration. This working paper provides an overview of the UMRIO-92 model, it gives information about the data sources, and methods used in the model. In the first part of the report the construction of single-region models is considered, and the second part deals with interregional trade and the modeling of spatial interconnectivity.

Other papers in the series currently include Working Paper 94-2: *Exports from Utah's Regional Economies*, and Working Paper 94-3: *Analytical Foundations, Research Findings, and Sensitivity Analysis*.

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Introduction

Information on the workings of the regional economy is useful to decision makers in and out of government. Moreover, the economic impact of alternative policy actions is a key ingredient in public policy analysis. The UMRIO-92 model was developed as a source of fundamental economic data for Utah, as a policy analysis tool, and as a key component of the Utah Fiscal Impact/Benefit-Cost Model.

UMRIO-92 Model Background

UMRIO-92 model is a generational descendent of two earlier input-output (I-O) models of Utah. The first was constructed for the Utah Governor's Office of Planning and Budget (Miller and Robison, 1990), and reflected a three region structure with no interregional trade. The second model was constructed for the Utah Division of Energy, conveyed detail on four internal subregions, and included interregional trade. Both the early Planning and Budget Office model, and the Division of Energy model conveyed a 1987 base-year.

UMRIO-92 reflects a 1992 base-year, and greater subregional detail. UMRIO-92 divides Utah into nine economic subregions. However, the greatest difference between UMRIO-92 and its predecessors is in the quality of its foundational data-base. The early Planning and Budget model, and the Division of Energy model, were constructed from data obtained entirely from otherwise published data sources. Chief among these is County Business Patterns, for SIC four-digit-level employment, adjusted in various ways to eliminate suppressed entries.

The County Business Patterns approach is common. The popular US Forest Service IMPLAN model, for example, uses a "County Business Patterns approach." However, a far better approach is to use otherwise confidential ES202 data, compiled by Utah Job Service. ES202 data are the point of departure for a process that ultimately provides a set of data that, when aggregated, generally reproduce other published economic information for Utah.

UMRIO-92 Model Multiplier Spreadsheets

The UMRIO-92 model is constructed with specialized computer software and stored as binary files. Critical arrays, including multipliers, base-line employment, sales, earnings and others are translated into PC spreadsheet form and, after considerable formatting and incorporation of report-writer features, these spreadsheets serve as the workhorse for conducting economic analysis.

The UMRIO-92 spreadsheets convey models for nine separate regions. In addition, each model comes in two forms, a "type II" model, and an EB/I-O model. The full UMRIO-92 modeling package thus includes eighteen model spreadsheets, one for each of nine regions, and one for each of two types of model.

Organization of this Report

The report is divided into two broad parts. Part I considers the construction of single-region models, while part II takes up the issue of interregional trade and the modeling of spatial interconnectivity. Part I of our report begins with the selection and definition of UMRIO-92's nine economic subregions. The presentation includes a brief history of past Utah definitions. Reflecting the importance of our foundational data base, we move next in chapter two to details on the construction of our various data components.

While UMRIO-92 includes an amount of field attention uncommon in most contemporary I-O modelling endeavors, UMRIO-92 is nonetheless primarily a non-survey modeling effort, i.e., a regional I-O model constructed on the basis of national I-O model technical coefficients. In chapter 3 we detail adjustments we made to national model coefficients, primarily to eliminate the effect on coefficients of the 1982 national recession.

Accurate export estimates are critical to an economic base portrayal of the regional economy, and to the overall accuracy of model multipliers. As with other non-survey modeling approaches, we form a mechanical estimate of regional exports. However, these form but the point of departure for our final export estimates. Through a consensus process of knowledgeable Utah economists, we replace mechanical export estimates in many of the more economic sectors with survey, or informed judgement estimates. Chapter 4 details our export estimating process.

In chapter 5 we discuss our process for regionalizing national model technical coefficients. Our approach follows in large measure standard pool-quotient technique procedures. However, the fact that we have export estimates that are less than as well as greater than mechanical estimates requires the application of a modified regionalization technique. In chapter 5 we present technical detail on this technique.

Chapter 6 concludes our consideration of single region modeling issues with a discussion of our UMRIO-92 regional I-O accounting conventions. Our accounting structure reflects special care to address problems of transboundary income and expenditure flows recently highlighted in the regional I-O literature. We also distinguish between the form in our type II versus EB/I-O UMRIO-92 models.

Part II includes two chapters and details our approach to interregional modelling and UMRIO-92. The first of the two chapters, chapter 7 presents the issues of interregional trade, and provides the basic interregional structure of UMRIO-92. In chapter 8 we take up modeling technique, and disclose our method for actually outfitting UMRIO-92 with interregional trade coefficients.

The appendix at the end of the document presents output, earnings, and employment multipliers, both type II and EB/I-O, for each of the nine UMRIO-92 models.

PART I: Individual Region Models

1. Defining UMRIO-92 Subregions

Defining a region for the purposes of economic analysis poses many problems and the appropriate regional delineation depends on the application of the analysis and resource availability. Developing regions which make sense economically, are useful analytically, yet are still capable of being modeled accurately with the resources at hand has proven to be a challenge in the implementation of UMRIO-92.

1.1 Utah's Multi-County Districts

During the 1960s, with the encouragement of the federal government, the Utah State Planning Coordinator's Office (which is the antecedent to the planning function within the Utah Office of Planning and Budget), began a process to regionalize the state into multicounty districts. At the time, the federal government was undertaking a major expansion of national social programs, and the Congress wanted to insure these programs were consistent with efforts at the state and local level. In its efforts to implement this national policy, the State Planning Coordinator, in consultation with local government officials, created seven Multi-County Districts (MCDs) for planning and development. These MCDs are comprised of the following counties:

1. Bear River: Box Elder, Cache, and Rich;
2. Wasatch Front: Davis, Morgan, Salt Lake, Tooele, and Weber;
3. Mountainland: Summit, Utah, and Wasatch;
4. Central: Juab, Millard, Piute, Sanpete, Sevier, and Wayne;

5. Southwestern: Beaver, Garfield, Iron, Kane, and Washington;

6. Uintah Basin: Daggett, Duchesne, and Uintah;

7. Southeastern: Carbon, Emery, Grand, and San Juan.

While issues of urbanization and economic development within Utah provided some impetus for establishing the MCDs, the driving force was the desire on the part of the federal government to have sub-state regions as the basis for operating and planning certain programs. The federal government's intent was to provide a compatible regional basis to achieve its program objectives with the least possible duplication of effort among the various levels of government.

The process which resulted in the eventual formation of the seven MCDs, listed below, began in the mid-1960s and concluded in the early 1970s. In a report issued during 1971, the State Planning Coordinator defined regions "as those areas that are linked by common problems, resources, and opportunities. The people of a region are interdependent economically and socially."[1] Thus in its efforts to regionalize the state into MCDs, the Planning Coordinator was aware that an important element in grouping counties into regions is the extent to which these groups form functional economies. However, that the MCDs form functional economies was not the primary consideration in delineating them. In the same 1971 report, the Planning Coordinator said the MCDs "are a framework to provide:

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[1]Utah State Planning Coordinator, Utah Multi-County Districts for Planning and Development (Salt Lake City, Utah: 1971), page 3.

1. a means of strengthening the role of county and municipal elected officials in the execution of programs;
2. a way of improving communication between various levels of government in planning and development efforts;
3. a uniform basis for coordinating major area-wide plans and programs each with the other;
4. a method for coordinating Federally assisted programs at substate levels with state programs; and
5. a geographically consistent area-wide basis for gathering and analyzing information and statistics."[2]

Absent from this list is a concern that the MCDs form functional economies. Rather, the emphasis is on grouping counties so as to improve the effectiveness of all levels of government. Though in the sense that delivering government services within a functional economy is less costly than delivering these services in a region covering parts of different economies, an area which is delineated so as to minimize the cost of providing services may also form a functional economy.

Prior to the Planning Coordinator's establishment of the MCDs, three multi-county organizations existed to coordinate the planning and operation of certain programs which effected people from several counties. By date of organization, these three were:

[2] Ibid., page 10.

1. Five County Association, organized in 1957, including Beaver, Garfield, Iron, Kane, and Washington Counties;
2. Six County Commissioners Organization, organized in 1961, including Juab, Millard, Sanpete, Sevier, Piute and Wayne Counties; and
3. Wasatch Front Regional Council, organized in 1968, including Davis, Morgan, Salt Lake, Tooele, and Weber Counties.[3]

Five County and Six County formed themselves essentially to take advantage of increasing returns to scale in the provision of certain services and as a means to more effectively advance the common interests of each of the member counties. Wasatch Front Regional Council was formed for similar reasons, although, an additional reason was that the U.S. Department of Transportation mandated the formation of Metropolitan Planning Organizations (MPOs) to plan the transportation systems, and program federal transportation assistance, for counties located in metropolitan areas. In the sense that the counties which banded together to form these three organizations perceived linkages within their groups which characterize functional economies, then these three groups of counties might be thought of as functional economies. This rationale probably applies better to Five County and Six County than it does to the Wasatch Front Regional Council. If the criteria mandated by the U.S. Department of Transportation in forming MPOs were applied to the counties along the Wasatch Front Mountains today, instead of 1968, certainly Utah

[3] Morgan and Tooele Counties were not added to the Wasatch Front Regional Council until 1972.

County, and possibly Summit and Wasatch Counties as well, would be included in the Wasatch Front Regional Council.

When establishing the MCDs, the Planning Coordinator wanted to encourage the formation of Associations of Government (AOGs), which would constitute "a voluntary agreement between county and municipal officials to establish an organization through which greater communication concerning area-wide problems and better coordination of programs and activities at all levels of government can be achieved."[4] Given this concern to nurture cooperation among local governments, it would only have made sense for the Planning Coordinator to bless the three existing AOGs by establishing them as MCDs. And this is precisely what was done in the cases of Five County, which became the Southwest MCD, and Six County, which became the Central MCD. Originally, for various reasons, two MCDs were established within the Wasatch Front Regional Council:

1. Weber River, including Davis, Morgan, and Weber Counties; and
2. Great Salt Lake, including Salt Lake and Tooele Counties.

However, by 1975, the Planning Coordinator and local officials viewed the five counties as one unit, the Wasatch Front MCD.

1.2 UMRIO-92 Model Regions

[4] Utah Multi-County Districts for Planning and Development, page 36.

The fundamental issue with UMRIO-92 is that while it would be extremely useful to analyze economic impacts within small geographic areas, it is difficult to do so accurately with the resources at hand. Insofar as possible, the regions settled on for UMRIO-92 are the MCDs, which are also the regions within UPED. UMRIO-92, has three main regions: North, Southwest and Southeast, which correspond to the BEA's division of the state between three economic areas. BEA economic areas

> "are nodal functional areas delineated to facilitate regional economical [sic] analysis. Each area consists of an economic node--a standard metropolitan statistical area (SMSA), or similar area, that serves as a center of economic activity--and the surrounding counties that are economically related to the center. To the extent possible, each area includes the place-of-work and the place-of-residence of its labor force."[5]

The areas covering Utah are centered in Salt Lake City, for the north, Las Vegas, for the southwest, and Grand Junction, for the southeast. For the purposes of UMRIO-92, the Utah portion of BEA's Salt Lake City area has been divided into seven inter-connected subregions. The UMRIO-92 regions decided upon are comprised of the following counties:

1. Southwest: Beaver, Garfield, Iron, Kane and Washington;

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[5]U.S. Department of Commerce, Bureau of Economic Analysis, BEA Economic Areas (Revised 1977) Component SMSA's, Counties, and Independent Cities (Washington, D.C.: U.S. Government Printing Office, 1977), page 1. The BEA's methodology in forming economic areas is documented in Regional Economic Analysis Division, "The BEA Economic Areas: Structural Changes and Growth, 1950-73," Survey of Current Business 55:11 (November 1975), pages 12-25. BEA announced its intent to revise the economic areas in the Federal Register 58:44 (Tuesday, March 9, 1993), pages 13049-50.

2. Southeast: Grand and San Juan;

3. Carbon-Emery: Carbon and Emery;

4. Central: Juab, Millard, Piute, Sanpete, Sevier and Wayne;

5. Bear River: Box Elder, Cache and Rich.

6. Wasatch Front: Davis, Morgan, Salt Lake, Utah and Weber;

7. Summit-Wasatch: Summit and Wasatch;

8. Uintah Basin: Daggett, Duchesne and Uintah; and

9. Tooele: Tooele.

Regions 3 through 9 are the sub-regions within the main North region. The Southwest, Central, Bear River, and Uintah Basin regions match the MCDs, and the Southeast and Carbon-Emery UMRIO-92 regions together match the Southeast MCD. The divergence from MCDs occurs in the UMRIO-92 Wasatch Front, Summit-Wasatch, and Tooele regions.

Within the main north region, the UMRIO-92 Bear River, Wasatch Front, Summit-Wasatch, and Tooele regions are rapidly becoming one large metropolitan area. Of course, the western desert parts of Tooele and Box Elder Counties, and the mountainous parts of the other counties will never be urbanized, but the area encompassed by Cache Valley to the north, Utah Valley to the south, Tooele Valley to the west and Heber Valley to the east is developing the characteristics of a sprawling urban metropolis. Since this is such a large area, about 10,000 square miles, and its population is not expected to reach 3 million people until well into the twenty-first century, if ever, much of this metropolis will maintain an essentially rural, even unpopulated character. If this area's population does reach 3 million, the average population density will be just 300 people per square mile, which is less than five percent of the current density in Salt Lake City's most populated residential neighborhoods.

The point of these comparisons is that the northern Utah metropolitan area contains a number of geographically dispersed population centers separated by mountainous, unpopulated terrain. People are not, and never will be, uniformly spread throughout this 10,000 square mile region. Therefore, UMRIO-92 will be more realistic if it captures the variation in economic activity within this area implied by the geographic dispersal of its population. Certain goods and services, such as gasoline and food, are available throughout the area, while others, such as international air transportation and specialized medicine, are available only in Salt Lake City. An intermediate range of goods and services, such as cars or wholesale distribution, are available in the larger population centers, but are not available throughout the area. In addition, large numbers of people live in one population center, but work in another. To capture this variation in economic activity, both central place theory and commuting have been built into UMRIO-92.

Notwithstanding the fact that northern Utah will include urban, rural and unpopulated areas, it will still function as one economy. The question confronted in UMRIO-92, with respect to northern Utah, was whether the analytical benefits of separating this large functional economic area into smaller inter-related sub-regions outweighed the costs, in terms of reduced accuracy of results (at least at the sub-regional level), and increased staff requirements. The decision was made that the benefits do exceed the costs, although the degree of certainty about this result is not as high as might be liked.

Tables 1 through 3 indicate most of these regions have closed labor markets in the sense that more than 90 percent of the income generated in a given region is also received there, and, conversely, more than 90 percent of the income received in a given region is also generated there. To the extent a closed labor market reflects a functional economy, most of the UMRIO-92 regions are functional economies. Two of the sub-regions, Summit-Wasatch and Tooele, do not have closed labor markets, and so, in that sense, are not functional economies. However, since it will be useful to estimate impacts within each of these areas separately from the Wasatch Front, they are treated as separate economic regions.

Our analysis of the Journey to Work data from the 1990 Decennial Census, presented in tables 2 and 3, supports the delineations we have made. During 1989, according to these data, 97 percent of the income generated in the Southwest was received there, and 91 percent of the income generated in the Southeast was received there. Conversely, 91 percent of the income received in the Southwest was generated there, and 93 percent of the income received in the Southeast was generated there. In both regions, much of the income leakages (both income flowing in from outside and income flowing out from inside), are out-of-state. Thus, neither the Southwest nor the Southeast are closely linked to other regions within Utah. While the North is not strongly linked to either the

Southwest or the Southeast, several of the subregions within the North are strongly inter-linked.

The most important linkages involve the Wasatch Front trading core. In many respects, Summit County is becoming a suburb of the Salt Lake area, and Wasatch County is becoming a suburb for both the Provo-Orem and the Salt Lake areas. In Summit County, 39 percent of resident income is generated in Salt Lake County, while in Wasatch County, 19 percent is generated in Summit, 15 percent in Salt Lake and 13 percent in Utah. Only 47 percent of resident income in Wasatch County is earned within the county. Tooele County is unique because of the Tooele Army Depot (TAD). Because TAD employs several hundred Salt Lake County residents, 21 percent of income generated in Tooele County is received by Salt Lakers. But as with Summit and Wasatch, Tooele is becoming a suburb of Salt Lake, which generates 14 percent of Tooele resident income. Though not as strongly linked to the Wasatch Front as the Summit-Wasatch and Tooele regions, the Bear River region is still linked. In Box Elder County, 9 percent of resident income is generated in Weber County and 4 percent is generated in Davis, while 14 percent of the income generated in Box Elder is received by Weber residents. Clearly, Box Elder and Weber Counties are linked, so that a model which treats them as separate regions will need to capture the interaction between the two. In sum, then, the Journey to Work data suggest it is reasonable to treat the Southwest, Southeast, and North as distinct economic regions.

The seven sub-regions of Northern Utah have a complex interrelationship. The five counties of the Wasatch Front, which include about 4,500 square miles of land and almost 1.5 million people, serve as the trading center for a much larger, much less densely populated, peripheral area. Using the lexicon of central place, the Uintah Basin, Carbon-Emery, and Central regions of the periphery import higher order goods and services from the Wasatch Front core and export lower order, and specialized, goods and services to the core. There is no significant commuting between these three regions and the core. The three other regions of the northern periphery--Bear River, Summit-Wasatch, and Tooele--have a similar central place relationship to the Wasatch Front core, but, in addition, there is significant commuting between these regions and the core. As discussed above, these four metropolitan regions of North Utah--Wasatch Front, Bear River, Summit-Wasatch, and Tooele--can be viewed as containing one sprawling metropolis, and, in that sense, together form the central place trading core for North Utah. However, because it is useful to isolate impacts specific to each of these regions, and separate from the Wasatch Front, they are considered as four distinct, but strongly inter-related economic regions. The interrelationships are captured with both central place and commuting.

2. Constructing the 1992 County-Level Data Base for UMRIO-92

The point of departure for constructing UMRIO-92 is a set of county-specific earnings and value added (gross state product, or GSP) estimates, reflecting the six-digit I-O code level of sectoral detail for 1992. In this section we document our procedures for arriving at these two data sets.

2.1 Disaggregating REIS County Earnings Estimates to Secotrs of the UMRIO-92 Model

2.1.1 Building Complete Files for 1989

Though our aim is to construct earnings and GSP data estimates for 1992, data available requires that we start with 1989. We make use of fundamentally three 1989 data items shown symbolically as follows:

(2.1) $$\underset{(800x29)}{\left\{\begin{matrix} ES202 \\ Wage+Salary \\ 1989 \end{matrix}\right\}} =$$ Job Service ES202 wages and salaries with SIC four-digit sectoral detail, providing approximately 800 rows, for Utah's 29 counties arrayed on columns.

(2.2) $$\left\{\begin{array}{c} REIS \\ Earnings \\ 1989 \\ \\ \end{array}\right\}_{(100x29)} =$$

US Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System (REIS), earnings with SIC two-digit detail, providing approximately 100 rows of sectoral detail, and 29 columns for Utah Counties.

(2.3) $$\left\{\begin{array}{c} REIS \\ Wage+Salary \\ 1989 \\ \\ \end{array}\right\}_{(100x29)} =$$

US Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System (REIS), wages and salaries with SIC two-digit detail, providing approximately 100 rows of sectoral detail, and 29 columns for Utah Counties.

2.1.2 Eliminating Proprietor Losses in the REIS Earnings Array

REIS measures earnings as the sum of wages, salaries, other labor income (OLI), and proprietors' income. While the first of these items are logically never less than zero, proprietors' income will be less than zero when proprietors earn losses.

While for the most part we gauge the accuracy of our I-O model by the degree to which it faithfully reflects the economy during our base year, i.e., reflects published data, at the same time we want a model on which to forecast impacts, and otherwise present a "representative" picture of the economy, i.e., a picture of the economy in some sort of stable equilibrium, or steady-state. In such a state we argue there is no room for proprietor losses.

We eliminate proprietor losses by conducting an element-by-element comparison of earnings matrix (2.2), and wages and salaries matrix (2.3). Proprietor losses are indicated wherever earnings matrix (2.2) shows an entry less than wages and salaries matrix (2.3). In these cases we replace earning entries with the wage and salary entry, in effect revising proprietors' income from a position of loss, to one of zero. The adjustments give rise to a "revised" matrix of earnings:

(2.4) $$\underset{(100x29)}{\begin{Bmatrix} REIS \\ Earnings^{*} \\ 1989 \end{Bmatrix}} =$$ REIS earnings matrix (2.2) revised via REIS wage and salary matrix (2.3) to eliminate negative proprietors' income.

2.1.3 Expanding REIS Earnings from a two-digit to a four-digit Level

We obtain an earnings with SIC four-digit sectoral detail according to a simple mapping. Our mapping that makes use of ES202 wage and salary matrix (2.1), and our revised matrix of REIS earnings, matrix (2.4). ES202 wage and salary matrix (2.1) exhibits the four-digit detail we want.

2.1.3.1 The Relationship Between Two and

Four-Digit SIC Sectors

Two-digit SIC sectors can be broken down into constituent four-digit members. For example, "lumber and wood products," two-digit SIC sector 24, consists of "logging camps and logging contractors," four-digit SIC 2411, "sawmills and planning mills," four-digit SIC 2421, and a dozen or so other four-digit SIC sectors.

The operative assumption behind our mapping is that a given two-digit earnings estimate is distributed among constituent four-digit sectors according to the proportional distribution of ES202 wage and salary estimates among those same four-digit sectors. If, for example, sawmills and planning mills, SIC 2421, exhibits 40% of all lumber and wood products, SIC 24, ES202 wages and salaries for some county, then SIC 2421 gets 40% of all SIC 24 earnings shown for that county.

2.1.3.2 The Problem of Earnings where Wages and Salaries are Zero

A problem arises where adjusted REIS estimates show earnings in sectors for which ES202 shows no wages and salaries. For example, a given county might show positive REIS earnings for "lumber and wood products," two-digit SIC sector 24, while at the same time ES202 shows all zero wages and salaries for constituent four-digit SIC sectors, i.e., for SIC sectors 2411, 2421, 2426, and so on.

Conceptually the root of the problem is easy to visualize. For example, consider a one-person logging operation, or several such operations, operating in a given county. As sole proprietorships, these logging contractors create "proprietors' income" only. REIS will, in principle, pick up these income items, and report them as SIC 24 earnings in two-digit REIS earnings data (matrix (2.2)). At the same time, however, since no wage or salary income is generated, ES202 reports zeros in all four-digit members of SIC 24.

Our solutions, less than perfect, is to assume all four-digit sectors within a given two-digit group exist in the county reporting two-digit earnings (for which there is no ES202 wages and salaries). REIS earnings are distributed across these four-digit members equally. Thus, with a dozen or so four-digit members in SIC 24, our logging earnings discussed above will be distributed equally between four-digit members of SIC 24. The obvious error here is that logging will be incorrectly reported with approximately 1/12th of its actual earnings, while all other SIC 24 sectors will get the same amount, when the correct amount is zero.

While providing less than entirely satisfactory results, we need not be too troubled with our solution. Our final models are aggregated to roughly a SIC two-digit level, thus possibly non-existent industries appear only in the model estimation phase, and not in reporting.

2.1.3.3 Final Mapping and Matrix Formation

Our final matrix of earnings is matrix (2.4) mapped to a four-digit level. Matrix (2.4) earnings are distributed in proportion to matrix (2.1) ES202 wages and salaries is all sectors for which all elements are non-zero. where ES202 estimates are zero, but REIS indicates earnings, our procedure is as described previously. Symbolically, the mapping provides the following matrix:

(2.5) $$\left\{\begin{matrix} REIS \\ Earnings^{*} \\ 1989 \end{matrix}\right\}_{(800x29)} =$$

Adjusted REIS earnings (i.e., adjusted to eliminate negative proprietors' income) , matrix (2.4), mapped to a SIC four-digit level using Job Service ES202 wages and salaries, matrix (2.1).

2.1.4 Mapping SIC Sectors to I-O Sectors

UMRIO-92 is constructed according to the industry definitions of the 1982 US national I-O model. An overview of the 1982 national model appears in the July, 1991 Survey of Current Business, "Benchmark Input-Output Accounts for the U.S. Economy, 1982." Appendix A "Industry Classification of the 1982 Input-output Accounts" presents six-digit I-O industry definitions for the 1982 model, including the detailed SIC composition of I-O industries.

We formed a six-digit I-O/four-digit SIC crosswalk based on appendix A. We then employed the crosswalk to map our various data arrays from their present four-digit SIC row form, approximately 800 rows, to a six-digit I-O row structure, with some 500 rows. Symbolically, our adjusted earnings matrix (2.5) is mapped from a SIC row structure to an I-O row structure as follows:

(2.6)

$$\left\{\begin{matrix} REIS \\ Earnings \\ 1989 \\ (800x29) \end{matrix}\right\}^{*} \rightarrow map\ SIC\ into\ I\text{-}O \rightarrow \left\{\begin{matrix} REIS \\ Earnings \\ 1989 \\ (500x29) \end{matrix}\right\}^{*}$$

2.1.4.1 Redefinitions from National I-O

Sectors: Agriculture

The ES202 data file provides no information of farm income -- farm proprietors are not generally covered by unemployment insurance, nor are hire farm workers. Moreover, the national I-O model tracks considerable detail on agricultural sectors, "food grains," "feed grains," "tree nuts," etc., while comparable data on Utah agriculture is nowhere near this available. Recognizing a loss of precision in UMRIO-92 agricultural, our approach is to report all agriculture in two broad sectors, "crop," and "livestock."

The BEA provides a single "farm income" estimate for Utah (see: "Farm Income and Expenses," BEA, CA45). At the same time, Utah Agricultural Statistics, publishes overall crop and livestock cash receipts by county. We estimate crop and livestock earnings by assuming that crops and livestock operations exhibit identical sales/earnings ratios, and that these are uniform across all 29 Utah counties. Accordingly, we distribute BEA farm income across counties, to crops and livestock, in proportion to county-specific crop and livestock marketings.

2.1.4.2 Redefinitions from the National I-O Model:

Construction and Mining

The national I-O model presents great detail for construction sectors, distinguishing for example between "residential 1 unit structures," and "residential

2-4 unit structures." Also the national I-O draws a broad distinction between "new construction," and "maintenance and repair construction." In all, the national I-O model tracks 36 new constructions sectors, and 17 maintenance and repair construction sectors. While there is some local data for distinguishing between "new," and "maintenance and repair construction," at the state-level at least, there is no where near the national I-O model construction sector detail in our Utah data sources.

We decided to form a single UMRIO-92 construction sector. However, prior to formation of this sector, we find several re-mappings necessary due to inclusion in construction by the BEA of certain mining activities in the 1982 national I-O model. Our re-mappings result in a new sector, unique to UMRIO-92, which we name six-digit I-O 110600: "oil & gas drilling, exploration, and maintenance." Constituent 1982 national I-O model sectors included in our new 110600 include:

> 110601: Petroleum and natural gas well drilling.
>
> 110602: Petroleum, natural gas, and solid mineral exploration (also assigned all SIC 108 and SIC 148 information).
>
> 120215: Maintenance and repair of petroleum and natural gas wells.

Also we note that SIC 108, metallic minerals services, included by national I-O modelers in six-digit I-O sector 60200, nonferrous metal ores, except copper, is reassigned in UMRIO-92 to sector 110602: Petroleum, natural gas, and solid mineral exploration.

Our new "consolidated" construction sector includes national I-O model sectors 110101 through 110502, 110603 through 120214, and sector 120216. We code our new "consolidated" construction sector six-digit I-O sector 125000.

2.2. Using 1989 Earnings Data to Estimate Earnings in 1992

UMRIO-92 models Utah's economy in 1992. We start with 1989 because of data availability -- but 1992 is our target year. To estimate 1992 earnings from our I-O coded 1989 earnings array (2.6), first map ES202 wages and salaries, array (2.1), and a comparable array for 1992, into matching I-O codes. Our mapping scheme for the 1989 array is the same as that depicted in (2.6), and can be similarly characterized by the following:

(2.7) $$\left\{\begin{matrix} ES202 \\ Wage+Salary \\ 1989 \\ \\ (800x29) \end{matrix}\right\} \rightarrow map\ SIC\ into\ I\text{-}O \rightarrow \left\{\begin{matrix} ES202 \\ Wage+Salary \\ 1989 \\ \\ (500x29) \end{matrix}\right\}$$

The mapping scheme for the 1992 array differs from that of the 1989 array only in so far as 1992 showed several new industries. Taking account of these, the SIC to I-O mapping of 1992 ES202 data is characterized as follows:

(2.8) $$\left\{\begin{matrix} ES202 \\ Wage+Salary \\ 1992 \\ \\ (800x29) \end{matrix}\right\} \rightarrow map\ SIC\ into\ I\text{-}O \rightarrow \left\{\begin{matrix} ES202 \\ Wage+Salary \\ 1992 \\ \\ (500x29) \end{matrix}\right\}$$

We estimate 1992 earnings with six-digit I-O detail on the assumption that the ratio of earnings to ES202 wages and salaries has remained unchanged between to the two years. Importantly, just as there are in 1989 earnings in sectors for which there are no ES202 wages and salaries, so there are earnings in 1989 unmatched by 1992 ES202 wages and salaries. Drawing some comfort from the fact that these instances are relatively, we adopt the otherwise extreme procedure of simply replacing the zero 1992 ES202 wages and salaries estimate with the corresponding 1989 earnings estimate -- i.e., carry forward the 1989 estimate.

The following pair of matrix calculations provide our 1992 six-digit I-O earnings estimate:

(2.9) $$\left\{\begin{matrix}(Earnings89)/\\(Wage+Salary)\\ratios\end{matrix}\right\}_{(500x29)} = \left\{\begin{matrix}REIS\\Earnings^{*}\\1989\end{matrix}\right\}_{(500x29)} \div \left\{\begin{matrix}ES202\\Wage+Salary\\1992\end{matrix}\right\}_{(500x29)}$$

(2.10) $$\left\{\begin{matrix}Earnings\\Estimate\\1992\end{matrix}\right\}_{(500x29)} = \left\{\begin{matrix}(Earnings89)/\\(Wages+Salaries)\\ratios\end{matrix}\right\}_{(500x29)} * \left\{\begin{matrix}ES202\\Wage+Salary\\1992\end{matrix}\right\}_{(500x29)}$$

where all algebra is implicitly element-by-element.

2.3. Six-Digit I-O GSP Data Estimates for 1989 and 1991

To build our UMRIO-92 model we need county-specific estimates of value added with six-digit I-O code level of sectoral detail. Using elements from data arrays developed thus far, our procedure is to first estimate a GSP array for 1989, and then use this to estimate GSP for 1991.

Our 1989 estimating procedure makes use of value added/earnings ratios from the 1982 U.S. national I-O model. Features of the 1982 national model require, however, that we first make some preliminary adjustments in those that model.

2.3.1 Adjusting National Value Added Estimates to Eliminate Recession-year Property-Income Losses

2.3.1.1 Effect of the Business Cycle on the I-O Model

UMRIO-92 is fundamentally a non-survey I-O model, constructed on the basis of technical coefficients borrowed from the U.S. national I-O model. The most recent, fully-detailed (i.e., I-O six-digit) U.S. national I-O model is for year 1982.

A problem arises in using the 1982 national model. 1982 was a rather deep recession year, the so-called Reagan recession. In a recession, losses are more often than normally the reward for doing business. In the I-O model, industry losses are reflected in variable costs (produced inputs plus labor and indirect business taxes) in excess of gross revenues. The input-output balance required in I-O models is reflected in negative profit-income entries (six-digit I-O sector 90000 profit-type income, net interest, and capital consumption allowances) in industries with losses.

Our purpose in constructing UMRIO-92 is to obtain as far as possible with given funds an accurate snap-shot of Utah's economy for our 1992 base-year. Drawing the important distinction between *technical coefficients* and *regional I-O coefficients*, we are prepared to accept ten-year old national technology, i.e., 1982 U.S. national *technical coefficients* as surrogates for 1992 Utah *technical coefficients*. We are not willing, however, to accept losses in national industries in 1982, as losses in Utah industries in 1992. While there is reason to expect some correspondence between national and local technologies, there is no reason to expect correspondence between the national business cycle in 1982, and business conditions in Utah in 1992.

More generally, we are uncomfortable with incorporating losses in our base period UMRIO-92 I-O model. Thus, while there undoubtedly were Utah industries with losses in 1992, even if we had data on these losses, it is questionable whether we would want to incorporate these into our base period UMRIO-92 model. UMRIO-92 is to serve as a predictive devise. UMRIO-92's base period simply shows the economy in a steady-state equilibrium. Exogenous changes are entertained in the course of impact exercises, and the model indicates a new position of equilibrium. In such exercises we do not want industry losses to be carried forward as a general equilibrium condition of the economy.

2.3.1.2 Profit-Income Loss Adjustment

Our procedure for eliminating profit-income losses in the 1982 national I-O model is indicated below. First, consider symbolically the elements of value added in the 1982 national I-O model:

(2.11) W_{82} = value added

where:

$$W_{82} = (EComp_{82}) + IBT_{82} + B_{82}$$

(2.12) $(EComp_{82})$ = compensation of employees (six-digit I-O 88000)

(2.13) IBT_{82} = indirect business taxes (six-digit I-O 89000)

(2.14) B_{82} = profit-type income, net interest, and capital consumption allowances (six-digit I-O 90000)

Noting that 1977 (the next most-recent fully-detailed national I-O model) was more "normal" in terms of business cycle than 1982, we produce a "revised" estimate of 1982 profit-type income through the following calculation:

(2.15) $$B^*_{82} = \frac{(B_{77})}{(EComp_{77})} * (EComp_{82}) \text{ if } > B_{82}$$

$$B_{82} \; otherwise$$

where terms with subscripts "77" refer to the same items of value added as described earlier, except for 1977.

Our revised estimate of 1982 national model value added now appears as follows:

$$(2.16) \quad W^{*}_{82} = (EComp_{82}) + IBT_{82} + B^{*}_{82}$$

where considering individual industries j, it can be shown that:

$$(2.17) \quad W^{*}_{82_j} \geq W_{82_j} \quad all\ j$$

The revised national value added estimates (2.12) serve to assist in our estimation of county-specific six-digit value added estimates for Utah in 1992. We also make use of these adjusted values in the formation of the technical coefficients we borrow for use in constructing UMRIO-92. These latter adjustments are considered in a latter section below.

2.3.2 Disaggregation of REIS GSP Data

REIS provides estimates of Utah's gross state product (value added) at approximately a two-digit SIC level of detail. State-level is as detailed as it gets, there are no county-level GSP estimates. To construct UMRIO-92, we need GSP estimates with the same detail as our earnings estimates. Accordingly, GSP estimates must be sectorally disaggregated, to the six-digit I-O level, and spatially, to Utah's 29 counties. As with our earnings estimating procedure, we start with 1989, and use this to estimate 1992, our target year.

We start by making a very crude estimate of county-specific, six-digit I-O GSP for 1989. We form a set of six-digit value added/earnings ratios from the 1982 national I-O model. Our value added data are the adjusted values presented in (2.12) above. The earnings data are actually something less than "earnings," earning less OLI (other labor income). These data were obtained from the U.S. Department of Commerce, BEA, Regional Economic Analysis Division (READ). READ constructs the earnings less OLI estimates as part of their RIMSII regional I-O modeling program.

Symbolically, national value added/earnings (less OLI) ratios appear as follows:

(2.18)
$$\underset{(500x500)}{\left\{ \frac{W_{82}^{*}}{EOLI_{82}} \right\}} \underset{(500x29)}{\left\{ \begin{matrix} RIES \\ Earnings_{89} \end{matrix} \right\}} = \underset{(500x29)}{\left\{ \tilde{W}_{89} \right\}}$$

We must note that our national earnings estimates are "less OLI," while our Utah earnings estimates include OLI. The result of this is that our matrix of tentative GSP estimates (2.18) will systematically overstate GSP in sectors with high OLI relative to total earnings.

Two-digit GSP at the state-level is disaggregated between six-digit I-O sectors. Our procedure assumes that a given REIS two-digit GSP estimate is distributed across its the six-digit I-O sector membership in proportion to the distribution of tentative value added across those sectors as indicated in (2.18). Symbolically, the disaggregating procedure can be envisioned first with sectoral disaggregating step:

(2.19) $$\underset{(100x1)}{\left\{GSP_{89}\right\}} \rightarrow \underset{dissagregate}{sector} \rightarrow \underset{(500x1)}{\left\{GSP_{89}\right\}}$$

and second, with a spatial disaggregating step:

(2.20) $$\underset{(500x1)}{\left\{GSP_{89}\right\}} \rightarrow \underset{dissagregate}{sector} \rightarrow \underset{(500x29)}{\left\{GSP_{89}\right\}}$$

Matrix () is our final estimate of 1989 Utah GSP, by county and six-digit I-O sector.

We obtain our spatial and sectorally detailed estimate of 1992 Utah GSP by assuming stability in the 1989 ratio of GSP to earnings. Accordingly, we form ratios:

(2.21) $$\left\{\frac{(GSP_{89})}{(Earnings89^{*})}\right\}_{(500x29)} = \left\{GSP_{89}\right\}_{(500x29)} \div \left\{\begin{matrix} REIS \\ Earnings^{*} \\ 1989 \end{matrix}\right\}_{(500x29)}$$

and estimate 1992 Utah GSP as follows:

(2.22) $$\left\{GSP_{92}\right\}_{(500x29)} = \left\{\frac{(GSP_{89})}{(Earnings89^{*})}\right\}_{(500x29)} \left\{\begin{matrix} REIS \\ Earnings^{*} \\ 1992 \end{matrix}\right\}_{(500x29)}$$

2.4. Estimating Total Sales for UMRIO-92

(2.23) $$\left\{UTSales^{W}\right\} = \left\{\frac{\tilde{X}_{82}}{W^{*}{}_{82}}\right\}_{(500x500)} \left\{GSP_{92}\right\}$$

overstate sales where OLI is large

$$(2.24)\quad \left\{ UTSales^{E} \right\} = \left\{ \frac{\tilde{X}_{82}}{EOLI_{82}} \right\}_{(500x500)} \left\{ \begin{matrix} REIS \\ Earnings^{*} \\ 1989 \end{matrix} \right\}$$

overstate sales where OLI is large

$$(2.25)\quad \left\{ UTSales \right\} = AVG \left\{ \left\{ UTSales^{W} \right\} \Leftrightarrow \left\{ UTSales^{E} \right\} \right\}$$

The above arrays are for the foundational data for constructing UMRIO-92. By their construction, when UMRIO-92 model base-period data are summed, we can expect to see more aggregated published values.

3. Preparing National I-O Model Coefficients to Serve UMRIO-92 Model Construction

UMRIO-92, like most modern I-O modelling projects, uses I-O model technical coefficients borrowed from the national I-O model. Early in 1993, when UMRIO-92 model construction began, 1982 was the most recent U.S. national I-O model available. 1982 was a recession year, and many of the national model sectors exhibited negative value added coefficients. There is no role in our UMRIO-92 model for negative value added. Accordingly, this chapter details adjustments we made in national I-O coefficients in preparation for use in the UMRIO-92 model.

3.1 A Review of National Input-Output Accounting

The U.S. National I-O is constructed according to the so-called United Nations Conventions Regarding I-O model Construction. According to those conventions, flows between production and absorption are expressed with both "use," and "make table" detail. The standard expression of use and make algebra is Miller and Blair (1985) -- we adopt Miller and Blair notation.

The make matrix (or table) takes the industrial output of each industry the sum of gross revenues from the production of various commodities. By its construction, each row shows the national production of some commodity as the sum of its production in the many industries that produce it. Assuming in the national economy m commodities and n industries, the national model make matrix is defined as:

$\boldsymbol{M}$ = (mxn) national model make matrix with m (commodity) rows and n (industry) columns.

The use matrix shows the flow of commodities from production to consumption, i.e., from commodity production to consumption by industries, private consumption, consumption for investment purposes, and consumption by government. On columns the use tables give a different perspective. Column entries present the commodity input requirements of industry, and these are easily taken to represent a set of fixed-input production functions. Formally the national use matrix is presented as follows:

$\boldsymbol{U}$ = (mxn) national model use matrix with m (commodity) rows and n (industry) columns.

3.1.1 Summation Requirements

Given its row and column structure, the following summations requirements pertain to the national make matrix:

(3.1) $\boldsymbol{Q} = \mathbf{1}\boldsymbol{V}$

(3.2) $\boldsymbol{X} = \boldsymbol{V}\mathbf{1}$

There are summation requirements for the national use matrix, but these require the introduction of two additional matrix items: value added and final demand. Accordingly, total commodity production is expressed as a summation on the use matrix (i.e., summing the use of commodities by industry), plus a summation on the final demand matrix (i.e., summing commodity consumption by final users):

(3.3) $\boldsymbol{Q} = \boldsymbol{U}\mathbf{1} + \boldsymbol{E}\mathbf{1}$

where

$\boldsymbol{E}$ = (mxk) matrix showing consumption of m commodities by one of k final demand sectors.

Alternatively, gross revenues are shown as the sum of commodity input purchases by industry, or payments to primary factors, also know as the "sum of value added." Symbolically:

(3.4) $\boldsymbol{X} = \mathbf{1}\boldsymbol{U} + \boldsymbol{W}$

where:

$\boldsymbol{W}$ = (1xn) vector showing value added by industry.

3.1.2 National I-O Model in its Industry by Industry Analytic Form

Most non-survey regional I-O modeling endeavors rely on national model technical coefficients. The most typical form is to assume the technology embedded in an industry by industry input-output matrix, constructed with an "industry-based" technology. Following standard practice (e.g., Miller and Blair, 85) the national model, industry-by-industry (nxn), matrix of input-output technical coefficients, with industry-based technology, is given as follows:

$$(3.5) \quad \boldsymbol{A} = \boldsymbol{DB}$$

where

$$\boldsymbol{D} = \boldsymbol{V}\hat{\boldsymbol{Q}}^{-1}$$
$$\boldsymbol{B} = \boldsymbol{u}\hat{\boldsymbol{X}}^{-1}$$

3.2 Ridding the 1982 National I-O Model of Recession Effects

Equation (2.16) in an earlier section presented a vector of adjusted value added estimates for the 1982 national I-O model. We undertook the adjustments to eliminate negative profit-income form the 1982 national model. Value added measures the return to primary factors of production. Assuming industry expenditures on produced (i.e., non-primary) inputs were unaffected by the adjustment in value added, then a new vector of industry sales is given by the following modification to summing up condition (3.4):

$$(3.6) \quad \boldsymbol{X}^{*} = \boldsymbol{1U} + \boldsymbol{W}^{*}$$

where

W^* = vector of adjusted national model value added (see also equation (2.16).

where:

$$B = u\hat{X}^{-1}$$

3.2.1 A Cost of Production Theory of Prices

Implied in our construction of (3.16) is that the physical quantity of production has remained unchanged, because non-produced inputs are unchanged, as is wage and salary employment (see expression (2.16)). Only profit income has changed, from its below "normal" recession-year level, to a "more normal level" arrived at with the help of 1977 profit-income levels (see expression (2.16)).

The revised vector of industry total gross outputs X^* are thus the result of the given physical quantity of production times a revised set of industry output prices. Prices are revised upward by an amount needed to provide producers with a "normal" profit-type income. Our procedure is reminiscent of Adam Smith's "cost of production theory of prices" (Dobb, p46). According to Smith, the price of a commodity is governed by the cost of produced inputs plus labor, purchased at their "normal" prices, plus a "normal" return to fixed factors.

3.2.2 Adjusting the National Make Table

Summation condition (3.6) shows the gross revenues of a given industry to be the sum of revenues from sale commodities it produces. We construct a revised make table, revised in a manner consistent with our vector of revised industry revenues (3.6), as follows:

(3.7) $\boldsymbol{V}^{*} = \hat{\boldsymbol{X}}^{*}\boldsymbol{X}^{-1}\boldsymbol{V}$

giving rise a revision of summation condition (3.4) as follows:

(3.8) $\boldsymbol{X}^{*} = \boldsymbol{V}^{*}\mathbf{1}$

Adjustment (3.4) has the following meaning. Normal profit-income requires an increase in the price of industry output. In (3.4), the price of industry outputs (i.e., of the commodities produced by a given industry) are increased across the board. In other words, if the gross revenues of a given industry are to increase by say 10%, then we assume that the revenues from the sales of all commodities produced by that industry increase by 10%.

Make table algebra provides column summation condition (3.6). Accordingly, our revised make table (3.5) gives rise to a vector of revised commodity outputs:

(3.9) $\boldsymbol{q}^{*} = \mathbf{1}\boldsymbol{V}^{*}$

The meaning of the commodity output changes indicated by $\boldsymbol{q}^*$ is as follows. To make "normal profits," industries must charge more for the commodities they produce. Increased prices generate the needed increased industry revenues as indicated on row sums of our revised make table. In the meantime, the sum of commodities production with commodities so-priced is indicated by column sums of our revised make table. It will be noted that by the nature of the adjustments and subsequent summations, commodities produced disproportionately by industries with abnormal profits (recession-year losses), are the commodities whose prices will go up by the most. So we can happy with the logic of our adjusted make matrix (3.7).

3.2.3. Adjustments Needed in the National Use Table

Expressions (3.7), (3.8), and (3.9) exhibit consistent make matrix algebra on revised industry sales $\boldsymbol{X}^*$, commodity production $\boldsymbol{Q}^*$, commodity make $\boldsymbol{V}^*$. Expression (3.9) is consistent with revised industry sales $\boldsymbol{X}^*$. However, we are left with contraction regarding revised commodity production $\boldsymbol{Q}^*$, and summation condition (3.8). A reconciliation is provided though a biproportional adjustment on the national use table.

Given original and revised vectors of commodity production $\boldsymbol{Q}$, and $\boldsymbol{Q}^*$ respectively, we produce the following interim use and final demand matrices:

$$\{\boldsymbol{U}_1 \ \boldsymbol{B}_1\} = \hat{\boldsymbol{Q}}^* \hat{\boldsymbol{Q}}^{-1} \{\boldsymbol{U} \ \boldsymbol{B}\}$$

Additional column adjustments provide use and make tables that are consistent with our revised value added estimates as presented in chapter 2.

4. Estimating Exports for UMRIO-92 Subregions

Exports are of the greatest importance in regional I-O models. Export estimates that are too low lead to overstated multipliers, and thereby overstated impacts in economic impact assessments. Non-survey regional I-O modeling techniques estimate exports mechanically, and most of the shortcomings of these techniques can be traced to the inaccuracy of the mechanical export estimates (Isserman, 1980).

In constructing UMRIO-92, we start with a mechanical estimate of regional exports -- we call this our "tentative" export estimate. Tentative exports are estimated as the lower of a supply-demand-pool, or simple-location-quotient estimate (Schaffer and Chu, 1969). Robison and Miller (1988) show the kinship between the supply-demand-pool and simple-location-quotient techniques, demonstrating the sense in which the former is a special case of the latter. Recognizing this kinship, and the fact that pool and quotient techniques generally underestimate exports (Richardson, 1972), the larger of the pool or quotient technique export-estimate is adopted as the tentative estimate.

For each of our nine subregions, tentative export estimates are arranged in tabular form, ordered according to largest to smallest sector. Total industry sales are taken as the measure of total sales size. The tentative export estimates are next presented to a group of informed Utah economists, for their judgments as to accuracy.

The "group of informed Utah economists" is provided by the "Utah State Economic Coordinating Committee," or ECC. The ECC was organized by the

Utah Governor's Office of Planning and Budget to provide input on important economic policy issues. The ECC has approximately 30 members, all economists, from a mix of state agencies, universities, and the private sector. The ECC meets monthly.

An ECC meeting was dedicated to estimating exports in the UMRIO-92 model. Accordingly, a presentation was made describing the role of exports in regional I-O models, and presenting tentative estimates of exports for the nine subregions. Specifically, export estimates for the largest 40 industries (measured in terms of size of total sales) was given to ECC members. Top 40 industries typical accounted for over 90% of total regional sales, and in one case over 99%. Also circulated at the meeting was a list of definitions and key concepts associated with regional I-O and the estimating of tentative exports.

ECC members were asked to consider the tentative export estimates over the next several weeks, and contact Planning and Budget UMRIO-92 point persons where revisions were considered in order. The source of revision was left open, e.g., published material, or simply informed judgement. Planning and Budget received revisions for approximately half of all tentative export estimates. Revision ran both ways, some up relative to tentative, and others down. On net, the export revision exercise resulted in a reduction in overall exports of 10% to 20% depending on subregion.

5. Regionalizing Nation Model Technical Coefficients

The high cost of survey-based regional I-O models has spawned development of a variety of non-survey techniques. Currently popular are the supply-demand-pool (SDP), and simple-location-quotient (SLQ) techniques (Schaffer and Chu, 1969), and the Regional Purchase Coefficient (RPC) technique (Stevens et. al., 1983). A common feature of all three of these techniques is that national model technical coefficients are either left as is, or scaled downward -- but never upward.

In the previous chapter we discussed estimation of regional export for the nine subregions of Utah. In many cases, our export estimates were greater than that indicated by the mechanical procedure. This posses no problem in regionalization, national coefficients are simply scaled downward as needed. However, in other cases our export estimates are smaller than the mechanical estimates. Here an upward scaling of national coefficients is needed, and with that a departure from national technology. This chapter presents our method for adjusting national coefficients to accommodated unconditional export estimates.

The SDP technique assumes borrowed technology, usually national, and estimates regional exports as the excess of regional production over requirements. Crosshauling is not permitted. The RPC permits crosshauling by reducing SDP row-adjustment-factors and thereby raising, in-effect, selected SDP export estimates. Both SDP and RPC approaches preserve national technology through regional imports, i.e., regional demands not met by regional production are obtained via purchases from outside.

While regional exports in excess of SDP estimates are easily modeled, adjustments in the opposite direction, i.e., regional exports less than SDP estimates are more difficult. This case might be indicated by survey or published data, or it might be indicated by the RPC estimating equation. IMPLAN (US Department of Agriculture, 1986), for example, abandons RPC export estimates in favor of the SDP estimate when less than the SDP estimate. Whatever the source, export estimates less than SDP estimates suggest a substitution of the locally produced good for other inputs and thereby a departure from national technology. And it is this departure from national technology that raises the modeling difficulty.

The object of this paper is to modify the general SDP technique-mechanics to allow for departures from national technology, i.e., to allow for local input substitution. Our focus is not on export estimation itself, but rather on how to incorporate observed exports less than SDP export-estimates into the general framework of SDP models.

5.1 The Supply-Demand-Pool Technique

The standard SDP technique begins with an estimate of "regional requirements" (Isard, 1953). Assuming national technology at the regional level, regional requirements for commodity i are given as follows:

(5.1) $$R_i = \mathbf{n}_i \mathbf{X}$$

where:

$\mathbf{n}_i$ = row vector of national coefficients for sectors present in the region.

$\boldsymbol{X}$ = column vector of regional total gross outputs.

Sectors are defined broadly to include investment, personal consumption, and government. Accordingly, assuming n industrial sectors in the region, vector terms in (5.1) are of dimension n+3.

Regional exports are estimated as the excess of regional production over regional requirements:

$$(5.2) \quad \tilde{E}_i = \begin{cases} X_i - R_i > 0 \\ 0 \ \textit{otherwise} \end{cases}$$

where:

$\tilde{E}_i$ = the SDP estimate of regional commodity i exports.

The regional I-O model is obtained through the formation of scalars as follows:

$$(5.3) \quad D_i = \frac{X_i - \tilde{E}_i}{R_i}$$

Premultiplying both sides of (5.1) by (5.3) provides base period equilibrium for commodity i:

(5.4) $$X_i = D_i \mathbf{n_i X} + \tilde{E}_i$$

5.2 Supply-Demand-Pool Technique Extended to Permit Crosshauling

Crosshauling is incorporated into the structure of the SDP model through an estimate of regional exports greater than the SDP estimate (5.2). That is, for sectors i such that:

(5.5) $$E_i > \tilde{E}_i$$

where:

E_i = exports estimated independent of the SDP technique.

Export estimate E_i might result from an application of the RPC technique, e.g., IMPLAN, or it might be obtained in some other fashion, from survey or published data, or even based on simple assumption.

Scalars (5.3) are now replaced by scalars:

(5.6) $$D_i = \frac{X_i - E_i}{R_i}$$

and base period equilibrium is obtained by premultiplying both sides of (5.1) by (5.6) providing:

(5.7) $X_i = \mathrm{D}_i \boldsymbol{n_i X} + E_i$

Inasmuch as scalars (5.6) are always less than scalars (5.3), and scalars (5.3) are never greater than 1.0, scalars (5.6) are always less than 1.0. Crosshauling is indicated in (5.7) by the simultaneous export and import of commodity i. The export of commodity i is indicated by E_i, while the otherwise implicit import of commodity i is given by $R_i(1 - \mathrm{D}_i)$

5.3 Preservation of National Technology

In compact notation, the regional I-O coefficients matrix appears as follows:

(5.8) $\boldsymbol{A} = \bar{\mathrm{D}}\boldsymbol{N_r}$

where:

$\boldsymbol{A}$	=	regional I-O coefficients matrix of dimension n x n+3.
$\bar{\mathrm{D}}$	=	diagonal matrix of scalars estimated as in (5.3) or (5.7).
$\boldsymbol{N_R}$	=	n x n+3 partition of national coefficients matrix for sectors present in the region.

The SDP technique, either standard or extended to permit crosshauling, preserves national technology. Regional requirements in excess of regional production are assumed to be imported. Formally, the vector of regional imports is computed as follows:

(5.9) $$\boldsymbol{m} = (\mathbf{1})\{\boldsymbol{I} - \mathrm{D}\}\boldsymbol{N}_{\boldsymbol{R}}\hat{\boldsymbol{X}} + (\mathbf{1})\boldsymbol{N}_{\boldsymbol{N-r}}\hat{\boldsymbol{X}}$$

where:

$\boldsymbol{m}$ = row vector indicating total imports by each regional sector.

$\boldsymbol{N}_{\boldsymbol{N-R}}$ = partition of national coefficients matrix with rows for national industries not present in the region, and n+3 columns for regional sectors.

Regional imports appear as the sum of two components on the right-side of (5.9). These are commonly referred to as "competitive" and "non-competitive" imports respectively.

5.4 Deviation From National Technology: Observed Exports Less than SDP Exports

Consider now the case where observed exports are less than exports estimated with the SDP technique. Formally:

(5.10) $$E_i < \tilde{E}_i$$

In this case regional production absorbs more commodity i than indicated by national technology, and thereby a departure from national technology.

Our procedure for adjusting for departures from national technology begins with the formation of scalars:

$$(5.11) \qquad F_i = \frac{X_i - E_i}{R_i}$$

Given (5.11) and the derivation of $\tilde{E}_i > 0$ in (5.2), it is apparent that:

$$(5.12) \quad F_i > 1.0$$

A set of coefficients indicating a departure from national technology are given as follows:

$$(5.13) \qquad ,_i = (F_i - 1)\boldsymbol{n_i}$$

where:

$,_i$ = coefficients indicating row-wise proportional absorption of commodity i in excess of national technology.

5.5 Incorporating Input Substitution into the Non-Survey Model

For regional industries i other than those where (5.10) is observed, the non-survey regionalizing procedure presented in (5.4) and (5.7) allocates regional production to regional absorption and exports. If this allocation is accepted, excess regional absorption for industries i where (5.10) is observed must be met by a reduction in imports and/or factor services, i.e., the substitution of local commodity i for imports and factor services. This substitution can be expressed by revised imports and factor services as follows:

(5.14) $$\mathbf{m}^* + \mathbf{v}^* = \mathbf{m} + \mathbf{v} - \mathbf{s}$$

where:

$\mathbf{m}^*$ = revised vector of regional imports.

$\mathbf{v}^*$ = revised vector of regional factor payments.

$\mathbf{v}$ = vector of regional factor payments derived from national coefficients.

$\mathbf{s}$ = vector of import and factor service substitution.

and $\mathbf{m}$ is imports estimated with national coefficients as in (5.9). To be acceptable as a vector of import and factor service substitution, vector $\mathbf{s}$ must meet, at a minimum, the following necessary condition:

(5.15) $$\mathbf{s} \leq \mathbf{m} + \mathbf{v}$$

The task before us then is to estimate a vector $\mathbf{s}$ that meets condition (5.15) while accommodating excess local absorption of commodities i where (5.10) is observed.

5.6 A Crude Estimate of Import and Factor Service Substitution

The total demand by regional sectors for commodities absorbed in excess of national technology is given by the following:

(5.16) $$\boldsymbol{g} = (\mathbf{1}),\hat{X}$$

where:

$\boldsymbol{g}$ = demand by each industry j for commodities absorbed in excess of national technology.

$,$ = matrix formed from row vectors $,_i$

We might now simply let vector (5.16) serve as our estimate of import and/or factor service substitution vector $\boldsymbol{s}$. Assuming vector $\boldsymbol{g}$ satisfies (5.15), our final regional input-output coefficients matrix appears simply as:

(5.17) $$\boldsymbol{A}^{g} = , + \boldsymbol{A}$$

where:

$\boldsymbol{A}^{g}$ regional I-O coefficients matrix revised to reflect import and factor service substitution as indicated by vector $\boldsymbol{g}$

and rows of matrix $,$ are assumed to be arranged with the row structure of $\boldsymbol{A}$. It will be observed that use of $\boldsymbol{g}$, as an estimate of substitution vector $\boldsymbol{s}$, in the manner of regional I-O coefficients matrix-estimate $\boldsymbol{A}^{g}$, is tantamount to allowing SDP scalars D_i the fact that vector $\boldsymbol{g}$ limits the opportunities for applying the import and factor service substitution technique, i.e., limits application to those cases where vector $\boldsymbol{g}$ meets condition (5.15), there are other strong objections to $\boldsymbol{g}$ as an estimate of substitution vector $\boldsymbol{s}$, and therefore of $\boldsymbol{A}^{g}$ as an estimate of the regional I-O coefficients matrix. In particular, note that $\boldsymbol{s} = \boldsymbol{g}$ implies infinitely elastic substitution of local inputs for imports and factor services, i.e., it permits import and factor service substitution by a given industry j up to and including the point where $s_j = m_j + v_j$. Arguably, some imported commodities, particularly those comprising the set of non-competitive imports, and some factor services, are limitational in the production of regional commodities j. Aside from meeting condition (5.15), use of $\boldsymbol{g}$ as an estimate of $\boldsymbol{s}$ puts no limits on the degree of import and factor service substitution.

5.7 Inelastic Import and Factor Service Substitution

We hypothesize that import and factor service substitution is a function of two things, an industry's demand for commodities absorbed in excess of national technology, g_j, and that industry's ability to substitute, as indicated by the size of its would-be imports, m_j, and factor payments, v_j. Industries j who otherwise import a substantial portion of their inputs, and/or have substantial factor payments, have a wider range of opportunities to substitute local inputs for factor services and non-local inputs than do industries with smaller would-be imports and factor payments. Accordingly, we offer the following as a general expression for industry j's substitution of imports and factor services:

(5.18) $$\bar{s}_j = f(g_j, m_j + v_j)$$

with the following properties:

$$\frac{\partial \bar{s}_j}{\partial g_j} > 0$$

and

$$\frac{\partial \bar{s}_j}{\partial (m_j + v_j)} > 0$$

We will also require that industries j with no demand for commodities absorbed in excess of national technology, do not participate, as it were, in our process of regional import and factor service substitution. That is:

$$\bar{s}_j = 0 \;\; if \;\; g_j = 0$$

Assume $\boldsymbol{s} = \bar{\boldsymbol{s}}$ satisfies necessary condition (5.15), then our procedure for estimating the revised regional I-O coefficients matrix, though more complex than the case where $\boldsymbol{s} = \boldsymbol{g}$ is nonetheless simple. We first form the following vector indicating the absorption of each commodity i in excess of national technology:

(5.19) $$\boldsymbol{f} = ,\boldsymbol{X}$$

where:

$\boldsymbol{f}$ = vector of regional commodities with excess absorption.

Clarifying the contents of (5.19), it is easily shown that:

$$\tilde{E}_i - E_i > 0$$

(5.20) $$f_i =$$

$$0 \quad otherwise$$

Given (5.19), we next perform an otherwise standard RAS bi-proportional adjustment on matrix $\boldsymbol{,}$, yielding a second matrix $\boldsymbol{,}^*$, with the following properties:

(5.21) $$\boldsymbol{f} = \boldsymbol{,}^* \boldsymbol{X}$$

and

(5.22) $$\boldsymbol{\bar{S}} = (\mathbf{1}) \boldsymbol{,}^* \boldsymbol{\hat{X}}$$

where:

$\boldsymbol{,}^*$ = revised matrix of coefficients indicating local absorption in excess of national technology.

Our revised regional I-O coefficients matrix, adjusted now to accommodate the vector of import and factor services substitution $\boldsymbol{\bar{S}}$, appears as:

(5.23) $$\boldsymbol{A}^* = \boldsymbol{,}^* + \boldsymbol{A}$$

where:

A^{*} = regional I-O coefficients matrix revised to reflect import and factor service substitution as indicated by vector $\tilde{s}$.

5.8 An Approach for Estimating Inelastic Import and Factor Service Substitution

There may be any number of explicit expressions exhibiting the properties of general expression (5.18). We offer the following as a simple approach in the mechanically-efficient spirit of the SDP technique:

(5.24) $$\tilde{s} = ((m + v)\tilde{(})R$$

where:

$(= g(1/(1)g[1])$ = vector g normalized.

and:

(5.25) $$R = \frac{(1)f}{(m + v)(}$$

Postmultiplying both sides of (5.24) by a sum vector provides substitution necessary to absorb local production equal to $(1)f$, the overall excess local absorption of commodities, an obvious requirement for $s = \tilde{s}$ to be accepted as our substitution vector.

Work is in progress to test the general properties and applicability of (5.24) as an estimator of import and factor services substitution. We do note that a sufficient condition for passing necessary condition (5.15) is that:

(5.26) $$R \leq 1.0$$

We also note that the likelihood that (5.26) is met increases as the overall need for substitution, $(1)f$ diminishes, reducing the numerator in (5.25), and as the industries j demanding substantial commodities with regional absorption in excess of national technology, industries j with relatively large g_j, tend also to be industries with greater opportunity for import and factor service substitution, i.e., industries j with relatively large $m_j + v_j$ Even if sufficient condition (5.26) fails, the likelihood that less stringent but necessary condition (5.15) is met increases as the g_j are spread between the industries of the region, thus spreading the burden of import substitution across industries.

6. Accounting Structure and Closure of UMRIO-92 Model

The defining feature of I-O models is their detailed treatment of interindustry trade. In addition, regional I-O models are typically "closed" with regard to household income and spending, providing a so-called type II I-O model (Miller and Blair, 1985). Beyond households, several authors, and particularly Hirsch (1973), have suggested extending endogeneity to local government and regional investment. Economic-base (EB) models (Andrews, 1954; Lane, 1966; Tiebout, 1962; Isard, 1960) are normally closed with regard to households, local government, and investment, and we refer to our I-O model closed in this fashion as the EB/I-O model (Robison, 1989).

6.1 Input-Output Flow Equilibrium

Our I-O flow accounts are constructed in a general manner, enabling us to build one UMRIO-92 model closed with regard to household spending (type II model), and a second UMRIO-92 model closed in addition with regard to local government and regional investment (EB/I-O model). To disclose the specific formation and workings of the two models forms, let us begin by considering the I-O accounts for a representative region. Matrix (6.1) presents base-period intersectoral flows for the representative region.

(6.1)

$$\begin{pmatrix} [\mathbf{X}] \\ C^* \\ R^* \\ I^* \\ F^* \end{pmatrix} = \begin{pmatrix} \{\mathbf{x}\} & [\mathbf{C_x}] & [\mathbf{R_x}] & [\mathbf{I_x}] & [\mathbf{F_x}] & [\mathbf{E_x}] \\ (\mathbf{V_{cx}}) & 0 & V_{cr} & 0 & V_{cf} & V_{ce} \\ (\mathbf{V_{rx}}) & 0 & V_{rr} & 0 & V_{rf} & V_{re}+Y_r \\ (\mathbf{V_{ix}}) & 0 & V_{ir} & 0 & V_{if} & V_{ie}+Y_i \\ (\mathbf{0}) & 0 & 0 & 0 & 0 & Y_f \end{pmatrix} \begin{pmatrix} [\mathbf{1}] \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{pmatrix}$$

Multidimensional arrays appear bold, and double subscripts denote a to-from relationship. Specific definitions in (6.1) are as follows:

$\{\mathbf{X^*}\}$ = interindustry trade.

$[\mathbf{X}]$ = industry total gross outputs.

$(\mathbf{V_{cx}})$ = income generated in the business sector devoted to consumer goods purchases.

$(\mathbf{V_{rx}})$ = payments to state and local government from income generated in the business sector.

$(\mathbf{V_{ix}})$ = local investment spending from income generated in the business sector.

$[\mathbf{C_x}]$ = business sales of consumer goods to regional residents.

$[\mathbf{R_x}]$ = business sales to state and local government.

V_{cr} = income generated in state and local government devoted to consumer goods purchases.

V_{rr} = payments to local government from income generated in state and local government.

V_{ir} = local investment spending from income generated in state and local government.

$[\mathbf{I_x}]$ = business sales of investment goods for use in region.

$[F_x]$ = industry sales to regionally-located federal government.

V_{cf} = income generated in regionally-located federal government devoted to consumer goods purchases.

V_{rf} = payments to state and local government from income generated in regionally-located federal government.

V_{if} = local investment spending from income generated in regionally-located federal government.

$[E_x]$ = business sales to non-residents.

V_{ce} = factor service export and outside transfer payment income devoted to consumer goods purchases.

V_{re} = payments to state and local government from factor service export and transfer payment income.

V_{ie} = local investment spending from factor service export and transfer payment income.

C^* = resident consumer goods spending.

R^* = revenues of state and local government.

I^* = gross private investment expenditures in region.

F^* = revenues of regionally-located federal government.

Y_r = exogenous revenues of state and local government.

Y_i = exogenous investment expenditures.

Y_f = exogenous revenues of regionally-located federal government.

6.2 Type II Model

Matrix (6.1) shows intersectoral flows. The shift to I-O analysis is accomplished by converting in a familiar fashion flow data to I-O coefficients, and these in turn to I-O multipliers (Miller and Blair, 1985). The following presents the I-O analytic model in terms of type II I-O multipliers, i.e., multipliers for a model closed with respect to the household sector. In this model formation, gross business sector sales and resident consumption expenditures appear as a function of type II I-O output multipliers and exogenous business and consumer expenditure flows as follows:

(6.2) $$\begin{Bmatrix}[\boldsymbol{X}] \\ C^{*}\end{Bmatrix} = \begin{Bmatrix}\{\boldsymbol{B}^{II}\} & [\boldsymbol{b}^{II}] \\ (\boldsymbol{b}_{cx}^{II}) & b_{cc}^{II}\end{Bmatrix}\begin{Bmatrix}[\,,^{II}] \\ ,_{c}^{II}\end{Bmatrix}$$

where:

$$\begin{Bmatrix}\{\boldsymbol{B}^{II}\} & [\boldsymbol{b}^{II}] \\ (\boldsymbol{b}_{cx}^{II}) & b_{cc}^{II}\end{Bmatrix} = \begin{Bmatrix}\{\boldsymbol{I} - \boldsymbol{A}\} & [-\boldsymbol{a}_{c}] \\ (-\boldsymbol{a}_{cx}) & 1\end{Bmatrix}^{-1}$$ = matrix of type II output multipliers.

$\boldsymbol{A} = \{\boldsymbol{x}\}\{\hat{\boldsymbol{X}}\}^{-1}$ = matrix of regional I-O coefficients.

$[\,,^{II}] = [[\boldsymbol{R}_{x}] + [\boldsymbol{I}] + [\boldsymbol{F}_{x}] + [\boldsymbol{E}]]$ = exogenous business sector sales.

$,_{c}^{II} = V_{cr} + V_{cf} + V_{ce}$ = exogenous income devoted to consumption spending.

$[\boldsymbol{a}_{c}] = [\boldsymbol{C}_{x}]\dfrac{1}{C^{*}}$ = consumer spending coefficients.

$(\boldsymbol{a}_{cx}) = (\boldsymbol{V}_{cx})\{\hat{\boldsymbol{X}}\}^{-1}$ = consumer spending-capture coefficients.

The model in the form of (6.2) is expressed in terms of traditional I-O output multipliers. The model is alternatively expressed in terms of earnings or employment multipliers by outfitting, in the usual fashion, with direct earnings or direct labor coefficients (Miller and Blair, 1985).

6.3 The EB/I-O Model

The rational for endogenizing the household sector is the obvious fact that a portion of income generated by regional economic activity feeds-back to the local economy through induced consumer spending. A number of analysts have argued that a similar logic applies with all but equal force to local government and investment (e.g., Isard, 1960, and Hirsch, 1973). Inasmuch as economic-base models customarily endogenize local government and investment, as well as household spending (Andrews, 1954), we refer to the so-closed I-O model as the EB/I-O model.

Our EB/I-O model indicates overall economic activity, total business sales, resident consumer spending, state and local government revenues, federal government revenues, and local investment as a function of regional inflows: business exports, exogenous private income, outside investment, and the outside revenues of the government sectors. The model appears in terms of EB/I-O output multipliers as follows:

(6.3)

$$\begin{Bmatrix} [\boldsymbol{X}] \\ C^{*} \\ R^{*} \\ I^{*} \\ F^{*} \end{Bmatrix} = \begin{Bmatrix} \{\boldsymbol{B}^{\boldsymbol{EB}}\} & [\boldsymbol{b}_{\boldsymbol{c}}^{\boldsymbol{EB}}] & [\boldsymbol{b}_{\boldsymbol{r}}^{\boldsymbol{EB}}] & [\boldsymbol{b}_{\boldsymbol{i}}^{\boldsymbol{EB}}] & [\boldsymbol{b}_{\boldsymbol{f}}^{\boldsymbol{EB}}] \\ (\boldsymbol{b}_{\boldsymbol{cx}}^{\boldsymbol{EB}}) & b_{cc}^{EB} & b_{cr}^{EB} & b_{ci}^{EB} & b_{cf}^{EB} \\ (\boldsymbol{b}_{\boldsymbol{rx}}^{\boldsymbol{EB}}) & b_{rc}^{EB} & b_{rr}^{EB} & b_{ri}^{EB} & b_{rf}^{EB} \\ (\boldsymbol{b}_{\boldsymbol{ix}}^{\boldsymbol{EB}}) & b_{ic}^{EB} & b_{ir}^{EB} & b_{ii}^{EB} & b_{if}^{EB} \\ (\boldsymbol{0}) & 0 & 0 & 0 & 1 \end{Bmatrix} \begin{Bmatrix} [\boldsymbol{E}] \\ V_{ce} \\ V_{re}+Y_{r} \\ V_{ie}+Y_{r} \\ Y_{f} \end{Bmatrix}$$

where:

$$\begin{Bmatrix} \{\boldsymbol{B}^{\boldsymbol{EB}}\} & [\boldsymbol{b}_{\boldsymbol{c}}^{\boldsymbol{EB}}] & [\boldsymbol{b}_{\boldsymbol{r}}^{\boldsymbol{EB}}] & [\boldsymbol{b}_{\boldsymbol{i}}^{\boldsymbol{EB}}] & [\boldsymbol{b}_{\boldsymbol{f}}^{\boldsymbol{EB}}] \\ (\boldsymbol{b}_{\boldsymbol{cx}}^{\boldsymbol{EB}}) & b_{cc}^{EB} & b_{cr}^{EB} & b_{ci}^{EB} & b_{cf}^{EB} \\ (\boldsymbol{b}_{\boldsymbol{rx}}^{\boldsymbol{EB}}) & b_{rc}^{EB} & b_{rr}^{EB} & b_{ri}^{EB} & b_{rf}^{EB} \\ (\boldsymbol{b}_{\boldsymbol{ix}}^{\boldsymbol{EB}}) & b_{ic}^{EB} & b_{ir}^{EB} & b_{ii}^{EB} & b_{if}^{EB} \\ (\boldsymbol{0}) & 0 & 0 & 0 & 1 \end{Bmatrix} =$$

$$\begin{Bmatrix} \{\boldsymbol{I}-\boldsymbol{A}\} & [-\boldsymbol{a}_{\boldsymbol{c}}] & [-\boldsymbol{a}_{\boldsymbol{r}}] & [-\boldsymbol{a}_{\boldsymbol{i}}] & [-\boldsymbol{a}_{\boldsymbol{f}}] \\ (-\boldsymbol{a}_{\boldsymbol{cx}}) & 1 & -''_{cr} & 0 & -''_{cf} \\ (-\boldsymbol{a}_{\boldsymbol{rx}}) & 0 & 1-''_{rr} & 0 & -''_{rf} \\ (-\boldsymbol{a}_{\boldsymbol{ix}}) & 0 & -''_{ir} & 1 & -''_{if} \\ (\boldsymbol{0}) & 0 & 0 & 0 & 1 \end{Bmatrix}^{-1}$$

matrix of EB/I-O output multipliers.

$$(\boldsymbol{a}_{\boldsymbol{rx}}) = (\boldsymbol{V}_{\boldsymbol{rx}})\{\hat{\boldsymbol{X}}\}^{-1} =$$ state and local government revenue-capture coefficients.

$$(\boldsymbol{a}_{\boldsymbol{ix}}) = (\boldsymbol{V}_{\boldsymbol{ix}})\{\hat{\boldsymbol{X}}\}^{-1} =$$ local investment-capture coefficients.

$[\boldsymbol{a_r}] = [\boldsymbol{R_x}]\frac{1}{R^*} =$ state and local government spending coefficients.

$[\boldsymbol{a_i}] = [\boldsymbol{I_x}]\frac{1}{I^*} =$ local investment spending coefficients.

$[\boldsymbol{a_f}] = [\boldsymbol{F_x}]\frac{1}{F^*} =$ federal government spending coefficients.

$''_{cr} = \frac{V_{cr}}{R^*} =$ consumer spending-capture coefficient from income generated in state and local government.

$''_{cf} = \frac{V_{cf}}{F^*} =$ consumer spending-capture coefficient from income generated in federal government.

$''_{rr} = \frac{V_{rr}}{R^*} =$ state and local government revenue-capture coefficient from income generated in state and local government.

$''_{rf} = \frac{V_{rf}}{F^*} =$ state and local government revenue-capture coefficient from income generated in federal government.

$''_{ir} = \frac{V_{ir}}{R^*} =$ local investment-capture coefficient from income generated in state and local government.

$$\text{"}_{if} = \frac{v_{if}}{F^*} =$$ local investment-capture coefficient from income generated in federal government.

Our EB/I-O model in (6.3) appears in terms of I-O output multipliers. As with the type II model, the EB/I-O model is easily expressed in terms of earnings or employment multipliers, by outfitting it in the usual fashion with direct earnings or

direct labor coefficients (Miller and Blair, 1985).

6.4 Spreadsheet Form of Type II Model

It is useful in constructing multiplier spreadsheets for the UMRIO-92 model to convey both type II and EB/I-O models according to the same general format. Accordingly, in multiplier spreadsheets, the type II model appears in parallel form to the EB/I-O model (6.3) as follows:

$$(6.4) \qquad \begin{Bmatrix} [\mathbf{X}] \\ C^* \\ R^* \\ I^* \\ F^* \end{Bmatrix} = \begin{Bmatrix} \{\mathbf{B}^{II}\} & [\mathbf{b}_c^{II}] & [\mathbf{b}_r^{II}] & [\mathbf{b}_i^{II}] & [\mathbf{b}_f^{II}] \\ (\mathbf{b}_{cx}^{II}) & b_{cc}^{II} & b_{cr}^{II} & b_{ci}^{II} & b_{cf}^{II} \\ (\mathbf{0}) & 0 & 1 & 0 & 0 \\ (\mathbf{0}) & 0 & 0 & 1 & 0 \\ (\mathbf{0}) & 0 & 0 & 0 & 1 \end{Bmatrix} \begin{Bmatrix} [\mathbf{E}] \\ V_{ce} \\ R^* \\ I^* \\ F^* \end{Bmatrix}$$

where:

$$
\begin{Bmatrix}
\{\boldsymbol{B}^{II}\} & [\boldsymbol{b}_c^{II}] & [\boldsymbol{b}_r^{II}] & [\boldsymbol{b}_i^{II}] & [\boldsymbol{b}_f^{II}] \\
(\boldsymbol{b}_{cx}^{II}) & b_{cc}^{II} & b_{cr}^{II} & b_{ci}^{II} & b_{cf}^{II} \\
(\boldsymbol{0}) & 0 & 1 & 0 & 0 \\
(\boldsymbol{0}) & 0 & 0 & 1 & 0 \\
(\boldsymbol{0}) & 0 & 0 & 0 & 1
\end{Bmatrix}
=
\begin{Bmatrix}
\{\boldsymbol{I} - \boldsymbol{A}\} & [-\boldsymbol{a}_c] & [-\boldsymbol{a}_r] & [-\boldsymbol{a}_i] & [-\boldsymbol{a}_f] \\
(-\boldsymbol{a}_{cx}) & 1 & -\text{"}_{cr} & 0 & -\text{"}_{cf} \\
(\boldsymbol{0}) & 0 & 1 & 0 & 0 \\
(\boldsymbol{0}) & 0 & 0 & 1 & 0 \\
(\boldsymbol{0}) & 0 & 0 & 0 & 1
\end{Bmatrix}^{-1}
=
$$

matrix of type II output multipliers.

It is easily shown that parallel output multiplier terms from (6.4) and (6.2), $\{\boldsymbol{B}^{II}\}$, $[\boldsymbol{b}_c^{II}]$, $(\boldsymbol{b}_{cx}^{II})$, b_{cc}^{II}, are mathematically identical. In addition, the following results linking (6.4) to (6.2) are also easily show:

$$
\begin{aligned}
[\boldsymbol{b}_r^{II}] &= \{\boldsymbol{B}^{II}\}[\boldsymbol{a}_r] \\
b_{cr}^{II} &= (\boldsymbol{b}_{cx}^{II})[\boldsymbol{a}_r] + b_{cc}^{II}\text{"}_{cr} \\
[\boldsymbol{b}_i^{II}] &= \{\boldsymbol{B}^{II}\}[\boldsymbol{a}_i] \\
b_{ci}^{II} &= (\boldsymbol{b}_{ci}^{II})[\boldsymbol{a}_i] \\
[\boldsymbol{b}_f^{II}] &= \{\boldsymbol{B}^{II}\}[\boldsymbol{a}_f] \\
b_{cf}^{II} &= (\boldsymbol{b}_{cx}^{II})[\boldsymbol{a}_f] + b_{cc}^{II}\text{"}_{cf}
\end{aligned}
$$

As with the type II model in its traditional form (6.2), the model as it appears in (6.4) is easily expressed in terms of earnings or employment multipliers, by outfitting it in the usual fashion with direct earnings or direct labor coefficients (Miller and Blair, 1985).

PART II: Interregional Trade Among UMRIO-92's Nine Economic SubRegions

7. The Structure of Utah's Space Economy

In chapter 1 we described how we divided Utah into nine smaller subregional economies. The purpose of this chapter is to establish, largely on a priori grounds, the structure of trade that characterizes the spatial interconnectedness of the Utah economic landscape.

7.1 Background, and Extensions Needed to Construct UMRIO-92

Central place theory (CPT) and regional input-output (I-O) have long served as important though independent branches of regional science. CPT explains the spatial structure of regions, the size and location of settlements in space, while regional I-O explains the structure of regional interindustry trade. CPT has advanced in a primarily formal literature, while regional I-O is a highly applied technology, with many of its more prominent advances resulting from empirical exercises.

Mulligan (1979) demonstrated the theoretical kinship between CPT and regional I-O. Inspired by Mulligan's work, Robison and Miller (1991) constructed the first empirical central place-based regional input-output model. In constructing their model, Robison and Miller (1991) advanced a new non-survey data-reduction technique, one specifically aimed at central place-based regional I-O modeling. The technique's inaugural application resulted in a two-order model with strictly hierarchal, one-way trade. Later Robison et. al. (1993) extended the technique to construction of a three-order model, again with strictly hierarchal, one-way trade.

Though empirically based, Robison and Miller (1991), and Robison et. al. (1993) nonetheless aimed at exploring fundamentally theoretical issues, e.g., feedback effects in the case of Robison and Miller (1991), and the determinants of centrality in the case of Robison et. al. (1993). While limiting the scope of the analysis, the strictly hierarchical one-way trade assumption was otherwise acceptable given the fundamentally theoretical focus of these earlier works.

UMRIO-92 is an exercise in applied regional economics -- the aim is to construct a model primarily for the purposes of impact analysis, that captures as far as possible the actual structure of the Utah economy. An important part of that structure is likely entails "two-way trade," i.e., goods flowing both up as well as down the trade hierarchy. CPT would predict the flow of raw and semi-finished goods from rural to urban places, for finishing or advanced processing for example, and instances such as these of non-hierarchical trade are assumed away with one-way trade. Accordingly, an important part of UMRIO-92 is the relaxation of the one-way trade assumption of Robison and Miller (1991), and Robison et. al. (1993), allowing for unrestricted trade.

7.2 Fundamentals of Central Place Based Regional I-O

7.2.1 Taxonomy

The link between CPT and regional I-O is found in a common feature: regional trade in goods and services. Trade is explicit in regional I-O models, tracked as sales to and purchases from the various sectors of the model. Regional I-O sectors represent industry aggregates, normally defined aspatially on the basis of more-or-less homogenous commodity outputs.

Trade in CPT is a spatial phenomenon. The regional landscape is viewed as a collection of discrete settlements in an otherwise unsettled plain. Individual settlements, or places, are ordered according to the goods and services they provide to themselves and to other places. To the extent that a particular place supplies other places, it is said to dominate those other places. The collection of dominated places, together with the unsettled regions they dominate, are referred to as comprising the "complementary region" of the dominant place (Christaller, 1966).

The pattern of dominant places and overlapping complementary regions gives rise to a trade hierarchy, i.e., a hierarchy of central places. In the strict Christaller (1966) model, the trade hierarchy reflects trade in "central place goods and services" only. More realistic treatments include a balancing trade in non-central place goods and services.

Parr (1987) provides a complete taxonomy of goods and services in a central place hierarchy. "Central place goods and services" are items for which there is essentially ubiquitous demand, groceries, consumer durables, movies, air travel, accounting, legal and business services, and so on. In contrast, "specialized goods and services" are items for which production is unique to particular regions, agricultural products, timber, input-oriented manufacturing, military installations, federal government offices, and so on. There are also factor services, principally labor services, with trade in these reflected in the pattern of commuting.

In Christaller's theoretically ideal model, trade in central place goods and services is strictly hierarchical, i.e., central place goods and services flow down but never up the trade hierarchy. Lower-order places supply their own lower-order central place goods and services, and obtain higher-order central place goods and services from higher-order places. Higher-order places supply their own lower and higher-order central place goods and services. Trade balances are obtained through production and trade in specialized goods and services, and factor services. Lowest-order places, for example, derive their income from the export of specialized goods and services, and from outcommuting.

Central place trade is modeled in regional I-O terms by partitioning the regional I-O table according to the places of the central place hierarchy. The resulting model provides a spatial I-O analysis of the regional economy. The mathematics of the model are otherwise identical to that of the traditional interregional I-O model (Robison and Miller, 1991).

7.2.2 CPT and Economic Base Theory

One of several branches of modern central place research is the city size model (Beckmann, 1958; Dacey, 1966; and Parr, 1970). According to this model, a city's population is a function of its own population, plus the population of its complementary region. Parr, Denike, and Mulligan (1975) demonstrated the manner in which city size models can be cast in simple economic-base terms. Referring to the economic-base formulation, Mulligan (1979) demonstrated that basic-nonbasic ratios decrease with higher-order centers, "... the nonbasic sector becomes increasingly significant as higher and higher levels are considered."

Decreases in the basic-nonbasic ratio are matched by increases in economic-base multipliers.

Mulligan's result is not surprising. Production at a farm located in the otherwise unsettled plain provides, at the production site, an export base multiplier of 1.0. In contrast, a lowest-order place, perhaps a hamlet with a general store and post office, will have a multiplier greater than 1.0, depending on the respending, in the form of local patronage, at the store and post office. Ascending the trade hierarchy, each center offers a wider variety of goods and services, and thereby greater opportunities for the internal capture of multiplier effects. The highest-order place offers the widest variety of goods and services, and thereby the greatest opportunities for multiplier capture. The highest-order place can be expected to exhibit the largest export-base multiplier.

The export-base/CPT kinship finds its roots in classical CPT. In describing the functional character of places, Christaller (1966) draws a distinction between "importance," or "nodality," and "centrality" (see also Preston, 1971). Nodality indicates "... the combined economic efforts of [a settlement's] inhabitants" (Christaller, 1966, p.18). Nodality might be measured by the number of employees, or gross product.

Centrality, on the other hand, indicates a settlement's relationship to its complimentary region, or trade dominated hinterland. Christaller describes centrality in terms of "surplus" and "deficit" of importance. Centrality indicates a surplus of importance, a surplus matched by a deficit of importance in the complementary region.

Centrality, or central functions, can be viewed as an element in the community economic-base. An economic-base study expresses total community income and employment as a function of export income and employment (Tiebout, 1962). A community's export industries are traditionally distinguished according to a homogeneity of outputs, wood products, agriculture, mining, and so on. In addition, it is often useful to identify a composite of industries serving a common buyer, "the tourism industry" for example (Robison et. al., 1991). Having bifurcated industry outputs as export and non-export, total community activity is explained in terms of export activity.

Proceeding along lines of composite, common-buyer industries, it is a conceptually simple matter to define that portion of the community economic-base attributable to its role as a central place. Accordingly, places of otherwise equal size, measured for example in terms of employment or income, will differ in terms of their function as central places, i.e., differ in terms of centrality.

Robison et. al. (1993) use centrality as an element in the economic base to examine economic spillovers from rural to urban regions in a three-order central place hierarchy. Implied by this work is that the importance of central place dominance as an element in the economic base of centers depends on the infrastructure development of lower-order places, and on the infrastructure development of intervening places. All else equal, central functions as an element in the economic base of a center varies inversely with the degree of infrastructure development in the dominated hinterland. The economic base/CPT formulation, and the findings of Robison et. al. (1993) will prove useful in assessing changes in the spatial distribution of economic activity in Utah.

7.3 Utah's Three Principal Trade Regions

Inspired by Fox and Kumar's analysis, the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) launched a research initiative aimed at identifying the "regional economic structure of the U.S. space economy" (U.S. Dept. of Commerce, Regional Economic Analysis Division, 1975). The typical "BEA economic area" is centered on a standard metropolitan statistical area, or other dominant trading core, with boundaries drawn (as county combinations) with the aim of capturing relatively closed markets for labor, business inputs, and consumer goods. Figure 1 shows the BEA economic areas for the vicinity of Utah.

We might quarrel with the BEA over a boundary placement here or there. And regional economic boundaries are in reality not sharp but rather fuzzy zones of transition from one center's dominance to another. However, limitations notwithstanding, we can generally agree with the BEA's portrayal of Utah's space economy.

Here then is our description of Utah's space economy. In northern Utah the Wasatch Front's market shadow fills the region, and spills beyond political boundaries into the Great Basin portion of southern Idaho, to Malad and Preston, Idaho, and into the western end of Wyoming's Great Divide Basin, to Kemmerer, Evanston, Green River, and Rock Springs, Wyoming. To the east, the Wasatch

Front dominates all of the Uintah Basin, including Roosevelt, Duchesne and Vernal, Utah.

To the south and west, three other branches of Wasatch Front economic dominance can be seen. One extends up Spanish Fork Canyon to Price and Helper. Another extends southwest across the Wasatch Plateau to as far as Richfield. And the third extends west to Tooele and Grantsville and beyond into the western Salt Lake Desert.

Economically prominent as the Wasatch Front is, its economic dominance falls short of southern-most Utah. Southern Utah beyond Price on the east and Richfield on the west is economically dominated by centers outside of Utah. Las Vegas, Nevada dominates southwestern Utah to include most notably St. George and Cedar City. And Grand Junction, Colorado dominates southeastern Utah, Moab, Monticello and Blanding.

We thereby agree with the BEA, and view Utah's space economy as consisting of portions of three larger functional economic areas, one centered on the Wasatch Front, a second on Grand Junction, Colorado, and a third on Las Vegas, Nevada. While retaining the BEA's fundamental definition of Utah's space economy, in the next chapter we identify further political and economic subdivisions, these for the purposes of UMRIO-92 regional economic analysis.

7.4 A Central Place-Based Regional I-O Portrayal of Utah's Space Economy

As a political entity, Utah's boundaries are simply those indicated on a common highway map. However, for the purposes of constructing an accurate economic model our interest in Utah the political entity is nominal only -- our real interest is in Utah's economic boundaries, i.e., in the structure of Utah's space economy.

Northern Utah is clearly dominated by the Wasatch Front, Weber, Davis, Salt Lake, and Utah Counties. In contrast, southwestern Utah experiences primary dominance from Las Vegas, Nevada, while southeastern Utah experiences primary dominance from Grand Junction, Colorado (see: BEA,).

Figure 1 presents our delineation of Utah's subregional structure. Our subregional characterization is informed by a mix of sometimes conflicting sources, including the U.S. Department of Commerce, Bureau of Economic analysis (BEA) (Regional Economic Analysis Division, 1975), and Rand McNally (1984). There is, unfortunately, no general method for the empirical identifying hierarchical trade structures. We rely on judgement, tempered by local and reliable knowledge of the study area.

The structure of trade assumed among the various subregions of figure 1 is most precisely conveyed in terms of intra and interregional I-O trade matrices. The following table provides notation for tracking subregions in mathematical notation.

Subregion	Notation
Wasatch Front	WF
Bear River	BR
Carbon-Emery	CE
Central Utah	CU
Southeastern	SE
Southwestern	SW
Tooele County	TO

Uintah Basin	UB
Wasatch-Summit	WS

Using the above notation, matrix (2.1) presents the intra and interregional trade structure of UMRIO-92 model as a partitioned array of I-O coefficients.

$$
\left\{
\begin{matrix}
A_{WF,WF} & A_{WF,TL} & A_{WF,WS} & A_{WF,BR} & A_{WF,CE} & A_{WF,CU} & A_{WF,UB} & A_{WF,SW} & A_{WF,SE} \\
A_{TL,WF} & A_{TL,TL} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
A_{WS,WF} & 0 & A_{WS,WS} & 0 & 0 & 0 & 0 & 0 & 0 \\
A_{BR,WF} & 0 & 0 & A_{BR,BR} & 0 & 0 & 0 & 0 & 0 \\
A_{CE,WF} & 0 & 0 & 0 & A_{CE,CE} & 0 & 0 & 0 & 0 \\
A_{CU,WF} & 0 & 0 & 0 & 0 & A_{CU,CU} & 0 & 0 & \\
A_{UB,WF} & 0 & 0 & 0 & 0 & 0 & A_{UB,UB} & 0 & 0 \\
A_{SW,WF} & 0 & 0 & 0 & 0 & 0 & 0 & A_{SW,SW} & 0 \\
A_{SE,WF} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & A_{SE,SE}
\end{matrix}
\right\}
$$

UMRIO-92 is an ambitious modeling project. The overall intra/interregional I-O coefficients matrix shown above conveys 1,234 rows and columns, a large matrix even by modern region regional I-O modeling standards.

8. Methods for Building the Interregional Trade Component of UMRIO-92

Interregional I-O coefficient matrices for the UMRIO-92 model are estimated using the technique developed by Robison and Miller (1991), with extension to upper-hierarchical trade as discussed below. Interregional trade arrays are constructed using a composite of two closely related non-survey I-O modeling techniques. Strictly hierarchical trade, i.e., down the trade hierarchy only, is conveyed by I-O coefficients in the upper-right triangle of the interregional I-O matrix. These are estimated according to the technique advanced in Robison and Miller (1991), and Robison et. al. (1993). Trade from lower to higher order places, non-hierarchical trade, appears in the interregional I-O matrix's lower-left triangle. These are estimated with a technique detailed below.

8.1 Down-Hierarchy Trade-Estimating Algorithm: Single Region Core-Periphery Trade

Consider a single core-periphery trade region. Let the entities of the core-periphery region be designated by subscripts C and P, i.e., a trading core C, and a dominated periphery P. Let $\boldsymbol{N_{CP}}$ be an array of national model I-O coefficients with the row and column structure of $\boldsymbol{A_{CP}}$ the core to periphery interregional I-O coefficients matrix. Let $\boldsymbol{H_{CP}}$ be an array of 1's and 0's that map elements of $\boldsymbol{A_{PP}}$ into the row and column structure of $\boldsymbol{A_{CP}}$

The distinguishing feature of the trade estimating procedure introduced by Robison and Miller (1991) is formation of a "gross import requirements matrix."

In the present case, the gross import requirement matrix is given by $\boldsymbol{G}_{CP}$ with coefficients indicating the demand by the peripheral subregion, for commodities produced in the core, in excess of that satisfied by peripheral subregion industries. Assuming national technology, an estimate of $\boldsymbol{G}_{CP}$ is given by the following:

(8.1) $$\boldsymbol{G}_{CP} = \left\{ \boldsymbol{N}_{CP} - \boldsymbol{H}_{CP}\boldsymbol{A}_{PP} \right\}$$

We next let $\boldsymbol{R}_{CP}$ be a vector indicating the gross import demand by the peripheral subregion for core commodities, and estimate these as follows:

(8.2) $$\boldsymbol{R}_{CP} = \boldsymbol{G}_{CP}\boldsymbol{X}_{P}$$

where $\boldsymbol{X}_{P}$ is total gross outputs for the peripheral subregion. Vector (8.2) now serves to form scalars:

(8.3) $$\mathrm{D}_{CP_i} = \begin{cases} E_{C_i}/R_{CP_i} & \text{if } E_{C_i} < R_{CP_i} \\ 1.0 & \text{otherwise} \end{cases}$$

where E_{C_i} is exports of commodity i from the core. Arrayed in a diagonal matrix, scalars (8.3) premultiply (8.1) yielding our estimate of interregional I-O coefficients thus:

$$\boldsymbol{A}_{CP} = \left\{ \hat{\mathrm{D}}_{CP} \right\} \boldsymbol{G}_{CP}$$

8.2 Up-Hierarchy Estimating Algorithm: Single Region Core-Periphery Trade

The up-hierarchy case for single region core-periphery trade appears as the simple complement of the down-hierarchy case. Accordingly, we form a gross import requirement matrix $\boldsymbol{G_{PC}}$ indicating the demand by the core subregion for commodities produced in the periphery in excess of that satisfied by core industries. An estimate of this term is given by the following:

$$\boldsymbol{G_{PC}} = \left\{ \boldsymbol{N_{PC}} - \boldsymbol{H_{PC}A_{CC}} \right\} \tag{8.4}$$

We next compute gross import demand by the core for periphery commodities as follows:

$$\boldsymbol{R_{PC}} = \boldsymbol{G_{PC}X_C} \tag{8.5}$$

where $\boldsymbol{X_C}$ is the core's total gross outputs. Vector (8.5) serves to form scalars:

$$D_{PC_i} = \begin{cases} E_{P_i}/R_{PC_i} & \text{if } E_{P_i} < R_{PC_i} \\ 1.0 & \text{otherwise} \end{cases} \tag{8.6}$$

where E_{P_i} is exports of commodity i from the periphery. Arrayed in a diagonal matrix, scalars (8.6) premultiply (8.4) providing interregional I-O coefficients thus:

$$\boldsymbol{A_{PC}} = \left\{ D_{PC} \right\} \boldsymbol{G_{PC}}$$

Applying the algorithms of this and the previous section provides us with the elements along the top partition row and first column of our interregional UMRIO-92 I-O model.

8.5 Implied by the Central Place-Based Interregional Trade Estimating Technique

The technique of Robison and Miller (1991) is a spatial variation of the standard single-region SDP technique, with similarities in approach to the Harvard Economic Research Projects's multiregional input-output (MRIO) model (Polenske, 1980). Like the MRIO approach, the Robison-Miller technique estimates interregional I-O coefficients through proportional adjustments of national coefficients across industries in the destination region. The MRIO approach bases its adjustments on externally gathered data on gross interregional commodity shipments (Rodgers, 1973), while the Robison-Miller approach estimates gross interregional shipments internally, based on assumptions regarding the hierarchical structure of trade, and a spatial extension of the SDP logic.

The standard SDP technique assumes regional demands are satisfied from regional supplies with only excess supplies being exported. The technique thereby assumes maximum intraregional trade and no crosshauling. With clear parallels, the Robison-Miller interregional trade estimating technique assumes excess demands in dominated subregions are satisfied from excess supplies in dominating subregions. The technique thus assumes maximum trade between dominating and dominated subregions, and no crosshauling, either between subregions or with the outside world.

It has been argued that the maximum intraregional trade assumption of the SDP technique is reasonable provided the region is in some sense a function economic area, i.e., provided the region exhibits some degree of market closure for labor and other business and consumer goods and services (Robison and

Miller, 1988). Likewise, the maximum trade assumption in the interregional context appears reasonable provided the larger region exhibits some degree closer, i.e., provided the larger region is in some sense a functional economic area.

References

Andrews, R.B. 1954. "Mechanics of the Urban Economic Base: Special Problems of Base Identification," Land Economics, 30(3), 260-269.

Beemiller, R. M. 1992. Unpublished electronic file of earnings less other labor income coefficients for the 1977 national input-output model.

Berry, B.J.L., J.B. Parr, B.J. Epstein, A. Ghosh, and R.H.T. Smith. 1988. Market Centers and Retail Location, Theory and Applications, Englewood Cliffs: Prentice Hall.

Christaller, W. 1966. Central Places in Southern Germany (C.W. Baskins, trans.). Englewood Cliffs, M.J., Prentice Hall.

Craven, J. 1979. The Distribution of the Product, London: George Allen & Unwin Ltd.

Fox, K.A. and K. Kumar. 1965. "The Functional Economic Area: Delineation and Implications for Economic Analysis and Policy," Papers of Regional Science Association, 15, 57-85.

Hirsch, W.Z. 1973. Urban Economic Analysis, McGraw-Hill, New York.

Isard, W. 1960. Methods of Regional Analysis: an Introduction to RegionalScience, Cambridge: The MIT Press.

Lahr, M.L. 1992. "An Investigation into Methods for Producing Hybrid Regional Input-Output Tables," unpublished doctoral dissertation, University of Pennsylvania.

Lane, T. 1966. "The Urban Base Multiplier: An Evaluation of the State of the Art," Land Economics, 42(3), 339-347.

Losch, A. 1938. "The Nature of Economic Regions," Southern Economic Journal, 5, 71-78.

Miller, R.E. 1969. "Interregional Feedbacks in Input-Output Models: Some Experimental Results," Western Economic Journal, 7, 41-50.

Miller, R.E. and P. Blair. 1985. Input-Output Analysis: Foundations and Extensions. Englewood Cliffs: Prentice Hall.

Miller, R.E. 1966. "Interregional Feedback Effects in Input-Output Models: Some Preliminary Results," Papers of the Regional Science Association, 17, 105-125.

Miller, J.R., and M.H. Robison. 1990. "Input-Output Models for
the Three Economic Regions of Utah." Report submitted to State of Utah Office of Planning and Budget as part of the development of a state and local government fiscal impact benefit-cost model.

Parr, J.B. 1987. "Interaction in an Urban System: Aspects of Trade and Commuting," Economic Geography, 63(3), 223-240.

Polenske, K.R. 1980. The United States Multiregional Input-Output Accounts and Model, Lexington: D.C. Heath.

Richardson, H.W. 1972. Input-Output and Regional Economics. New York: Halsted Press.

Robison, M.H. and J.R. Miller. 1991. "Central Place Theory and Input-Output Analysis," Papers in Regional Science, 70(4), 399-417.

Robison, M.H. and J.R. Miller. 1988. "Cross-hauling and Non-Survey Input-Output Models: Some Lessons From Small-Area Timber Economies," Environment and Planning A, vol. 20, 1523-1530.

Robison, M.H. 1989. "An Input-Output Alternative to Community Economic Base Models: Technique and Review of a Recent Controversy," Special Session on Regional Input-Output Modeling, 27th Annual Meeting of the Western Regional Science Association, San Diego, California.

Robison, M.H., J.R. Hamilton, K.P. Connaughton, N. Meyer and R. Coupal. 1993. "Spatial Diffusion of Economic Impacts and Development Benefits in Hierarchically Structured Trade Regions: An Empirical Application of Central Place-Based Input-Output Analysis, Review of Regional Studies, volume 23, in-press.

Rogers, J.M. 1973. State Estimates of Interregional Commodity Trade, 1963. Lexington: Lexington Books.

Rose, A.Z. and B.H. Stevens. 1991. "Transboundary Income and Expenditure Flows in Regional Input-Output Models," Journal of Regional Science, 31(3), 253-272.

Round, J.I. 1978. " An Interregional Input-Output Approach to the Evaluation of NonSurvey Methods," Journal of Regional Science, 179-194.

Schaffer, W. and K. Chu. 1969. "Nonsurvey Techniques for Constructing Regional Interindustry Models." Papers of the Regional Science Association, 23, 83-101.

Tiebout, C.M. 1962. The Community Economic Base Study. New York: Committee for Economic Development.

U.S. Dept. of Commerce, Bureau of Economic Analysis, Regional Economic Analysis Division. 1975. "The BEA Economic Areas: Structural Changes and Growth, 1950-73," Survey of Current Business, 14-25.

U.S. Department of Commerce, Bureau of Economic Analysis. 1979. "The Detailed Input-Output Structure of the U.S. Economy: 1972," Vol. I: The Use and Make of Commodities by Industry, Vol. II: Total Requirements for Commodities and Industries.

U.S. Department of Commerce, Bureau of Economic Analysis. 1978. "The U.S. National Income and Product Accounts, 1975-77." Survey of Current Business 58(7): 37.