

The Conceptual Derivation of the Nonsurvey Regional Input-Output Model

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I. Introduction

The qualitative growth of nations requires the balanced economic growth among regions. Concern for the economic growth at the regional level demands a great deal of information on the structural interdependence of the regional economy under consideration. The regional input-output (I-O) analytical system serves as an extensive response to this need (Richardson [18]).¹⁾ The construction cost of a survey-based regional I-O

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1) The I-O analysis is a method of arranging economic information at the sectoral level on the basis of the linkage between the microeconomics of the firm and the macroeconomics of the economy. All I-O models consist of three parts, a transactions table, a technical coefficients matrix and an interdependence coefficients matrix. The transactions table is the base of an I-O model from which the technical and interdependence coefficients are derived. For details on the theoretical framework of the I-O analysis, see Miernyk [12] and Yan [22].

model in both temporal and monetary terms is enormous. For this reason, increasing attention has been paid in recent years to establishing representative regional I-O models through nonsurvey methods.²⁾ Recently, a nonsurvey I-O model was derived for the coal mining region in the State of Ohio from the U.S. national I-O model by using the supply-demand pool technique (Ro [19]).³⁾ This paper presents the conceptual outline of this empirical nonsurvey regional I-O model with the purpose of providing an example to regional economists who are willing to construct regional I-O models in an inexpensive way.

This paper is organized into five sections. Section II presents the hypothetical regional I-O model to be constructed. Since the national economy is larger than the regional economy, the national I-O model is reduced to reflect the size and structure of the regional economy. Section III describes this reduction procedure. Section IV explains how to estimate the regional I-O model from this reduced national I-O model. Finally, section V provides a brief discussion on the analytical merit of the regional I-O model as concluding remarks.

II. The Hypothetical Regional Input-Output model

The first step in the construction of a nonsurvey regional I-O model is to appropriately identify economic sectors within the region under

2) Even there have been efforts to produce regional, industry-specific multipliers with less-demanding data requirements than those of the nonsurvey I-O analysis; for example, see Davis [5] and Drake [4].

3) To date, a considerable number of attempts have been made to develop nonsurvey techniques of obtaining regional I-O models from national models. Schaffer, et al. [20] outlined the most salient nonsurvey techniques such as the location quotient technique and its modification, the pool technique and its modification and the iterative procedure, and on the basis of their comparison went on to conclude that the simple location quotient and supply-demand pool techniques provide better regional estimates than others do. The use of the simple location quotient requires balancing corrections, while the supply-demand pool approach needs no balancing corrections. For details on this, see Ro [19].

consideration. In order to use the national I-O information in the construction of regional I-O models industries reported for the region are assumed to be grouped into n endogenous (processing) sectors according to the following two categories: (1) industries producing similar and closely related products, and (2) the conformity with the level of aggregation used in preparing the national I-O model.

In addition to the n endogenous sectors, the regional economy under consideration is assumed to include two sets of exogenous sectors: two primary input sectors and three final demand sectors.⁴⁾ The primary input sectors are "Value Added" and "Import" sectors.⁵⁾ Entries for these sectors are mainly wages and imports respectively. Included in the final demand sectors are "Household Consumption", "Government Consumption" and "Export" sectors.⁶⁾ Private purchases are the elements of the household consumption vector. The government consumption includes purchases by the regional government and all other final consumptions than exports. Exports are defined as residuals.

The transactions table of the above hypothetical regional economy is outlined in Table 1. In this transactions table, regional outputs (X_i) and regional final consumptions (X_h and X_g) are assumed to be known. Variables to be estimated are then regional transactions (x_{ij}), export (E_i), household consumptions (H_i), government consumptions (G_i), imports (M_j) and value added (V_j).

The second step is to reduce the national transactions to reflect the

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- 4) The number of primary input and final demand sectors is not restricted by the theory, but the convention. Most small scale I-O models include two or three primary input and final demand sectors; for example see Hushak, et al. [6] and Ro [19].
 - 5) The primary inputs include payments to households in the form of wages, salaries, rental income, interest income and profits; payments to government; imports of goods and services; inventory depletion; and capital consumption or depreciation.
 - 6) The final demands include household purchases, exports, government purchases, gross inventory accumulation and gross private capital formation. The final demand sectors are the autonomous sectors which determine the level of output of an economy.

Table 1. Simplified Regional Transactions Table

<div>Inputs</div> <div>Outputs</div>			Purchasing Sectors					Total	
			Processing Sectors			Consumption Sectors		Export Sector	Gross Outputs
			1	2	3 n	Household	Government		
Producing sectors	Processing sectors	1	x_{11}	x_{12}	$x_{13} \cdots x_{1n}$	H_1	G_1	E_1	X_1
		2	x_{21}	x_{22}	$x_{23} \cdots x_{2n}$	H_2	G_2	E_2	X_2
		3	x_{31}	x_{32}	$x_{33} \cdots x_{3n}$	H_3	G_3	E_3	X_3
		\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\vdots
		n	x_{n1}	x_{n2}	$x_{n3} \cdots x_{nn}$	H_n	G_n	E_n	X_n
	Value Added sector		V_1	V_2	$V_3 \cdots V_n$	D_{vh}	D_{vg}		
	Import sector		M_1	M_2	$M_3 \cdots M_n$	D_{mh}	D_{mg}		
Total Gross Inputs			X_1	X_2	$X_3 \cdots X_n$	X_h	X_g		

size and structure of the regional economy. The final step is then, given this reduced national table and given estimates of regional outputs (X_i) and regional final consumptions (X_h and X_g), to estimate regional transactions (x_{ij}), exports (E_i), imports (M_j) and value added (V_j). Or, given the national I-O system

$$X_i^* = \sum_j^n a_{ij}^* X_j^* + H_i^* + G_i^* + E_i^* \quad (1)$$

plus regional outputs and regional final consumptions, the task is to estimate values in the regional system

$$X_i = \sum_j^n a_{ij} X_j + H_i + G_i + E_i, \quad (2)$$

where a_{ij}^* and a_{ij} are the $n \times n$ technical coefficients ($a_{ij}^* = x_{ij}^*/X_j^*$, $a_{ij} = x_{ij}/X_j$) in the nation and region respectively, X_i^* ($X_i^* = X_j^*$, $\forall i=j$) and X_i ($X_i = X_j$, $\forall i=j$) are the i^{th} sector's outputs, H_i^* and H_i are household consumptions, G_i^* and G_i are government consumptions, and E_i^* and E_i are exports.

The total transactions of a regional economy consist of two components: purchases and sales among all economic sectors within the region, and purchases and sales with economic sectors outside the region. Purchases from outside the region are the imported input needs, but they are not a part of the interdependence of a regional economy. In order to express the pure

structural interdependence of a regional economy, all imports must be excluded from the regional transactions. The adjustment of these regional imports is all about the derivation of nonsurvey regional I-O models directly from national I-O models.

Regional imports consist of competitive and noncompetitive components. The competitive components are the regional goods and services imported from outside the region due to the region's insufficient production capacity, while the noncompetitive components are goods and services not produced in the region but used by the producing sectors within the region. The noncompetitive components of regional imports are adjusted automatically when the national I-O model is reduced to reflect the size and structure of the region's economy. The competitive components are adjusted through applying the supply-demand pool technique to this reduced national model.

III. The Reduced Matrix of National Technical Coefficients

1. National Technical Coefficients and Regional Weights

The major problem in deriving the regional technical coefficients from national ones is the problem of product and industry mix (Miernyk [12], Richardson [17]). This problem is attributable to the possible difference between regional and national production functions and between regional and national industrial compositions. The difference in the production functions, according to Boisvert [1], can possibly be corrected by using highly disaggregated national coefficients,⁷⁾ because the input structure in industries at the higher level of disaggregation is more similar throughout the nation than at the lower level of disaggregation (see also Miernyk

7) The national I-O model is constructed at several different levels of sectoral disaggregation. For example, the 1972 U.S. national I-O model is at four different levels of disaggregation; 85, 97, 365 and 496 sector levels of disaggregation. For more on this, see Ro [19].

[12]). That is, at the higher level of sectoral disaggregation the national coefficients reflect more reliable regional coefficients.

The difference in the industrial composition between regional and national economies, on the other hand, can be partially corrected by making an adjustment on the national technical coefficients with regional weights representing the importance of individual sectors in the region. The use of some measure of gross output is considered to be ideal in this weighting scheme, but no figures on regional gross output at the relatively high level of disaggregation are available in practice (Shen [21], Boisvert, et al. [2]). The next best alternative used in the literature is value added; for instance, see Shen [21] and Boisvert [1]. However, the value added figures at the relatively high level of disaggregation are also not available for most regions, and in this case the weighting scheme often relies exclusively on disaggregated employment data (Boisvert, et al. [2]). The present paper uses the regional employment figures as regional weights in computing the regional technical coefficients from the national ones.

2. The Reduced National Technical Coefficients Matrix

In order to obtain the regional technical coefficients, the m sector matrix of the national technical coefficients is reduced in two steps to include only n endogenous sectors identified in the region, where $m > n$. First, sectors in the national model with zero production in the region are excluded. Then the remaining sectors are aggregated to a total number of n endogenous sectors for the region.

Of the m endogenous sectors of the national economy, k sectors are assumed to have zero production in the region. The inputs from these k sectors are the noncompetitive imports to the region. Those inputs are not produced in the region, but are employed by the remaining $m-k$ sectors which produce in the region. In order to reflect the pure regional

economy these noncompetitive imports must be excluded from the regional transactions. To do so, the technical coefficients of the k sectors of the national economy with zero production in the region are not used in computing the elements of the reduced national technical coefficients matrix, but allocated directly to the regional imports.

The national technical coefficients for the reduced number of n endogenous sectors are estimated by aggregating the original national technical coefficients for the remaining $m-k$ endogenous sectors producing in the region. The aggregation follows the conventional two steps; aggregations by row and column (Boisvert, et al. [2]). The technical coefficients for a number of individual sectors in the $m \times m$ original national matrix (a_{gq}^*) are aggregated by row.

$$a_{iq}^* = \sum_g^{\sigma} a_{gq}^*, \quad (3)$$

where σ stands for an arbitrary number. This is a simple aggregation of a number of rows into one row (or a simple aggregation of a number of elements in a column into one element) of the original national technical coefficients matrix. The consequence of the aggregation by row is a new non-square matrix $(n \times (m-k))$ of the national technical coefficients.

The aggregation by column is little more complicated than the aggregation by row. In order to correct the possible difference between regional and national industrial composition, the national technical coefficients aggregated by row (a_{iq}^*) are weighted by the regional disaggregated employment figures at the m sector level (U_q) , and then aggregated into a single element of the reduced national technical coefficients matrix (a_{ij}^*) .

$$a_{ij}^* = \sum_q^{\sigma} a_{iq}^* (U_q / \sum_q^{\sigma} U_q), \quad (4)$$

where σ stands for an arbitrary number. This aggregation generates the $n \times n$ reduced matrix of the national technical coefficients.

The aggregation by column weights the national technical coefficients aggregated by row according to the disaggregated industry's importance in the region. The industry's importance is measured by the proportion of employment among all original disaggregated sectors comprising any single aggregated sector in the reduced national technical coefficients matrix. The reduced matrix of the national technical coefficients, therefore, reflects the difference between regional and national industrial composition when it is used in computing the regional technical coefficients matrix (Boisvert, et al. [2]).

As pointed out in the preceding discussions, when the national disaggregated sector is not producing in the region, its technical coefficient is not used in computing the technical coefficients of the reduced national matrix, but allocated directly to the regional imports. This procedure resolves only the problem of the noncompetitive components of the regional imports. The competitive components of the regional imports must still be determined and excluded from the regional transactions. The competitive components are the goods and services imported from outside the region due to the region's insufficient production capacity. The adjustment of these competitive imports can be accomplished through the application of the supply-demand pool technique to the reduced matrix of the national technical coefficients.

IV. The Nonsurvey Regional Input-Output Model

The supply-demand pool technique is a method of generating the regional transactions table from the national transactions table on the basis of the commodity balance of the regional economy.⁸⁾ This approach

8) The regional outputs (X_i), if not available directly from the published data, can be computed on the basis of the regional employments (U_i) and national sectoral average productivities of labor as the national outputs (X_i^*) divided by the national

begins by finding the initial estimates of regional transactions (\hat{x}_{ij}), household consumptions (\hat{H}_i) and government consumptions (\hat{G}_i). The regional transactions are estimated as

$$\hat{x}_{ij} = a_{ij}^* X_j, \quad (5)$$

where a_{ij}^* and X_j stand for the national technical coefficients and the regional outputs respectively.⁸⁾ The value of \hat{x}_{ij} represents that the i^{th} sector's output that the j^{th} sector needs as inputs, or the input requirement of sector j from sector i . Consequently, $\sum_j^n \hat{x}_{ij}$ represents the region's total input requirements from the i^{th} sector.

The regional household consumptions are estimated as the region's share of the nation's household consumption vectors.

$$\hat{H}_i = H_i^* (X_h / X_h^*), \quad (6)$$

where X_h and X_h^* stand for the total household consumption in the region and nation respectively, and H_i^* represents the national household consumption of individual sector's outputs.⁹⁾ The regional government consumptions are estimated in a similar way.

$$\hat{G}_i = G_i^* (X_g / X_g^*), \quad (7)$$

where G_i^* is the national government consumption of the i^{th} sector's outputs and X_g^* and X_g are the total government consumptions in the nation and region respectively.¹⁰⁾ Naturally, the sum of the estimated

employments (U_i^*).

$$X_i = U_i (X_i^* / U_i^*).$$

This procedure was suggested by Mustafa [15]. Equation (5) provides more precise estimates of sectoral outputs of the regional economy if it is applied to highly disaggregated information on output and employment.

- 9) Information on the regional total consumption demand is hardly available from the published data. The regional total consumption demand is the regional total final demand with the export demand excluded. This includes household and government consumptions. The regional total household consumption (X_h) can be estimated as the national total household consumption (X_h^*) multiplied by the ratio of regional total to national total per household income (Y_h / Y_h^*).

$$X_h = X_h^* (Y_h / Y_h^*),$$

where Y_h and Y_h^* stand for the total per household income in the region and nation respectively.

- 10) The regional total government consumption (X_g), if not available from the published data, can be estimated in a similar way by applying the ratio of regional total to

household and government consumptions ($\hat{H}_i + \hat{G}_i$) represents the region's total consumption requirements from the i^{th} sector.

The sum of these estimated regional total input and consumption requirements defines the estimated regional total output requirements (\hat{X}_i).

$$\hat{X}_i = \sum_j \hat{x}_{ij} + \hat{H}_i + \hat{G}_i. \quad (8)$$

The value of \hat{X}_i represents the amount of output required for the region's self-sufficiency in the i^{th} sector.

Then the commodity balance of an individual sector (b_i) is the output realized in the region (X_i) less the regional total output requirements (\hat{X}_i).¹¹⁾

$$b_i = X_i - \hat{X}_i. \quad (9)$$

The value of b_i is either positive, zero, or negative. If b_i is positive or zero, imports (m_{ij} , m_{ih} and m_{ig}) are assumed to be zero, the regional technical coefficients (a_{ij}) are set equal to the national technical coefficients (a_{ij}^*), exports (E_i) are set equal to the commodity balances (b_i), and final consumptions (H_i and G_i) are set equal to the estimated final consumptions (\hat{H}_i and \hat{G}_i).

$$a_{ij} = a_{ij}^*, \quad (10)$$

$$x_{ij} = \hat{x}_{ij}^{12)}, \quad (11)$$

$$H_i = \hat{H}_i; G_i = \hat{G}_i, \quad (12)$$

$$m_{ij} = 0; m_{ih} = 0; m_{ig} = 0, \quad (13)$$

$$E_i = b_i. \quad (14)$$

When b_i is negative, exports (E_i) are set at zero, and the regional technical coefficients (a_{ij}), transactions (x_{ij}), final consumptions (H_i and G_i) and imports (m_{ij} , m_{ih} , m_{ig}) are computed as follows.

$$a_{ij} = a_{ij}^* (X_i / \hat{X}_i), \quad (15)$$

national total outputs (X_i / X_i^*) to the national total government consumption (X_g^*).

$$X_g = X_g^* (X_i / X_i^*),$$

where X_i and X_i^* represent total outputs in the region and nation respectively.

11) The concept of commodity balances was developed by Isard [8].

12) $x_{ij} = \hat{x}_{ij}$ since $x_{ij} = a_{ij} X_j$ and $\hat{x}_{ij} = a_{ij}^* X_j$, and since $a_{ij} = a_{ij}^*$.

$$x_{ij}=a_{ij}X_j^{13)}, \quad (16)$$

$$H_i=\hat{H}_i(X_i/\hat{X}_i); \quad G_i=\hat{G}_i(X_i/\hat{X}_i), \quad (17)$$

$$m_{ij}=\hat{x}_{ij}-x_{ij}; \quad m_{ih}=\hat{H}_i-H_i; \quad m_{ig}=\hat{G}_i-G_i, \quad (18)$$

$$E_i=0. \quad (19)$$

The regional imports (M_j , D_{mh} and D_{mg} for the processing, household consumption and government consumption sectors respectively) are computed as the sum of the respective noncompetitive imports (α_j , α_h and α_g) and competitive imports (m_{ij} , m_{ih} and m_{ig}); i.e., $M_j=\alpha_j+\sum_i^n m_{ij}$, $D_{mh}=\alpha_h+\sum_i^n m_{ih}$ and $D_{mg}=\alpha_g+\sum_i^n m_{ig}$. The regional value added (V_j) is then defined as residual; i.e., $V_j=X_j-\sum_i^n x_{ij}-M_j$. Resulted is the complete regional I-O transactions table estimated from the national transactions table.

V. Concluding Remarks

The fundamental assumption behind I-O models is a set of constant fixed coefficient production functions (Richardson [17]). This assumption makes I-O models simpler, but somewhat unrealistic in the sense that the linearity assumption in reality is violated by changes in product prices, input substitutions and technological changes. A linear production function is a first approximation of a nonlinear production function and the question of whether or not the errors caused by first approximation are small enough to be ignored is a matter of empirical resolution. Chenery, et al. [3] concluded on the basis of their empirical work that the assumption of linear production function is not unreasonable in the real world (see also Miernyk [12] and Richardson [17]).

The I-O analytical system is useful as a consistent forecasting tool. Consistent forecasting refers to the projection of a transactions table.¹⁴⁾

13) Or, $x_{ij}=\hat{x}_{ij}(X_i/\hat{X}_i)$ since $\hat{x}_{ij}=a_{ij}*X_j$ and since $a_{ij}X_j=a_{ij}*(X_i/\hat{X}_i)X_j$.

14) When an I-O transactions table is projected, the output of each industry is consistent with the demands, both final and from other industries, for its products. There is no guarantee, of course, that a consistent forecast will turn out to be right. What

Consistent forecasting provides an important guide to policy-makers. For example, consistent forecasts are basic to sensitivity analysis, and they can be used in making feasibility tests. The objective of a sensitivity analysis is to determine those elements or components of the economy which are more sensitive than others to alternative patterns of growth. Consistent forecasts are also useful in projecting income, employment and even population (for example, see Pullen [16] for the projection of employment and Huszar [7] for the projection of population).

One of the major problems involved in consistent forecasting is the stability problem of the I-O coefficients. For short term forecasts, it is fairly safe to assume that the I-O coefficients will not change significantly in the sense that the rate of technological change is slow enough for the I-O coefficients of one year to be assumed to hold in the years before and after (Miernyk [13]). In making long-projections, one cannot assume that the I-O coefficients will remain constant. For such projections, it is necessary to use a dynamic model. Increasing attempts have been made in the recent literature to develop dynamic I-O models (for example, see Liew [11] and Leontief [9]).

The I-O analytical system is useful for more than analyzing the structural interdependence of the economy. If I-O tables are available for two or more regions, for example, they can be used for making a detailed comparative analysis of the regional economies involved. The comparative analysis could be used by regional policy-makers to help determine the types of investment which would do most to stimulate growth.

The I-O analytical system is preferable to other growth models in studying regional growth.¹⁵⁾ The system facilitates the impact analysis at

the consistent forecast does is to insure that projections for individual sectors will add up a total projection.

15) The five most popular models of regional growth are economic base models, regional

the micro level by providing various kinds of sectoral impact coefficients (multipliers). That is, the system enables the examination of the impact of a particular sector of interest on the rest of the regional economy. This analytical merit makes the regional I-O analysis to be expanded to estimate the economic impact of public policies. Given the best available estimates of the associated changes in current levels of sectoral outputs, for example, regional economic impacts of environmental regulations can be estimated and evaluated through regional I-O models (for example, see Ro [19]). Other regional growth models do not provide sectoral multipliers, but only aggregate average multipliers.¹⁶⁾

Another preferable feature of the I-O analysis over other growth models is that its empirical implementation at the regional level is relatively more free from data restrictions. Economic and social data at the regional level are generally very poor in detail and statistical reliability, and even rarely published (Morrison, et al. [14]). Other regional growth models strictly require a set of primary data, while the regional I-O analysis can be reasonably implemented through the adaptation of the national I-O model to a regional economy. The adaptation of the national I-O model is also consistent with reducing the high cost of data gathering and processing in the estimation of the regional I-O model.

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input-output models, regional econometric models, shift-share models, and gravity models. These models are well explained in Richardson [18].

- 16) For details on the limitations of regional growth models, see Richardson [18].

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