CENTRAL-PLACE THEORY AND INTERCOMMUNITY INPUT-OUTPUT ANALYSIS

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A.E. Research Series 90-10
September 1990

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I. INTRODUCTION

Central place theory and input-output analysis are strong supports in the structure of regional science. For decades these supports have served independently in the foundation of the discipline. But it is time for another wing in the structure, one requiring a new foundation, constructed with a combination of the two supports.

The new wing is intercommunity input-output analysis. Our purpose here is to show how principles of central place theory can guide construction of an intercommunity input-output model. Of primary interest is the possibility of cutting corners to save construction cost. Short-cut or hybrid methods are standard practice in regional input-output analysis. For example, many assume national technology at the regional level. No one is entirely comfortable with the assumption but, if tract housing will do, the cost of victorian mansions should probably be avoided. An analog in intercommunity analysis is the assumed character of intercommunity trade. Models are easier to construct, for example, where hierarchical trade is reasonably assumed.

In the following we explore the relationship of trade hierarchies and interindustry relationships first in a theoretical sense, and then in the empirical context of a western timber economy, one facing a large reduction in its timber harvest. In section II we argue that many regional impact assessment questions require an intercommunity focus, an emphasis on the spatial aspects of the regional economy. We present a basic abstract intercommunity input-output model in Section III, and show how different intercommunity trade relationships affect its structure. In the various parts of Section IV we describe our method of applying this model in our western timber economy, and present intercommunity sawmill multipliers under alternative assumptions about hierarchical trade. In the final section we offer some thoughts on the generality of our findings.

II. Spatial Considerations in Regional Impact Assessment

When addressing impact assessment issues in timber economies we immediately recognized the shortcomings of using counties as the building blocks for region building. For example, errors can result when counties are not grouped to form functional economic areas (Robison and Miller, 1988).

Appropriate county grouping, however, does not always solve the spatial aggregation problem. Often information is needed at the community level. This is the case, for example, in the analysis of changes in the traditional extractive economic base occurring in rural areas across the western United States. Here, even single county models are often inappropriate. Community-level analysis is needed.

When community-level analysis is called for, we cannot avoid central place considerations. There has been work to incorporate space, transport costs and distance-decay, into regional multiplier formation (Caceres, 1979; Erickson, 1977; Richardson and Gordon, 1978). And the behavior of economic-base multipliers in central place hierarchies has been extensively explored

(Chalmers et al., 1978; Horn and Prescott, 1978; Parr, Denike, and Mulligan, 1975; Seninger, 1978; Suarez-Villa, 1980; Thompson, 1982, 1983). Mulligan (1979) has even extended the theoretical features of this latter research "along lines consonant with input-output analysis." But no one has gone the final step, full integration of intercommunity input-output analysis with the principles of hierarchical trading systems. We offer some theoretical beginnings in the next section.

III. CENTRAL PLACE HIERARCHIES AND INTERCOMMUNITY INPUT-OUTPUT ANALYSIS

In the strict hierarchy of Christaller (1966), the full array of regionally available goods is found only at the highest-order place. With regard to goods uniquely available there, the highest-order place dominates a hinterland of lower-order places and isolated homesteads. Moving down the hierarchy, lower-order places offer progressively narrower arrays of goods and services. Sub-regions and patterns of sub-dominance also emerge. At the bottom of the hierarchy is the lowest-order place, a hamlet dominating a hinterland of isolated homesteads only. In the case of strictly hierarchical trade, goods flow down but never up the hierarchy. Lowest-order places derive their income from exporting primary materials from the region.

Portrayal of a central place hierarchy in input-output terms poses no technical problem. With m communities, input-output coefficients indicating interindustry and intercommunity trade appear in a partitioned matrix:

$$(1) \qquad A = \begin{Bmatrix} A_{11} & A_{12} & & \\ A_{21} & & & \\ & & & \\ & & & A_{mm} \end{Bmatrix}$$

where A_{rt} (r,t = 1,m) indicates trade between communities r and t. Consumer activity, particularly important in rural economies, is captured in coefficients for consumption expenditures and household income. Following standard practice, income coefficients occupy the bottom row, and consumption coefficients the far-right column of each matrix A_{rt}.

Diagonal elements of matrix A capture intracommunity, interindustry trade. Off-diagonal elements capture intercommunity, interindustry trade. If communities are arrayed from the upper left in descending hierarchical rank, strict hierarchical trade is represented by an upper triangular matrix. Elements in the lower left triangle represent violations of strict hierarchical trade.

Intercommunity Multipliers

Multipliers formed on the basis of (1) indicate not only the usual interindustry linkage, but also the areal character of that linkage through the trade hierarchy. To begin, it is useful to consider intercommunity multipliers in a form that suppresses interindustry detail. Anticipating our empirical considerations below, we develop these multipliers in their employment form.

Let:

$$(2) \qquad \boldsymbol{\lambda} = \begin{Bmatrix} \boldsymbol{\lambda}_1 & & \\ & \boldsymbol{\lambda}_2 & \\ & & \boldsymbol{\lambda}_m \end{Bmatrix}$$

be a partitioned, rectangular array of employment-sales ratios for the m communities. $\boldsymbol{\lambda}_r$ (r= 1,m) is a row vector of employment-sales ratios for community r industries. Partitioned array (2) has m rows, one for each community, and columns equal to the number of industries at all communities combined, i.e., columns equal to that of interindustry-intercommunity input-output coefficients matrix (1). The rectangular matrix of intercommunity employment multipliers B is defined as:

$$(3) \qquad B = \boldsymbol{\lambda}\{ I - A \}^{-1}\{\hat{\boldsymbol{\lambda}}\}^{-1}$$

where $\{\hat{\boldsymbol{\lambda}}\}^{-1}$ is a diagonal matrix of sales-employment ratios. A representative element of B , b_{rt_j} , indicates total employment at community r linked to a unit of industry j employment at community t.

Intercommunity Multipliers for Sawmills

Let us anticipate the impact of sawmill closures in our regional economy. Intercommunity sawmill multipliers are isolated as follows. A unit vector is formed for the sawmill sector of each community, and collected into a rectangular matrix

E_s . Matrix E_s has rows equal to the full dimension of the intercommunity-interindustry model (1), and columns equal to the number of communities with sawmills. Each column represents a particular sawmill-hosting community, and contains a 1.0 in the row for that sawmill and community, zeros otherwise.

Equation (4) is an expanded form of the sawmill multiplier matrix, which highlights the important link to the logging sector:

$$(4) \qquad BE_s = E_s^* + \lambda I_1 A\{\hat{\lambda}\}^{-1}E_s + \lambda\{I - I_1\}A\{\hat{\lambda}\}^{-1}E_s + \lambda\{I - A\}^{-1}A^2\{\hat{\lambda}\}^{-1}E_s$$

The term E_s^* in (4) is simply E_s with rows reduced to m, the number of communities. I_1 is a square matrix of zeros except on the main diagonal, at row-column intersections for logging sectors, where 1's appear. I_1 mathematically isolates logger-sawmill trade. The term $\lambda I_1 A\{\hat{\lambda}\}^{-1}E_s$ indicates sawmill-linked employment in the "first input-requirement round" (Isard, 1960). The term $\lambda\{I - I_1\}A\{\hat{\lambda}\}^{-1}E_s$ indicates sawmill-linked employment other than logging in the first input-requirement round. The term $\lambda\{I - A\}^{-1}A^2\{\hat{\lambda}\}^{-1}E_s$ indicates sawmill-linked employment in the second and all additional input-requirement rounds.

Intercommunity sawmill multipliers are affected by the spatial structure of trade. If hierarchical trade can be assumed, empirical estimation of the components of (4) is greatly simplified. Our purpose in the remainder of this paper is to estimate intercommunity sawmill multipliers for a rural timber economy in west-central Idaho, and explore the behavior of, and estimating procedure for these multipliers under alternative assumptions about the spatial structure of trade.

IV. AN APPLICATION OF INTERCOMMUNITY INPUT-OUTPUT ANALYSIS IN A WEST-CENTRAL IDAHO TIMBER ECONOMY

The West-Central Idaho Highlands (Highlands) occupies an uplifted plateau just north of Boise, Idaho. Boise, along with neighboring Nampa and Caldwell, form the dominant center of the Boise Functional Economic Area (Fox and Kumar, 1965; and U.S. Department of Commerce, 1975). Outside Boise-Nampa-Caldwell are a number of peripheral economies, one of which is the rural Highlands.

Logger-Sawmill Trade in the Highlands

Logging is the largest first-round sawmill input, accounting for $0.43 of every sawmill-revenue dollar in the U.S. input-output model (U.S. Department of Commerce, 1984). In small-area economies the portion is likely even greater. If we could assume that all Highlands communities were of the same order, with respect to logger-sawmill trade, estimation of the important logger-sawmill link would be greatly simplified. Each sawmill would simply be supplied by loggers located in its community. However, in the Highlands, such an assumption is untenable.

Highlands logger-sawmill trade is shown in from-to form in Table 1. Logging employment in 1987 is shown according to sawmills served. Rows designate logger headquarters, columns show sawmill locations. Sawmill employment in 1987 is shown in Table 2.

Data in Tables 1 and 2 were obtained from a survey by the U.S. Forest Service. The data are interesting from a hierarchical trade standpoint. Clearly logger-sawmill trade is not hierarchical. And making hierarchical assumptions would result in inaccurate community economic impact information. To be accurate, multipliers must reflect these intercommunity trade flows. By adding the sawmill employment of Table 2 to the logging employment along the principal diagonal of Table 1, and then dividing columns of Table 1 by sawmill employment, we have an estimate of the first two terms of the intercommunity sawmill multiplier matrix (4), $E_s^* + \lambda I_1 A\{\hat{\lambda}\}^{-1}E_s$. These estimates are shown in Table 3. For example, linked to each job in the Emmett sawmill are an additional .2241 logging jobs at Emmett, .1080 logging jobs at Horseshoe Bend, .0184 at Garden Valley, and so on.

To complete the intercommunity timber economy model we must estimate the remaining elements, $\lambda\{I - I_1\}A\{\hat{\lambda}\}^{-1}E_s$ and $\lambda\{I - A\}^{-1}A^2\{\hat{\lambda}\}^{-1}E_s$, of multiplier matrix (4). Elaboration of these elements requires a consideration of the hierarchical structure of general intercommunity trade.

<u>Sawmill Multipliers Assuming No General Trade Dominance</u>

Absence of trade dominance means an economy with no intercommunity trade. In this section logger-sawmill trade is treated as an exception. Absence of general intercommunity trade means all off-diagonal sub-matrices of (1) are zero, except for the occasional logger-sawmill element. In this case intercommunity sawmill multipliers (4) can be obtained from the logging and sawmill employment data of Tables 1 and 2 and a set of multipliers for individual communities.

Consider community r. Employment linked to logging is given by a logging employment multiplier as follows:

$$(5) \qquad b_{rr_l} = \lambda_r \{ I - A_{rr} \}^{-1} e_{r_l} (\lambda_{r_l})^{-1}$$

where e_{r_l} is a unit vector for community r's logging sector, $(\lambda_{r_l})^{-1}$ is the logging sales-employment ratio, and other terms are as defined earlier.

This leaves employment linked to sawmills, other than the logging and logging linked employment tracked in (5). A community r sawmill multiplier net of logging and logging-linked employment is given as follows:

$$(6) \qquad b^{*}_{rr_s} = 1 + \lambda_r \{ I - A_{rr} \}^{-1} \{ a_{r_s} - e_{r_l} \alpha_{r_{ls}} \} (\lambda_{r_s})^{-1}$$

where a_{r_s} is the sawmill column of community r input-output coefficients, $\alpha_{r_{ls}}$ is the community r, logger-sawmill input-output coefficient, $(\lambda_{r_s})^{-1}$ is the community r sawmill sales-employment ratio, and e_{r_l} is a unit vector for the logging sector. The asterisk (*) indicates that logging and logging linked employment is removed.

Estimating multipliers (5) and (6) requires two items for each community, an estimate of the community input-output coefficient matrix A_{rr}, and an estimate of the vector of employment-sales ratios λ_r. Using national I-O model data and a standard supply-demand-pool method, augmented by a method to allocate county employment data among communities, we estimated I-O coefficients and employment-sales ratios for each of our nine Highlands communities. While this method itself may be worthy of discussion, it is outside the main focus of the paper. We present a brief outline in the Appendix.

Logging and net-of-logging sawmill multipliers for our nine communities, estimated according to expressions (5) and (6), appear in Table 4. Intercommunity sawmill multipliers, assuming no intercommunity trade (except for logger-sawmill) are computed from information in Tables 1, 2 and 4 and appear in Table 5. Second row elements of Table 5 are the total multipliers of Table 5 as a percent of Table 3 logging and sawmill employment only multipliers. The increase therefore reflects sawmill employment links at communities in addition to sawmill and logging employment. These include industries supplying loggers and sawmills, and household consumption linkages.

Intercommunity Sawmill Multipliers with General Trade Dominance

Our general dominance in the Highlands is in the form of two-order trade. A dominant community supplies not only its own needs, but a portion of the needs of some number of communities as well. In our intercommunity model, general inter-order trade appears in matrix (1) as non-zero off-diagonal elements in addition to logger-sawmill trade.

We see three obvious instances of dominance in the Highlands. In the north, McCall dominates neighboring New Meadows. In the south, Emmett dominates Horseshoe Bend and Garden Valley. And finally, on the west side Council dominates neighboring Cambridge and Midvale. Thus, we see the Highlands economy with three subregions and a two-order trading hierarchy. Our judgments on dominance were informed by visits to the region, community proximities and populations, and patterns of newspaper circulation.

The complexity of the mathematical presentation increases with the introduction of trade dominance. Consider a simple two-community subregion, a subregion with one dominant place, which we will denote with subscript d, and one dominated place, which we will denote with subscript h. And let us briefly set aside logger-sawmill trade, and assume trade is "strictly" hierarchical.

The intercommunity input-output coefficients matrix for our two-community subregion is given by:

$$\begin{Bmatrix} A_{dd} & A_{dh} \\ 0 & A_{hh} \end{Bmatrix} \tag{7}$$

where A_{dd} and A_{hh} represent intracommunity trade, and A_{dh} represents intercommunity trade. Intercommunity employment multipliers are given by:

$$(8) \qquad \begin{Bmatrix} B_{dd} & B_{dh} \\ B_{hd} & B_{hh} \end{Bmatrix} = \begin{Bmatrix} \lambda_d & 0 \\ 0 & \lambda_h \end{Bmatrix} \begin{Bmatrix} 1-A_{dd} & -A_{dh} \\ 0 & 1-A_{hh} \end{Bmatrix}^{-1} \begin{Bmatrix} \hat{\lambda}_d & 0 \\ 0 & \hat{\lambda}_h \end{Bmatrix}^{-1}$$

where B_{dd} is a row vector of employment multipliers indicating total employment at community d per unit of exogenous employment in each of community d's industries, and B_{dh} is a row vector of intercommunity employment multipliers, indicating total employment at community d per unit of exogenous employment at community h. Definitions for B_{hd} and B_{hh} reflect the same for community h.

Solving matrix equation (8) yields the following:

$$(9) \qquad B_{dd} = \lambda_d\{1 - A_{dd}\}^{-1}\{\hat{\lambda}_d\}^{-1}$$

$$(10) \qquad B_{dh} = \lambda_d\{1 - A_{dd}\}^{-1}A_{dh}\{1 - A_{hh}\}^{-1}\{\hat{\lambda}_h\}^{-1}$$

$$(11) \qquad B_{dh} = 0$$

$$(12) \qquad B_{hh} = \lambda_h\{1 - A_{hh}\}^{-1}\{\hat{\lambda}_h\}^{-1}$$

With strictly hierarchical trade, there are no linkages from lower to higher-order communities, so higher-order community activity has no multiplier effect on lower-order communities ($B_{dh} = 0$ as in equation (12)). Also, intracommunity multipliers like (9) and (10) appear the same as community multipliers in the no-dominance setting. However, there are multiplier effects on the dominant from the dominated place. As indicated in (10), these are expressed as a relationship between the Leontief inverse matrices of the two places, and intercommunity input-output coefficients matrix, A_{dh} .

We develop a set of intercommunity employment multipliers like (10) for each Highlands subregion, and from these estimate intercommunity sawmill multipliers assuming two-order strictly hierarchical trade. First we must estimate intercommunity input-output coefficients, A_{dh} , for our Highlands subregions.

Estimating Intercommunity I-O Coefficients

Let us start with a two-community subregion, community d and community h. Our supply-demand-pool application provides us with export vectors for these communities which we denote F_d and F_h (see appendix). Lower-order community exports, F_h , leave the region altogether. In contrast, defining its dominance, a portion of community d's exports, F_d , serve some import needs of community h. Our approach is to estimate community d exports in service of community h, and then fashion from these the intercommunity input-output coefficients A_{dh}.

Much as the familiar supply-demand-pool technique begins with an estimate of the region's total demand for commodities, or "regional requirements" (Schaffer and Chu, 1969), we begin with an estimate of community h's total demand for imports. Let N_{dh} be an array of national model input-output coefficients with the same row and column structure as A_{dh} . Let H_{dh} be a matrix with this same row and column structure, but consisting solely of unit and null vectors. For industries present at both communities, columns of H_{dh} contain a 1 in the row of that industry, zeros otherwise. Should there be industries present at community h, but not present at community d, columns of H_{dh} contain all zeros.

Let G_{dh} be a matrix of coefficients indicating the demand for commodities by community h in excess of that satisfied by community h industry. Given its row dimension, G_{dh} tracks only commodities produced at community d. Assuming national technology, an estimate of coefficients matrix G_{dh} is given by:

$$G_{dh} = \{ N_{dh} - H_{dh}A_{hh} \} . \qquad (13)$$

Next let R_{dh} be a column vector indicating the total import demand by community h, of commodities produced at community d. Vector R_{dh} is obtained as follows:

$$R_{dh} = G_{dh}X_h \qquad (14)$$

where X_h is the total gross output vector for community h (see appendix).

Now, in a fashion with obvious parallels to the standard supply-demand-pool technique, form a vector of scalars ρ_{dh} as follows:

$$(15) \qquad \hat{\rho}_{dh_i} = \begin{cases} F_{d_i}/R_{d_i} \ \mathit{if} \ F_{d_i} < R_{d_i} \\ 1.0 \ \mathit{otherwise} \end{cases}$$

where the subscript i refers to the ith industry. Arrayed in a diagonal matrix, scalars (15) are premultiplied by (13) yielding our estimate of the intercommunity input-output coefficients matrix:

$$(16) \qquad A_{dh} = \{ \hat{\rho}_{dh} \} G_{dh}$$

The case of a three-community subregion, with a dominant community d, and two dominated communities, say communities h and k, follows directly from the two-community case. Instead of (15), we now have:

$$(17) \qquad \rho_{d,h+k_i} = \begin{cases} F_{d_i}/(R_{d_i}+R_{k_i}) \ \mathit{if} \ F_{d_i} < (R_{d_i}+R_{k_i}) \\ 1.0 \ \mathit{otherwise} \end{cases}$$

and instead of (16), we now have:

$$(18) \qquad A_{dh} = \{ \hat{\rho}_{d,h+k} \} G_{dh}$$

and

(19) $$A_{dk} = \{ \hat{\rho}_{d,h+k} \} G_{dk}$$

Sawmill Multipliers for a Two-Order Highlands Economy

Multipliers either stay the same or increase with the introduction of dominance. A decrease would be illogical. Dominance brings no change to lower-order community multipliers. With trade otherwise strictly hierarchical, a lower-order community's only link to other communities is logger-sawmill trade.

Things are different with higher-order communities. The designation "higher-order" reflects recognition of a general supply relationship from higher to lower-order communities. And higher-order community multipliers must capture these supply links. Let us return to our two community subregion, communities d and h, and consider intercommunity sawmill multipliers given two-order trade.

With two-order trade we have two multipliers that did not exist in the no dominance case. Multiplier b_{dh_1} indicates employment at community d linked, on account of dominance, to logging at community h. Multiplier b_{dh_1} is isolated from the array of two-order intercommunity employment multipliers (10) and appears as follows:

$$(20) \qquad b_{dh_l} = \lambda_d\{1 - A_{dd}\}^{-1}A_{dh}\{1 - A_{hh}\}^{-1}\{\hat{\lambda}\}^{-1}e_{h_l}$$

where e_{h_l} is a unit vector for the community h logging sector, and other terms are as defined earlier.

Similarly, with dominance a sawmill at community h will have an employment impact on community d independent of logging trade between the two. Let $b^*_{dh_s}$ be a multiplier indicating the employment at community d linked on account of general trade dominance to community h sawmills. The asterisk (*) indicates that logging and logging-linked employment, tracked in (20), is removed. Isolated from the array of two-order intercommunity employment multipliers (10), the sawmill multiplier is given as:

$$(21) \quad b^*_{dh_s} = \lambda_d\{1 - A_{dd}\}^{-1}A_{dh}\{e_{h_s}+\{1 - A_{hh}\}^{-1}\{a_{h_l} - e_{h_l}\alpha_{h_{ls}}\}\}(\lambda_{h_s})^{-1}$$

where e_{h_s} is a unit vector for the community h sawmill sector, a_{h_l} is the column vector of logging sector input-output coefficients for community h, $\alpha_{h_{ls}}$ is the logging-sawmill input-output coefficient for community h, and other terms are as defined earlier.

Multiplier forms (20) and (21) apply as well for three-community subregions. Given our estimates of intercommunity input-output coefficients (16), for the McCall-New Meadows two-community subregion, and (18) and (19), for the Council-

Cambridge-Midvale, and the Emmett-Horseshoe Bend-Garden Valley three-community subregions, and other multiplier elements estimated earlier, we form logging and sawmill net-of-logging multipliers, like (20) and (21), for dominant-dominated community relationships of our two-order Highlands economy. These estimates appear in Table 6.

Multipliers of Table 6 are applied to sawmill and logging employment of Tables 1 and 2 to yield employment linkages on account of dominance. For example, consider the 17.2 Horseshoe Bend loggers, and 2.9 Garden Valley loggers serving the Cascade Sawmill (see Table 1). Multiplying the logging employment by appropriate multipliers of Table 6 provides an estimate of employment at Emmett linked to this logging employment 6.05 [= (.3166)(17.2) + (.2091)(2.9)]. Inasmuch as this logging is in the first instance linked to the sawmill at Cascade, an intercommunity sawmill multiplier, indicating Cascade's impact on Emmett on account of Emmett's trade dominance, is formed by dividing the Emmett employment linked to Horseshoe Bend and Garden Valley logging, which is in turn linked to the Cascade sawmill, by total Cascade sawmill employment, .0630 (=6.05/96). Adding this "attributable-to-dominance" multiplier component to our "no-dominance" Emmett-Cascade multiplier, from Table 5, yields our intercommunity multiplier estimate assuming two-order trade, .8540 (=.7910 + .0630). This multiplier, along with similarly estimated multipliers for other intercommunity relationships with dominance appears in Table 7.

Second row elements show the with-dominance multiplier as a percent of the no-dominance multiplier.

The Emmett-Cascade multiplier is not necessarily typical. There are cases where sawmills as well as loggers increase the multipliers with dominance. The McCall-New Meadows, Council-Midvale, and Emmett-Horseshoe Bend multipliers are examples of this. And in the case of the Emmett-Emmett, and Council-Council multipliers, we have an entirely different source of with-dominance multiplier change. As indicated in Table 1, loggers at Horseshoe Bend and Garden Valley serve the Emmett Sawmill, and it is on account of these loggers, and Emmett's dominance of Horseshoe Bend and Garden Valley, that the Emmett-Emmett multiplier changes (increases 2.1% as indicated in Table 7). But the multiplier increases this time because of a feedback linkage (Miller, 1966). Through logging links, the sawmill at Emmett generates general employment effects at Horseshoe Bend and Garden Valley. But because Emmett dominates Horseshoe Bend and Garden Valley, these employment effects feed back to Emmett. A similar chain of linkages account for the increase in the Council-Council with-dominance multiplier. The McCall-McCall multiplier remains unchanged because the McCall sawmill is served strictly by McCall loggers.

Concluding Comments

While our empirical analysis involves a rural timber economy, and the relationship there between loggers and sawmills, much of our work has implications beyond this specific setting.

Of course, the theoretical blending of central place theory and input-output analysis stands on its own. But the empirical approach, of assuming hierarchical trade unless otherwise indicated, and of focusing on dominant regional industries, could have broad application elsewhere.

Like Lösch (1938), we suspect that real economic regions differ more from each other than they do from the central place ideal. By starting with the ideal, and identifying those features that deviate from it, a region's form and character can be identified and captured in the economic model.

Two-order strictly hierarchical trade, except for logger-sawmill trade, characterizes the simple rural economy of the Highlands. Elsewhere we might expect more systematic divergence from strictly hierarchical trade. For example, we could find regions where the outputs of agricultural industries, or other extractive industries, systematically flow up the hierarchy, in some stepped pattern of processing and reprocessing. And most certainly we could find economies with greater than two-order trade. The possible variations probably defy general theorizing.

Our simple hybrid Highlands model has introduced the central place, input-output blend, and it has served to indicate an empirical application of this blend in the form of an intercommunity input-output model. The direction of further research would seem to be in the direction of modeling hierarchically more complex economies. Given the difficulties exhibited in our simple two-order Highlands model, however, movement in the direction of more complexity would seem clearly to require further development of cost-cutting techniques as well.

APPENDIX

A Method for Constructing Community Input-Output Models

Following standard practice (e.g., Miller and Blair, p. 171), we form "industry-by-industry" national input-output coefficients, with industry-based technology, as the product of the normalized Make and Use matrices of the 1977 national input-output model (U.S. Department of Commerce, 1984). We construct a vector of corresponding national employment-sales ratios from national model total gross outputs, and national employment (Yuskavage, 1985).

County employment data for sectors other than agriculture are from 1984 County Business Patterns 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 then updated to 1987 by controlling to Idaho Job Service estimates published at roughly the two-digit SIC level (1988). Wage and salary agricultural employment is from U.S. Department of Commerce, Bureau of Economic Analysis, (1989).

We allocate county employment to communities with the information from yellow page listings of local telephone directories. A file is created indicating the number of listings in each sector at each community. County employment is then distributed to communities proportional to the number of yellow page listings at communities. Agricultural employment in the Highlands is located outside communities, at dispersed and isolated homesteads and farm settlements. This employment is assigned to communities according to the location of agricultural input suppliers, and where agricultural workers and proprietors obtain local consumer goods. Assuming these are determined solely on the basis of some index of centrality, and letting the total of all other community employment serve as a surrogate for this index, agricultural employment is allocated to communities simply on the basis of total non-agricultural employment at communities.

For each community r, we form a set of national model input-output coefficients, N_{rr}, reflecting only industries present at community r plus a household sector. The household column is obtained from normalized national model personal consumption expenditures. For the household row, we want coefficients that generate income available for consumer spending by community r residents. We assume all corporate profit leaves the community, and all wage and salary, and proprietary and rental income stays. Coefficients derived from the national model indicating these latter income types are scaled downward by the ratio of "Personal Consumption Expenditures" to "National Income" (U.S. Department of Commerce, Bureau of Economic Analysis, 1978).

A vector, X_r , of community r total gross outputs is formed as the product of national model sales-employment ratios and community r employment. The household row of X_r indicates total community r household income available for consumer spending and is computed as the dot product of X_r and the household row of matrix N_{rr}.

Let Y_r be a vector of non-household community r final demand, equal to government and investment purchases. Community r's share of national model state and local government purchases, and federal non-defense purchases, are presumed to be proportional to community r's share of national state and local government employment, and federal government employment (U.S. Department of Commerce, Bureau of the Census, 1979, and Yuskavage, 1985). Community r's share of national model investment spending is assumed to be proportional to community r's share of total national employment.

Let A_{rr} be a matrix of community r input-output coefficients. These are estimated according to a standard supply-demand-pool technique (Schaffer and Chu, 1969). Let R_r be a vector of gross requirements for community r computed as follows:

(A1) $$R_r = N_{rr}X_r + Y_r$$

From requirements (A1), supply-demand-pools scalars γ_{r_i} are formed:

(A2) $$\gamma_{r_i} = \begin{cases} X_{r_i}/R_{r_i} \ \mathit{if}\ R_{r_i} > X_{r_i} \\ 1.0 \ \mathit{otherwise} \end{cases}$$

Forming scalars (A2) into a diagonal matrix $\{\hat{\gamma}_r\}$, provides:

(A3) $$A_{rr} = \{\hat{\gamma}_r\}N_{rr}$$

Community r, industry i exports, F_{r_i}, are given as:

$$F_{r_i} = \begin{cases} X_{r_i} - R_{r_i} \text{ if } X_{r_i} > R_{r_i} \\ 0 \text{ otherwise} \end{cases} \tag{A4}$$

And finally, our community r, supply-demand-pool input-output model appears as follows:

$$X_r = A_{rr}X_r + \{\hat{\gamma}_r\}Y_r + F_r \tag{A5}$$

Table 1: Highlands Logging Employment by Sawmill and Community in 1987

Sawmills	Emmett	Horseshoe Bend	Council	Midvale	McCall	New Meadows	Cascade
Logging HQs							
Emmett	39.0	26.9	1.9	0.0	0.0	10.8	45.3
Hshoe Bend	18.8	19.8	0.1	0.0	0.0	0.0	17.2
Garden Val	3.2	2.4	0.0	0.0	0.0	0.0	2.9
Council	26.8	11.7	58.5	0.0	0.0	2.4	12.4
Cambridge	1.6	0.2	9.3	0.0	0.0	0.3	13.8
Midvale	0.0	0.0	0.3	3.5	0.0	0.0	0.0
McCall	13.8	8.2	6.1	0.0	1.4	35.2	35.0
New Meadows	6.9	2.7	5.1	0.0	0.0	43.4	14.8
Cascade	9.0	10.2	5.1	0.0	0.0	0.0	12.9

Source: Payette National Forest, Supervisor's Office, McCall, Idaho 83638

Table 2: Highlands Logging Employment by Community in 1987

Emmett	174.0
Horseshoe Bend	106.0
Council	68.0
Midvale	8.5
McCall	4.6
New Meadows	80.0
Cascade	96.0

Source: Payette National Forest, Supervisor's Office, McCall, Idaho 83638

Table 3: Intercommunity Sawmill Multipliers Indicating only Sawmill & Logging Employment

Sawmills	Emmett	Horseshoe Bend	Council	Midvale	McCall	New Meadows	Cascade
Emmett	1.2241	0.2538	0.0279	0.0000	0.0000	0.1350	0.4719
Hshoe Bend	0.1080	1.1868	0.0015	0.0000	0.0000	0.0000	0.1792
Garden Val	0.0184	0.0226	0.0000	0.0000	0.0000	0.0000	0.0302
Council	0.1540	0.1104	1.8603	0.0000	0.0000	0.0300	0.1292
Cambridge	0.0092	0.0019	0.1368	0.0000	0.0000	0.0038	0.1438
Midvale	0.0000	0.0000	0.0044	1.4118	0.0000	0.0000	0.0000
McCall	0.0793	0.0774	0.0897	0.0000	1.3043	0.4400	0.3646
N Meadows	0.0397	0.0255	0.0750	0.0000	0.0000	1.5425	0.1542
Cascade	0.0517	0.0962	0.0750	0.0000	0.0000	0.0000	1.1344
Total	1.6845	1.7745	2.2706	1.4118	1.3043	2.1512	2.6073

Table 4: Single Community logging & Sawmill Employment Multipliers

	Logging	Sawmill[a]
Emmett	1.6762	1.4349
Hshoe Bend	1.1536	1.1014
Garden Val	1.2697	
Council	1.4513	1.2839
Cambridge	1.3909	
Midvale	1.1417	1.0971
McCall	1.6504	1.4068
N Meadows	1.3426	1.2165
Cascade	1.5755	1.3872

[a] The multipliers are net of all logging and logging-linked employment.

Table 5: Intercommunity Sawmill Employment Multipliers
Assuming No General Trade Dominance

Sawmills	Emmett	Horseshoe Bend	Council	Midvale	McCall	New Meadows	Cascade
Emmett	1.8106	0.4254	0.0468	0.0000	0.0000	0.2263	0.7910
	147.91	167.62	167.62	na	na	167.62	167.62
Hshoe Bend	0.1246	1.3168	0.0017	0.0000	0.0000	0.0000	0.2067
	115.36	110.96	115.36	na	na	na	115.36
Garden Val	0.0234	0.0287	0.0000	0.0000	0.0000	0.0000	0.0384
	126.97	126.97	na	na	na	na	126.97
Council	0.2235	0.1602	2.5325	0.0000	0.0000	0.0435	0.1875
	145.13	145.13	136.13	na	na	145.13	145.13
Cambridge	0.0128	0.0026	0.1902	0.0000	0.0000	0.0052	0.1999
	139.09	139.09	139.09	na	na	139.09	139.09
Midvale	0.0000	0.0000	0.0050	1.5672	0.0000	0.0000	0.0000
	na	na	114.17	111.01	na	na	na
McCall	0.1309	0.1277	0.1481	0.0000	1.9091	0.7262	0.6017
	165.04	165.04	165.04	na	146.36	165.04	165.04
N Meadows	0.0532	0.0342	0.1007	0.0000	0.0000	1.9448	0.2070
	134.26	134.26	134.26	na	na	126.08	134.26
Cascade	0.0815	0.1516	0.1182	0.0000	0.0000	0.0000	1.5989
	157.55	157.55	157.55	na	na	na	140.95
Total	2.4606	2.2473	3.1432	1.5672	1.9091	2.9461	3.8310
	146.07	126.64	138.43	111.01	146.36	136.95	146.94

Table 6: Intercommunity Multiplier Components Due to the Addition of Dominance

Logging HQ / Dominant Community	Logging: Horseshoe Bend	Garden Valley	Cambridge	Midvale	New Meadows
Emmett	0.3166	0.2091			
Council			0.0439	0.0601	
McCall					0.1638

Logging HQ / Dominant Community	Sawmill: Horseshoe Bend	Midvale	New Meadows
Emmett	0.1740		
Council		0.0352	
McCall			0.1006

Table 7: Intercommunity Sawmill Employment Multipliers
Assuming Two-Order Trade Dominance

Sawmills	Emmett	Horseshoe Bend	Council	Midvale	McCall	New Meadows	Cascade
Emmett	1.8487	0.6633	0.0473	0.0000	0.0000	0.2263	0.8540
	102.10	155.92	100.99	na	na	100.00	107.97
Hshoe Bend	0.1246	1.3168	0.0017	0.0000	0.0000	0.0000	0.2067
	100.00	100.00	100.00	na	na	na	100.00
Garden Val	0.0234	0.0287	0.0000	0.0000	0.0000	0.0000	0.0384
	100.00	100.00	na	na	na	na	100.00
Council	0.2239	0.1603	2.5387	0.0600	0.0000	0.0437	0.1938
	100.18	100.05	100.25	na	na	100.38	103.37
Cambridge	0.0128	0.0026	0.1902	0.0000	0.0000	0.0052	0.1999
	100.00	100.00	100.00	na	na	100.00	100.00
Midvale	0.0000	0.0000	0.0050	1.5672	0.0000	0.0000	0.0000
	na	na	100.00	100.00	na	na	na
McCall	0.1374	0.1318	0.1603	0.0000	1.9091	0.9156	0.6270
	104.96	103.27	108.30	na	100.00	126.09	104.20
N Meadows	0.0532	0.0342	0.1007	0.0000	0.0000	1.9448	0.2070
	100.00	100.00	100.00	na	na	100.00	100.00
Cascade	0.0815	0.1516	0.1182	0.0000	0.0000	0.0000	1.5989
	100.00	100.00	100.00	na	na	na	100.00
Total	2.5055	2.4894	3.1622	1.6272	1.9091	3.1357	3.9256
	101.83	110.77	100.61	103.83	100.00	106.44	102.47

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