**Economic Impacts in Hierarchically Structured Trade Regions:
An Empirical Application of Spatial Input-Output Analysis**

by

M.H. Robison, J.R. Hamilton, N. Meyer,
K.P. Connaughton and R. Coupal*

A.E. Research Series, No. 91-13

October 1991

Paper Presented at the North American Meeting of the Regional Science Association International, New Orleans, Louisiana, November 1991.

*M.H. Robison, Assistant Professor, University of Idaho
J.R. Hamilton, Professor, University of Idaho
N. Meyer, Research Professor, University of Idaho
K.P. Connaughton, Research Forester, USDA Forest Service, Pacific Northwest Research Station, Portland, OR
R. Coupal, Research Associate, University of Idaho

Information on regional economic impacts is sought by decision makers in and out of government. Regional input-output (I-O) has evolved as the technique of choice in providing economic impact information. However, regional I-O applications often fall short of decision maker expectations. Information is generally lacking on the spatial diffusion of impacts.

In this paper we develop an interregional I-O model to examine rural to urban linkages in a broad region covering the market reach of Salt Lake City, Utah. The region includes northern Utah, southeastern Idaho, and western Wyoming. Southeastern Idaho, and part of western Wyoming is in turn trade dominated by Idaho Falls, Idaho. Accordingly, we view the larger region with a three-order trade hierarchy, with Salt Lake City generally dominant, and Idaho Falls locally dominant, over a smaller subregion. We carve the larger region into a set of trading core and peripheral subregions to model our perceived pattern of hierarchical trade.

We are guided in our selection of subregions, and in our modeling of interregional trade, by principles of central place theory. We divide the larger region into eight subregions. Six are selected as apparently semi-independent functional economies, while the other two are selected for convenience, covering broader expanses of the landscape with less focused economic activity.

Our modeling is fundamentally an exercise in interregional I-O analysis. The literature on interregional I-O is extensive (Isard, 1951; Leontief and Strout, 1963; Moses, 1955; Polenske, 1980). However, the literature on incorporating central place principles in the framing and estimation of interregional models is more modest. Eskelinen (1983) fashioned an interregional, "core-periphery" model from three survey-based models of Finland. And Robison and Miller (in press) constructed an intercommunity I-O model exhibiting a two-order trade hierarchy for a rural region in southwestern Idaho. Our model builds on this earlier work, extending the regionalizing approach of Robison and Miller, and the core-periphery framework of Eskelinen, to the three-order core-periphery trade hierarchy of the Salt Lake City-dominated regional economy.

In the next section we consider principles of central place theory in the context of interregional I-O analysis. We then offer a short-cut approach for estimating interregional trade. Following this, we turn to the Salt Lake City-dominated trade area, and divide it into eight interrelated subregions. We then focus on results, examining in particular spillovers, from lower to higher-order regions. A final section presents implications and conclusions.

Central Place Principles and Interregional I-O Modeling

Central place theory views the regional landscape with subregions defined and ordered according to the goods and services they provide to themselves and to other subregions (Berry et al., 1988). Parr (1987) provides a taxonomy of goods and services in a central place hierarchy, distinguishing between "central place" and "specialized" goods and services. "Central place goods and services" include items for which there is essentially ubiquitous demand, groceries, consumer durables, movies, air travel, accounting, legal and business services, and so on. "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.

Lower-order regions supply their own lower-order central place goods and services, and obtain higher-order central place goods and services from higher-order regions. Higher-order regions supply their own lower and higher-order central place goods and services. There is no trade in central place goods and services between same-order regions. Regions at the bottom of the trade hierarchy, lowest-order regions, derive their income from the export of specialized goods, raw agricultural and timber products for example, up the trade hierarchy for processing, or outside the region. Higher-order places derive their income from the supply of higher-order central place goods and services to lower-order places, and from the export of specialized goods to lower-order places and outside the region.

In this paper we focus on the role of rural industry in the economies of urban regions. Model estimation is simplified by assuming strictly hierarchical trade, i.e., goods flow down but never up the trade hierarchy. The assumption understates rural to urban impacts where non-hierarchical, rural to urban linkages exist. The understatement equals neglected feedback effects. We are encouraged by the literature on interregional feedbacks indicating that these are usually small in magnitude (Miller, 1966; Miller, 1967; and Robison and Miller, in press).

Supply-Demand-Pool Technique Applied to Interregional Trade

The well known supply-demand-pool technique (Schaffer and Chu, 1969) regionalizes national coefficients on the basis of regional supply and demand. An estimate of interregional trade is obtained by applying the same general procedure to interregional supply and demand (Robison and Miller, in press). We consider the outlines of the technique by focusing on a two-order trade hierarchy with a single core region, subregion C, dominating two peripheral regions, subregions R and T. The technique is easily generalized to any number of peripheral subregions, and to cases of three and higher-order trade.

Both core and peripheral subregions have exports. If trade is strictly hierarchical, exports of the peripheral subregions leave the region altogether, while exports of the core serve in part the import needs of the lower-order subregions. Our approach is to estimate the import needs of peripheral subregions, and then scale national coefficients to obtain an estimate of core exports in service of these peripheral subregion import needs.

Interregional I-O coefficients for our two-order core-periphery model appear as follows:

$$A = \begin{Bmatrix} A_{CC} & A_{CR} & A_{CT} \\ 0 & A_{RR} & 0 \\ 0 & 0 & A_{TT} \end{Bmatrix} \quad (1)$$

Strictly hierarchical trade, and no same-order trade, is highlighted by zero elements.

The supply-demand-pool technique starts with an estimate of a region's total demand for commodities, or "regional requirements." Similarly, we begin with an estimate of the periphery's demand for imports. Let N_{CR} and N_{CT} be arrays of national model input-output coefficients with the same row and column structures as A_{CR} and A_{CT}. Let H_{CR} and H_{CT} be similarly row and column-structured matrices, but this time consisting solely of unit and null vectors. For industries present at both core subregion C, and peripheral subregion R, columns of H_{CR} contain a one in the row for that industry, zeros otherwise. For industries present in the periphery but not present in the core, columns of H_{CR} contain all zeros. Matrix H_{CT} is constructed in the same manner for industries in core subregion C and peripheral subregion T.

Let G_{CR} and G_{CT} be matrices with coefficients indicating the demand for commodities by the respective peripheral subregions in excess of that satisfied by industries at these subregions. Given their row dimensions, G_{CR} and G_{CT} track only commodities produced in core subregion C. Matrices G_{CR} and G_{CT} can be thought of as "gross import requirements matrices" for the commodities produced in core subregion C. Assuming national technology, estimates of G_{CR} and G_{CT} are obtained as follows:

$$G_{CR} = \{ N_{CR} - H_{CR}A_{RR} \} \tag{2}$$

and

$$G_{CT} = \{ N_{CT} - H_{CT}A_{TT} \} \tag{3}$$

Next let R_{CR} and R_{CT} be column vectors indicating the total import demand by peripheral subregions R and T for commodities produced in core subregion C. Vectors R_{CR} and R_{CT} are obtained as follows:

$$R_{CR} = G_{CR}X_R \tag{4}$$

and

$$R_{CT} = G_{CT}X_T \tag{5}$$

where X_R and X_T are total gross output vectors for peripheral subregions R and T.

In parallel fashion to the supply-demand-pool technique, we now use (4) and (5) to form a vector of scalars $\rho_{C,R+T}$ as follows:

$$\rho_{C,R+T_i} = \begin{cases} E_{C_i}/(R_{CR_i}+R_{CT_i}) & \text{if } E_{C_i} < (R_{CR_i}+R_{CT_i}) \\ 1.0 & \text{otherwise} \end{cases} \tag{6}$$

where E_{C_i} is exports of commodity i from core subregion C. Arrayed in a diagonal matrix, scalars (6) premultiply (2) and (3) yielding an estimate of interregional core-periphery, input-output coefficients thus:

$$A_{CR} = \{ \hat{\rho}_{C,R+T} \} G_{CR} \tag{7}$$

and

$$A_{CT} = \{ \hat{\rho}_{C,C+R} \} G_{CT} \tag{8}$$

We later use the interregional coefficients estimating procedure of equations (2) through (8) to estimate interregional trade in the Salt Lake City and Idaho Falls-centered regional economies. But first let us describe those economies, define their principal subregions, and specify the character of their trade hierarchies.

The Hierarchal Structure of the Salt Lake City and Idaho Falls Trading Areas

Inspired by central place theory and the related notion of functional economic areas (Fox and Kumar, 1965), the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) mapped the principal trading areas of the U.S. economy (U.S. Department of Commerce, 1975). Figure 1 presents the BEA's mapping of the Intermountain West. Though based on county combinations, "BEA Economic Areas" freely cross political boundaries. The region centered on Salt Lake City, Utah, for example, extends into southern Idaho and southwestern Wyoming. Similarly, the area centered on Idaho Falls, Idaho extends into western (Teton County) Wyoming. The veracity of the BEA's trade regions is reflected in television availability. Southwestern Wyoming receives Salt Lake City television, and Teton County, Wyoming receives Idaho Falls television.

The BEA's mapping of U.S. trade areas is limited, however, by its implicit two-order, core-periphery structure. For example, while television availability verifies the Idaho Falls BEA economic area, Salt Lake City television is also available throughout the Idaho Falls BEA economic area. Newspaper circulation, yellow page listings, and common knowledge indicate a trade dominance by Salt Lake City over the entire Idaho Falls BEA economic area. Yet Idaho Falls is clearly locally dominant. It appears, therefore, that northern Utah, southeastern Idaho, and western Wyoming exhibit a three-order trade hierarchy, with Salt Lake City at the top of the three-order hierarchy, followed by Idaho Falls occupying the top of its own two-order trade hierarchy.

Figure 2 presents our sub-regional breakdown of the Intermountain West's three-order trade hierarchy. Shaded areas indicate regional trading cores. The "Salt Lake City core" includes Utah, Salt Lake, Davis, and Weber Counties, Utah -- a more or less continuous urban-suburban complex, locally known as the "Wasatch Front," Provo, Salt Lake City, and Ogden. The shaded area labeled "Idaho Falls core" includes Bannock, Bingham, Bonneville, Jefferson, and Madison Counties, Idaho, a more or less urban-suburban complex including Pocatello, Blackfoot, Idaho Falls, Rigby, and Rexburg, Idaho.

Peripheral areas are segmented in part according to political boundaries, to indicate economic linkages that cross these boundaries. We also break an eight county area, "Magic Valley," from what would otherwise be part of an unbroken Idaho Falls periphery. "Magic Valley" reflects an eight-county economic subregion centered on Twin Falls, Idaho. Twin Falls has its own television station, and the eight-county subregion reflects the market area of that television station. Magic Valley also receives Idaho Falls television, and Salt Lake City television, supporting our assumed three-order trade hierarchy. However, Magic Valley also receives Boise, Idaho television. Magic Valley yellow page listings, newspaper readership, and local knowledge suggest substantial market reach from Boise, as well as from Idaho Falls and Salt Lake City. Accordingly, we break out Magic Valley as a separate subregional economy, and model it as occupying overlapping market shadows of Boise, Idaho Falls and Salt Lake City.

Modeling Procedure: Individual Region Models

Our exercise begins with models for each subregion. These subregions, and short hand notation for identifying each in algebraic formulations are indicated below:

Subregion	Notation
Salt Lake City (Utah Core)	UC
Northern Utah Periphery	UP
Southwest Wyoming Periphery	SW
TriCounty	TC
Southeast Idaho Periphery	IP
Teton County, Wyoming	TE
Magic Valley	MG

Following standard practice (e.g., Miller and Blair, 1985), we form "industry-by-industry" national input-output coefficients as the product of the normalized Make and Use matrices of the 1977 national input-output model (U.S. Department of Commerce, 1979). We construct a vector of corresponding national employment-sales ratios from national model total gross outputs, and national employment (Yuskavage 1985). National employment-sales ratios are applied to model area employment estimates to yield estimated industry total gross outputs.

Our intention is to build models reflecting the regional economy in 1987. County employment data for sectors other than agriculture are from 1984 <u>County Business Patterns</u> obtained from Resource Economics and Management Analysis (1987) in a disclosure-unsuppressed form and bridged to the 537 industry/commodity detail of the 1977 national input-output model. These data are updated to 1987 by controlling to Idaho Job Service (1988) estimates published at roughly the two-digit SIC level. Revenues for agricultural sectors are obtained directly from the 1987 Census of Agriculture (U.S. Department of Commerce, Bureau of the Census, 1989), and Idaho Agricultural Statistics (Idaho Agricultural Statistics Service, 1990).

The household sector is customarily made endogenous in regional I-O models. Economic base models extend endogeneity to local government and investment as well (Hirsch, 1973, p. 192). We wanted models that reflect the economic base of regions. Accordingly, each model is closed with regard to households, state and local government, and a portion of investment. Only exports, a portion of consumption (exogenous consumption), and a portion of investment (exogenous investment) is left exogenous.

The household column is obtained from normalized national model personal consumption expenditures. For the household row, we want coefficients that reflect income available for consumer spending by regional residents (Rose and Stevens, 1991). We assume all corporate profit leaves the region, and that all wage and salary, proprietary, and rental income stays. Using aggregate measures from the National Income and Product Accounts (NIPAs) (U.S. Department of Commerce, Bureau of Economic Analysis, 1978), we scale "property-type income" coefficients of the national input-output model to exclude capital consumption allowances, and to reflect the leakage of corporate profits. So-scaled property-type income coefficients are added to "compensation of employees" coefficients, and these are scaled by the ratio of "personal consumption expenditures" to "national income," from the NIPAs, to provide our estimate of coefficients indicating the portion of income in regions available for consumption spending. We assume that 10% of income available for spending in the region is from outside income sources, and add this "exogenous spending" to the household row of our regional exports vector.

The state and local government column is obtained from normalized national model state and local government expenditures. Total state and local government expenditure in a region is estimated by applying the ratio of national state and local government spending to employment, to regional state and local government employment. For the state and local government row, we borrow national model value added coefficients. These are later scaled in the course of a supply-demand-pool regionalizing process to yield coefficients that generate indicated total state and local government revenues (equal expenditures), by industry, in proportion to the relative value added by industry.

The investment column is obtained from normalized national model investment expenditures. We estimate total investment spending in regions as a share of national investment spending. The regional share of national investment spending is assumed to be the same as the regions's share of national employment. We assume that 25% of all regional investment is exogenous, and add this amount to the investment row of our export vector. For the investment row, we again borrow national model value added coefficients, and later scale these to yield coefficients that generate indicated regional investment, by industry, in proportion to the relative value added by industries.

National model coefficients are adjusted according to a standard supply-demand-pool application to yield regionalized I-O coefficients and a vector of estimated exports for each region.

Modeling Procedure: Interregional Trade

We estimate interregional trade to indicate the role of rural industry in urban economies. The overall structure of our interregional model appears as follows:

$$\left\{\begin{array}{cccc:cccc}
A_{UC,UC} & A_{UC,UP} & A_{UC,TC} & A_{UC,SW} & A_{UC,IC} & A_{UC,IP} & A_{UC,TE} & A_{UC,MG} \\
0 & A_{UP,UP} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & A_{TC,TC} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & A_{SW,SW} & 0 & 0 & 0 & 0 \\
\hdashline
0 & 0 & 0 & 0 & A_{IC,IC} & A_{IC,IP} & A_{IC,TE} & A_{IC,MG} \\
0 & 0 & 0 & 0 & 0 & A_{IP,IP} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & A_{TE,TE} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & A_{MG,MG}
\end{array}\right\} \qquad (9)$$

Matrix (9) reflects our assumption regarding strict hierarchical trade. Intraregional trade appears on the principal diagonal, interregional trade on the off-diagonal. The upper-left partition reflects two-order trade in the BEA's Salt Lake City economic area. The Salt Lake City core (UC), supplies all peripheral subregions. Otherwise there is no interregional trade, either up the trade hierarchy, or between same-order subregions. The lower-right partition reflects two-order trade in the BEA's Idaho Falls economic area. The Idaho Falls trading core (IC), supplies all peripheral subregions. Again there is no trade up the hierarchy, or between same-order subregions.

The upper-right partition of matrix (9) reflects two-order trade between Salt Lake City and Idaho Falls, and three-order trade between Salt Lake City and the Idaho Falls peripheral subregions. Null elements reflect our assumed strict trade hierarchy.

Two-Order Trade in the Salt Lake City Economic Area

Interregional coefficient matrices in the upper-left Salt Lake City trade area are estimated according to the procedure presented in equations (2) through (8). The procedure entails the formation of the following "gross import requirements matrices:"

$$G_{UC,UP} = \{N_{UC,UP} - H_{UC,UP}A_{UP,UP}\}$$

$$G_{UC,TC} = \{N_{UC,TC} - H_{UC,TC}A_{TC,TC}\}$$

$$G_{UC,SW} = \{N_{UC,SW} - H_{UC,SW}A_{SW,SW}\}$$

Two-Order Trade in the Idaho Falls Economic Area

Interregional coefficient matrices in the lower-right Idaho Falls trade area are estimated according to equations (2) through (8). In this case the procedure requires one modification. As suggested above, Magic Valley is viewed as a subregional economy in the overlapping market reach of Boise, Idaho Falls, and Salt Lake City. We treat these three directions of dominance in an asymmetric fashion, estimating first two-order dominance from Boise and Idaho Falls, and then third-order dominance from Salt Lake City.

Trade between Boise and Magic Valley is summarized in an interregional coefficients matrix $A_{BO,MG}$ not shown in (9). Lacking information on the relative market pull of Boise (i.e., the Boise trading core, Ada and Canyon counties, Idaho) versus Idaho Falls (IC), we assume for industries present at both centers, an equal pull in both directions. Accordingly, we form a set of scalars ψ_i:

$$\psi_i = \begin{cases} 1.0 \text{ for industries present at Boise, but not present at Idaho Falls.} \\ 1/2 \text{ for industries present at both Boise and Idaho Falls.} \end{cases}$$

We then estimate import demands by subregions in Boise's periphery (Owyhee, Elmore, Washington, Adams, Valley, Payette, Gem, and Boise counties, Idaho, plus Magic Valley) according to the following variant of equations (4) and (5):

$$R_{BO,PB+MG} = G_{BOPB}X_{PB} + \{\Phi\}G_{BO,MG}X_{MG}$$

where "PB" denotes Boise's periphery not including Magic Valley, "BO" denotes Boise, and other subscripts are as defined previously. Scalars $\rho_{BO,PB+MG_i}$ are then formed as follows:

$$\rho_{BO,PB+MG_i} = \begin{cases} E_{BO_i}/R_{BO,PB+MG_i} \ \mathit{if} \ E_{BO_i} < R_{BO,PB+MG_i} \\ 1.0 \ \mathit{otherwise} \end{cases} \quad (17)$$

Finally, we estimate the Boise-Magic Valley interregional coefficients matrix according to the following:

$$A_{BO,MG} = \{\hat{\rho}_{BO,PB+MG}\}\{\Phi\}G_{BO,MG}$$

Interregional coefficient matrices for the Idaho Falls trade area, appearing in the lower-right partition of (9), are now estimated according to equations (2) through (8) with the following gross import requirements matrices:

$$G_{IC,IP} = \{N_{IC,IP} - H_{IC,IP}A_{IP,IP}\}$$

$$G_{IC,TE} = \{N_{IC,TE} - H_{IC,TE}A_{TE,TE}\}$$

$$G_{IC,MG} = \{N_{IC,MG} - H_{IC,MG}A_{MG,MG} - H_{IC,BO}A_{BO,MG}\}$$

Two and Three-Order Trade Between the Salt Lake City and Idaho Falls Economic Areas.

We are left with interregional coefficient matrices appearing in the upper-right partition of (9) reflecting Salt Lake City's dominance of Idaho Falls and the Idaho Falls trade area. These are estimated according to equations (2) through (8) with the following gross import requirements matrices:

$$G_{UC,IC} = \{N_{UC,IC} - H_{UC,IC}A_{IC,IC}\}$$

$$G_{UC,IP} = \{N_{UC,IP} - H_{UC,IP}A_{IP,IP} - H_{UC,IC}A_{IC,IP}\}$$

$$G_{UC,TE} = \{N_{UC,TE} - H_{UC,TE}A_{TE,TE} - H_{UC,IC}A_{IC,TE}\}$$

$$G_{UC,MG} = \{N_{UC,MG} - H_{UC,MG}A_{MG,MG} - H_{UC,IC}A_{IC,MG} - H_{UC,BO}A_{BO,MG}\}$$

Centrality, Interregional Spillovers, and Interconnectedness in the Three-Order Trade Hierarchy

We now consider some results of our interregional I-O modeling exercise focusing particularly on spillovers from lower to higher-order regions. Our approach is to examine these spillovers, in the context of central place theory, with the help of summary measures of intra and interregional interconnectedness.

Table 1 indicates gross income by subregion linked to economic activity at other subregions. Table 1 is derived by forming a Leontief inverse on interregional I-O coefficients (9), post multiplying these by the vector of exports, i.e., exports out of the larger region, and premultiplying the result by value added coefficients from the national model. Figures express millions of 1987 dollars.

Gross income for individual subregions appears in Table 1 as row sums in the far-right column. Viewing the eight subregions as a single region, column sums indicate the contribution of each subregion to the larger regional economy. Individual cell elements indicate the portion of row subregion gross income linked to export activity at column subregions. The Salt Lake City core (UC), has a gross income of $17,596.6 million. Of this, $1,022.5 million is attributable to export activity in the Northern Utah Periphery (UP), $42.7 million to export activity in the "TriCounty" subregion (TC), and so on.

Table 1 highlights the effect of assuming strictly hierarchical trade. Occupying the top of the three-order hierarchy, export activity of the Salt Lake City core explains income in the Salt Lake City core only. With a more complete specification of interregional trade, that included in particular flows of specialized goods from lower to higher-order regions, we would expect Salt Lake City core exports to explain income in lower-order subregions as well.

Moving down the hierarchy, exports of the Idaho Falls core explain a portion of that subregion's gross income, $1,898.6 million, and a portion of Salt Lake City core gross income, $73.5 million. Three-order trade is illustrated by subregions in the Idaho Falls periphery where each subregion explains gross income in both the Salt Lake City and Idaho Falls core economies.

Table 2 shows individual cell elements of Table 1 as a percent of row sums. Table 2 thereby indicates the dependence of row subregion income on the exports of other subregions. Given the assumption of strictly hierarchical trade, only the trading cores exhibit such dependence. If we subtract principal diagonal percentages of Table 2 from 100%, the result provides an indication of relative centrality. Accordingly, Idaho Falls depends on its role as a central place for approximately 25% (≈ 100% - 74.74%) of its gross income, compared to 13% (≈ 100% - 86.96%) for Salt Lake City. The Salt Lake City core has significant sources of specialized export income independent of its central place functions, Kennecott Copper and Hill Air Force Base for example. Similar sources of export income are less visible in the Idaho Falls core.

Gross Subregional Income as a determining factor in Central Place Dependence

We might suppose there to be a relationship between the dependence of core income on subregional activity and subregion size. Table 3 is constructed from information in Tables 1 and 2 to examine the relationship between the central place dependence on subregions, and the size of those subregions as indicated by relative gross incomes. The first block of data refers to the Idaho Falls trade area only. Percentage dependence appears as the first set of data, gross subregion income as the second set of data. Both data sets are arranged in descending order of magnitude. The data indicates that the greater the dominated subregion's income, the greater is the dependence of the core on that subregion for central place income.

The second block of Table 3 data refers to the overall region dominated by Salt Lake City, and this data contradicts in part the inference drawn on the basis of the Idaho Falls region alone. In particular, southwest Wyoming (SW), with a slightly smaller gross income than Magic Valley (MG), stands well above Magic Valley in terms of dependent gross income in the Salt Lake City core, 3.81% of Salt Lake City core income for southwest Wyoming as opposed to 1.02% for Magic Valley. This case can be explained by the intervening central place role of the Idaho Falls core, partially dominating Magic Valley, while southwest Wyoming is directly dominated by Salt Lake City only. Less easily explained is southwest Wyoming's (SW) transposition with the Idaho Falls core (IC), or Magic Valley's (MG) transposition with the southeast Idaho Periphery (IP).

Interregional Spillovers and Central Place Dependency

In search of an explanation of the transpositions indicated in Table 3, we constructed Table 4 that looks at relative interregional trade from the perspective of lower-order subregions. Table 4 shows individual cell elements of Table 1 as a percent of Table 1 column sums. The table thus indicates gross income in the broader regional economy explained by the export activity of the various subregions. Assuming strictly hierarchical trade, the broader regional contribution of Salt Lake City core exports is confined entirely to the Salt Lake City core. In contrast, 3.73% of Idaho Falls' broader regional contribution spills up the trade hierarchy to the Salt Lake City core. Lower-order subregions spill a greater proportion of their broader regional income contribution to the dominating core subregions.

Table 3 indicated a transposition of southwest Wyoming (SW) and the Idaho Falls core (IC). In particular, southwest Wyoming, with a gross income of $1,910.3 million, plays a larger role in the Salt Lake City core than does the Idaho Falls core (IC), with a gross income of $2,540.3 -- 3.81% for southwest Wyoming versus 0.42% for Idaho Falls. Table 4 indicates that this transposition is in part a reflection of southwest Wyoming's greater economic spillover to the Salt Lake City core, nearly 26% for southwest Wyoming versus less than 4% for the Idaho Falls core. Similarly, Table 3's transposition of the southeast Idaho periphery (IP), and Magic Valley (MG), is explained by their disparate spillovers to the Salt Lake City core, nearly 17% for the southeast Idaho periphery (IP) versus just over 7% for Magic Valley (MG). Thus, relative spillover helps explain the differential role of subregions in core area economies. Let us now examine the economies of subregions, and trade between dominated subregions and dominating cores, in search of features of the interregional economy that explain relative spillover.

Gross Subregional Income as an Indicator of Interregional Spillovers

Central place theory would predict an inverse relationship between order in the hierarchy and relative spillover. Hierarchical order mirrors the complexity of the commercial infrastructure. Lower-order subregions exhibit relatively undeveloped infrastructures, and thus obtain a larger share of their consumer and business needs from higher-order regions. The greater the share of needs obtained from outside, the greater are the spillover effects. But there are many confounding variables.

Table 5 ranks subregions in descending order according to the size of their spillovers as indicated by the sum of off-diagonal percentages in Table 4. Next to these, subregions are ranked in ascending order according to gross incomes from Table 1. Inspection of Table 5 indicates gross income as an imperfect indicator of hierarchical order as measured by relative spillover. The rankings of Table 5 yield Spearman rank correlation .73810.

The failings of gross income as an indicator of relative spillovers is not surprising. Spillovers are a function of the interconnectedness of lower and higher-order regions, and this depends on the mix of industries in both regions, and on the match between that mix and the needs of lower-order subregions. Table 5 suggests a less than perfect match.

The Mean of Interregional Coefficient Column Sums as an Indicator of Relative Spillovers

Hamilton and Jensen (1983) suggest "the mean of intermediate coefficient column sums" as an indicator of interconnectedness in regional I-O models. Directly focusing on interregional trade, we compute the mean of interregional coefficient column sums. For the southeast Idaho peripheral subregion (IP), for example, we compute the mean of interregional coefficient column sums according to the following:

$$\{ (1) A_{UC,IP} + (1) A_{IC,IP} \}[1]\frac{1}{n}$$

where (1) and $[1]$ are sum vectors, and n is the number of sectors in the southeast Idaho peripheral model (IP). Table 6 compares spillovers and the mean of interregional coefficient column sums for our eight subregions.

Mean coefficient sums in Table 6 are arranged in descending order, the idea being that high values indicate relative interregional interconnectedness and thus explain relative spillover and dependence on higher-order trade. While Table 6 exhibits a different ranking than gross incomes (Table 5), the mean of interregional coefficient column sums still provides an imperfect indicator of spillovers. Table 6 yields the same rank correlation as gross income Table 5, .73810.

The Percentage of Interregional Transactions as
an Indicator of Relative Spillovers

We observe that while the mean of interregional coefficient column sums provides a measure of interregional trade, there is no weighting of this trade according to the relative output of the lower-order subregion industries that generate this trade. A summary measure that captures these weighting effects is a variation on another summary measure of interconnectedness suggested by Hamilton and Jensen, "the percentage intermediate transactions." We vary the Hamilton-Jensen formulation to focus directly on interregional trade. For the southeast Idaho peripheral economy (IP), for example, we compute percentage of interregional intermediate transactions according to the following:

$$100*\{ (1) A_{UC,IP} X_{IP} + (1) A_{IC,IP} X_{IP} \} / (1) X_{IP}$$

Table 7 presents spillovers versus the percentage of interregional transactions for all subregions. Table 7 indicates considerable improvement over Table 6's unweighted mean of interregional coefficient column sums. Note that only subregions

TE and TC are transposed. Table 7 yields a rank correlation of .97619.

The Mean of Intermediate Coefficient Column Sums
as an Indicator of Relative Spillovers

Let us now follow Hamilton and Jensen and compute the mean of intermediate coefficient column sums for intraregion, rather than interregion trade. As with gross regional income, our focus here is on the degree of commercial infrastructure development in individual subregions. For our southeastern Idaho peripheral economy (IP), for example, the mean of intermediate coefficient column sums is computed as follows:

$$(1) A_{IP,IP}[1]\frac{1}{n}$$

where again, n is the number of sectors in the IP model.

Table 8 presents spillovers versus the mean of intermediate coefficient column sums for our eight subregional models. Mean coefficient column sums are arranged in ascending order, a low value indicating a less developed economy, with a greater need for the goods and services of higher-order regions. While Table 8 displays several transpositions, the movements in rank are small. Table 8 provides a rank correlation of .92857, indicating this as one of the better indicators of interregional spillovers.

Percentage of Intermediate Transactions as an Indicator of Relative Spillovers

Finally, following Hamilton and Jensen, we compute the percentage of intermediate transactions for intra rather than interregion trade. For our southeastern Idaho peripheral subregion (IP), the percentage of intermediate transactions is computed as follows:

$$100*(\ 1\ )A_{IP,IP}X_{IP}/(\ 1\ )X_{IP}$$

Table 9 presents the percentage of intermediate transactions for our eight subregions. As is apparent from inspection of the table, the ranking of spillovers and the percentage intermediate transactions is identical.

Discussion and Conclusions

Our analysis of interregional trade in hierarchically structured regions leads us to two prominent conclusions, one with implications for economic impact assessment, and one with implications in the more dynamic context of regional economic development policy.

The context of economic impact assessment is one where an exogenous shock in one part of the economy engenders changes in other parts of the economy. Our analysis indicates that impacts to higher-order dominating regions, from exogenous shocks in lower-order dominated subregions, vary inversely with the degree of economic infrastructure development in the lower-order subregions. Impacts to higher-order regions diminish as the economic development of the shock-receiving dominated subregion increase, or as economically developed, dominating regions intervene in the hierarchical path to the higher-order region.

An example where the structure of the trade hierarchy plays a potentially pivotal role in an economic impact assessment involves a water dispute between Texas and New Mexico. The dispute involves the Pecos River as it flows through predominantly agricultural southeastern New Mexico and western Texas. The entire region is trade dominated by El Paso Texas. An important consideration in judging the economic impact of water use in the region hinges on the agronomical fact that the water loses approximately ten times its productive potential, through evaporation and increased salinity, as it flows from New Mexico to Texas. Taking this into account, and recognizing that agricultural activity in predominantly rural southeast New Mexico economically benefits Texas through El Paso's trade dominance, decision makers in Texas are faced with the possibility that Pecos River water used in New Mexico may be more beneficial to the Texas economy than this same water used in Texas. Empirical consideration of this issue is pending the court's decision regarding the role of secondary impacts in the award of damages (Hamilton et al., 1990). Our analysis suggests that the relative impacts to New Mexico and Texas hinges in large measure on the impact-intercepting degree of commercial infrastructure development in rural southeastern New Mexico.

Our analysis of hierarchical trade has implications for economic development policy as well. Through threshold and import substitution effects, economic development policies often aim at deepening the economic infrastructure of targeted regions. Growth in lower-order subregions implies growth in higher-order regions through spillover effects. At the same time, however, as lower-order infrastructure development proceeds, spillovers can be expected to decline, implying more rapid growth at lower, as opposed to higher-order regions. Other things equal, we might expect an overall leveling effect from lower-order subregion development.

Improvements in transportation and communications, and technological change in agriculture and other predominantly extractive rural industries has led to greater spatial concentration in many regions of the rural west. However, other rural regions have grown and deepened their infrastructures, thus lessening their dependence on larger dominating regions. Our analysis helps explain these countervailing trends, and provides a framework where economic development policies, aimed at differential growth targets between regions, can be appropriately framed.

References

Berry, 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).

Eskelinen, H. 1983. "Core and Periphery in a Three-Region Input-Output Framework," Annals of Regional Science, 17, 41-55.

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.

Hamilton, J.R. and R.C. Jensen. 1983. "Summary Measures of Interconnectedness for Input-Output Models," Environment and Planning A, 15, 55-65.

Hamilton, J.R., M.H. Robison, N.K. Whittlesey, and J. Ellis. 1990. "The Role of Interregional Impact Spillovers in Regional Impact Assessment," paper presented at the Annual Meeting of the Western Regional Science Association, Monterey, California.

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

Idaho Agricultural Statistics Service, 1990. "Idaho Agricultural Statistics."

Idaho Job Service. 1988. "County Employment Estimates for 1987." Boise.

Isard, W. 1951. "Interregional and Regional Input-Output Analysis: A Model of a Space Economy," Review of Economic Statistics, 33, 318-328.

Leontief, W.W. and A. Strout. 1963. "Multiregional Input-Output Analysis," in T. Barna ed., Structural Interdependence and Economic Development (London, Macmillan).

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

Miller, R.E. 1967. "Interregional Feedbacks in Input-Output Models: Some Experimental Results," Western Economic Journal, 41-50.

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

Moses, L. 1955. "The Stability of Interregional Trading Patterns and Input-Output Analysis, American Economic Review, 45, 803-832.

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, MA, D.C. Heath).

Resource Economics and Management Analysis. 1987. "1984 County Business Patterns for Idaho, Wyoming, and Utah bridged in a disclosure-unsuppressed form and bridged to the 537 industry/commodity detail of the 1977 national input-output model. Unpublished Data Files.

Robison, M.H. and J.R. Miller. In press. "Central Place Theory and Input-Output Analysis," Papers in Regional Science.

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

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

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.

U.S. Department 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 the Census, 1989. "Census of Agriculture," computer tapes for census year 1987.

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.

Yuskavage, R.E., 1985. "Employment and Employee Compensation in the 1977 Input-Output Accounts," Survey of Current Business, 65.

Figure 1. Economic and political boundaries of THE INTERMOUNTAIN WEST

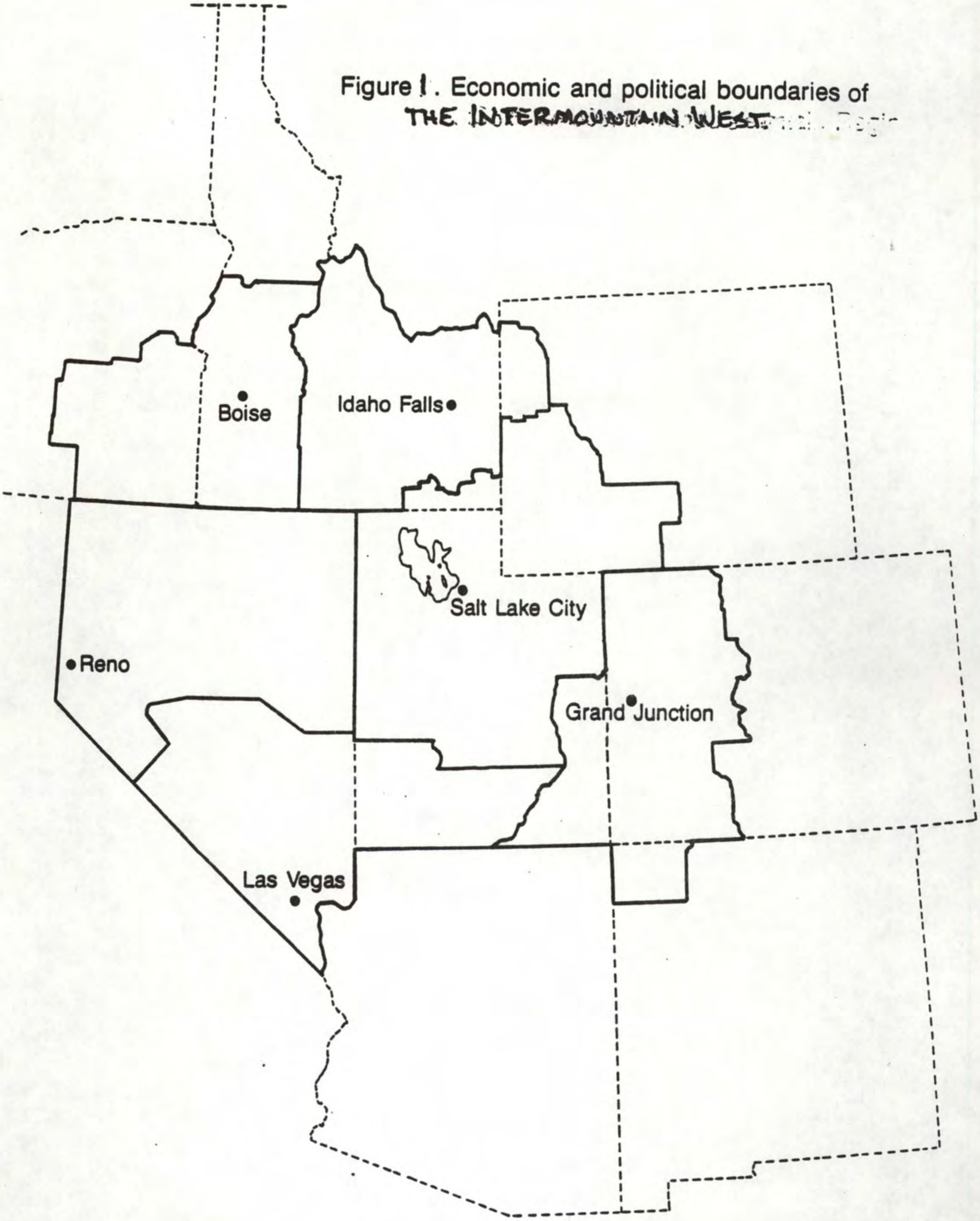

FIGURE 2

Salt Lake City/Idaho Falls Trade Area

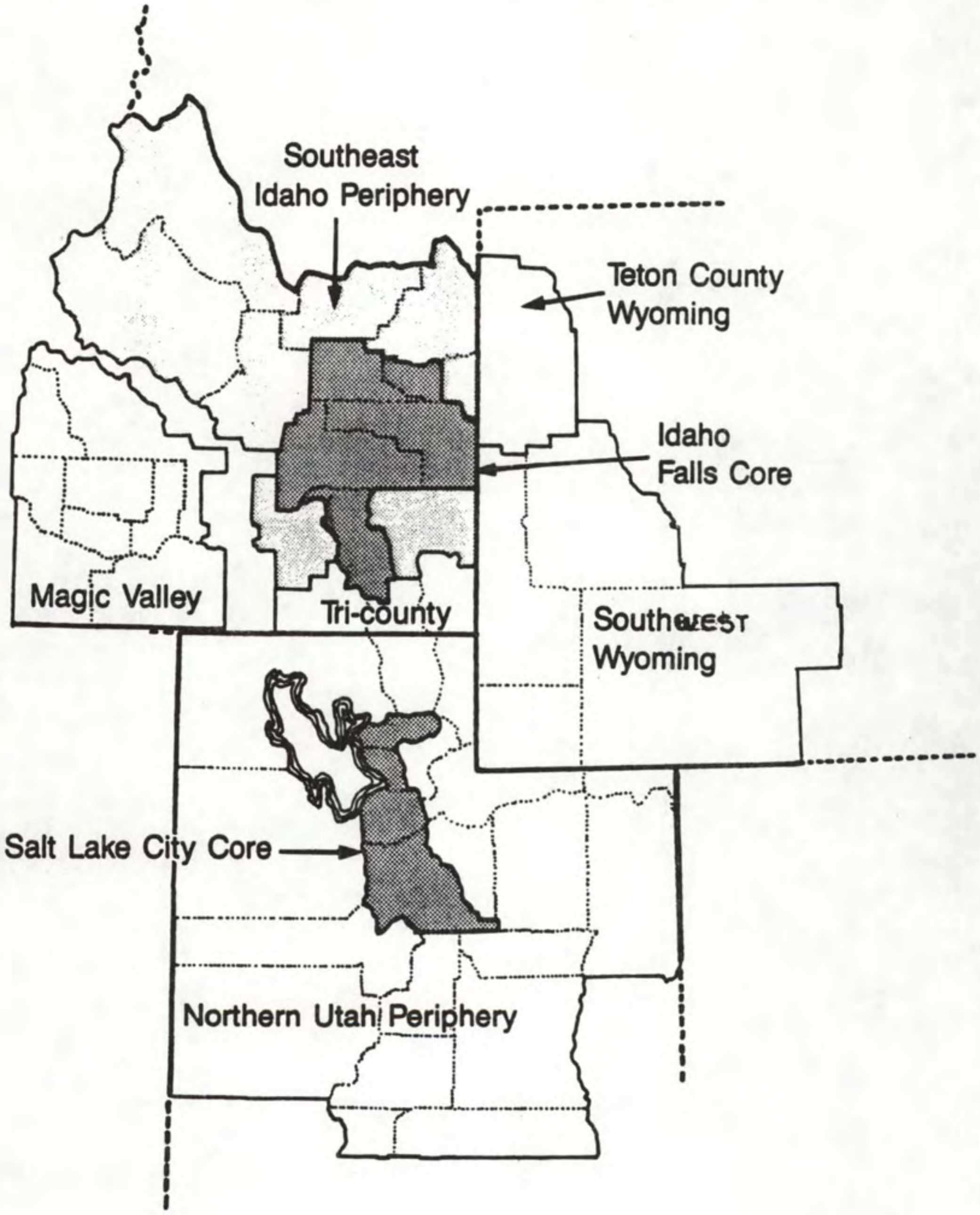

Table 1: Intermountain West, Subregion Gross Income by Location of Originating Economic Activity
(MILLIONS OF DOLLARS)

	UC	UP	TC	SW	IC	IP	TE	MG	Sum
UC	$15,301.7	$1,022.5	$42.7	$670.3	$73.5	$260.9	$45.5	$179.5	$17,596.6
UP		$3,608.5							$3,608.5
TC			$125.1						$125.1
SW				$1,910.3					$1,910.3
IC					$1,898.6	$287.8	$42.8	$311.1	$2,540.3
IP						$1,016.3			$1,016.3
TE							$270.5		$270.5
MG								$2,018.0	$2,018.0
Sum	$15,301.7	$4,631.0	$167.8	$2,580.6	$1,972.1	$1,565.0	$358.8	$2,508.6	

Table 2: Intermountain West, Percent of Subregion Gross Income by Location of Originating Economic Activity

	UC	UP	TC	SW	IC	IP	TE	MG	Sum
UC	86.96	5.81	0.24	3.81	0.42	1.48	0.26	1.02	100.0
UP		100.00							100.0
TC			100.00						100.0
SW				100.00					100.0
IC					74.74	11.33	1.68	12.25	100.0
IP						100.00			100.0
TE							100.00		100.0
MG								100.00	100.0

Table 3: Core Dependence on Subregion Exports Ranked Against Subregion Gross Incomes

Idaho Falls Core

Dependence		Subregion Gross Income	
IC	74.74	IC	$2,540.3
MG	12.25	MG	$2,018.0
IP	11.33	IP	$1,016.3
TE	1.68	TE	$270.5

Salt Lake City Core

Dependence		Subregion Gross Income	
UC	86.96	UC	$17,596.6
UP	5.81	UP	$3,608.5
SW	3.81	IC	$2,540.3
IP	1.48	MG	$2,018.0
MG	1.02	SW	$1,910.3
IC	0.42	IP	$1,016.3
TE	0.26	TE	$270.5
TC	0.24	TC	$125.1

Source: Tables 1 and 2.

Table 4: Intermountain West, Region-Wide Contribution to Gross Income by Subregions According to the Location of Income Generation

	UC	UP	TC	SW	IC	IP	TE	MG
UC	100.00	22.08	25.45	25.97	3.73	16.67	12.68	7.16
UP		77.92						
TC			74.55					
SW				74.03				
IC					96.27	18.39	11.93	12.40
IP						64.94		
TE							75.39	
MG								80.44
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 5: Intermountain West Subregions Ranked According to Relative Spillovers and Gross Incomes

Relative Spillovers		Gross Incomes	
IP	35.06	TC	$125.1
SW	25.97	TE	$270.5
TC	25.45	IP	$1,016.3
TE	24.61	SW	$1,910.3
UP	22.08	MG	$2,018.0
MG	19.56	IC	$2,540.3
IC	3.73	UP	$3,608.5
UC	0.00	UC	$17,596.6

Source: Tables 1 and 4.

Table 6: Intermountain West Subregions Ranked According to Relative Spillovers and the Mean of Interregional Intermediate Coefficient Column Sums

Relative Spillovers		Mean Coefficient Sums	
IP	35.06	IP	.13189
SW	25.97	SW	.11310
TC	25.45	TE	.11093
TE	24.61	MG	.08478
UP	22.08	UP	.06078
MG	19.56	IC	.05054
IC	3.73	TC	.04590
UC	0.00	UC	0

Source: Table 4 and interregional coefficients matrices.

Table 7: Intermountain West Subregions Ranked According to Relative Spillovers and the Percentage of Interregional Transactions

Relative Spillovers		Percentage Interregional Transactions	
IP	35.06	IP	14.17
SW	25.97	SW	11.02
TC	25.45	TE	9.92
TE	24.61	TC	9.71
UP	22.08	UP	7.07
MG	19.56	MG	6.50
IC	3.73	IC	3.70
UC	0.00	UC	0

Source: Table 4, interregional coefficients matrices, and subregion total gross output vectors.

Table 8: Intermountain West Subregions Ranked According to Relative Spillovers and the Mean of Intermediate Coefficient Column Sums

Relative Spillovers		Mean Coefficient Sums	
IP	35.06	SW	.43321
SW	25.97	IP	.44099
TC	25.45	TE	.53698
TE	24.61	TC	.54135
UP	22.08	MG	.54509
MG	19.56	UP	.56140
IC	3.73	IC	.57018
UC	0.00	UC	.64282

Source: Table 4 and intraregional coefficients matrices.

Table 9: Intermountain West Subregions Ranked According to Relative Spillovers and the Percentage of Intermediate Transactions

	Relative Spillovers		Percentage Intermediate Transactions
IP	35.06	IP	44.20
SW	25.97	SW	46.06
TC	25.45	TC	52.75
TE	24.61	TE	57.84
UP	22.08	UP	58.61
MG	19.56	MG	60.61
IC	3.73	IC	65.29
UC	0.00	UC	71.89

Source: Table 4, intraregional coefficients matrices, and subregion total gross output vectors.