4-1-1998

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DOI: 10.25148/etd.FI13101572

Recommended Citation

Alexandre, Pierre Kebreau, "On the accuracy of nonsurvey regional input-output multipliers : An empirical study" (1998). *FIU Electronic Theses and Dissertations*. 1090.
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FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

ON THE ACCURACY
OF NONSURVEY REGIONAL INPUT-OUTPUT MULTIPLIERS:
AN EMPIRICAL STUDY

A dissertation submitted in partial satisfaction of the
requirements for the degree of
DOCTOR OF PHILOSOPHY
IN
ECONOMICS
by

Pierre Kébreau Alexandre

1998

To: Dean Arthur W. Herriott
College of Arts and Sciences

This dissertation, written by Pierre Kébreau Alexandre, and entitled ON THE ACCURACY OF NON-SURVEY REGIONAL INPUT-OUTPUT MULTIPLIERS: AN EMPIRICAL STUDY, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

Ali Cem Karayalcin

Hassan Arvin-Rad

Maria Willumsen, Major Professor

Date of Defense: April 1, 1998

The dissertation of Pierre Kébreau Alexandre is approved.

Dean Arthur W. Heriott
College of Arts and Sciences

Dr. Richard L. Campbell
Dean of Graduate Studies

Florida International University, 1998

I dedicate this dissertation to:

My Late Father;

Léonette, Kemlie, and Kessie Alexandre, my family;

Thérèse, Lucner, Gertrand, Bernadette, and Monfort Alexandre, my parents;

All the residents of my small hometown, Gros-Morne-Gonaives, Haiti.

ACKNOWLEDGMENTS

I would like to express my thanks to the members of my committee for their helpful comments. Special thanks to my major professor, Dr. Maria Willumsen. I am indebted to Dr. Ali Cem Karayalcin, and Dr. Jorge Salazar-Carillo for their support, and encouragement.

Special thanks must go to Mrs. Marie M. Guillaume for typing many parts of this project, Félix Desnor, Jean-Robert Gayetan, Giyas Gökkent, Noel Gray, Joseph Yvard, Evan Krouse, Etzer Févrin, and Jodelle Dérisca for their general counsel.

ABSTRACT OF THE DISSERTATION

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Correct specification of the simple location quotients in regionalizing the national direct requirements table is essential to the accuracy of regional input-output multipliers. The purpose of this research is to examine the relative accuracy of these multipliers when earnings, employment, number of establishments, and payroll data specify the simple location quotients.

For each specification type, I derive a column of total output multipliers and a column of total income multipliers. These multipliers are based on the 1987 benchmark input-output accounts of the U.S. economy and 1988-1992 state of Florida data.

Error sign tests, and Standardized Mean Absolute Deviation (SMAD) statistics indicate that the output multiplier estimates overestimate the output multipliers published by the Department of Commerce-Bureau of Economic Analysis (BEA) for the state of Florida. In contrast, the income multiplier estimates underestimate the BEA's income multipliers. For a given multiplier type, the Spearman-rank correlation analysis shows that the multiplier estimates and the BEA multipliers have statistically different rank ordering of row elements. The above tests also find no significant different differences, both in size and ranking distributions, among the vectors of multiplier estimates.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

A. Purpose of the Study

Input-output analysis has been used extensively to describe the economies of nations and regions. One of the main applications of the analysis, especially at the regional level, has been in impact studies. The impact of a change in final demand on total output and income in a region is measured through the use of input-output multipliers. Regional input-output multipliers are estimated in one of two ways: through survey-based methods or nonsurvey techniques; sometimes, a compromise is sought between the two. The former involves surveying a sample of firms in the region to determine their purchases and sales patterns. Nonsurvey techniques use a national input-output table as a basis for regional technology and then make adjustments to take into account various differences between the region's economy and that of the nation. Therefore, it is important to investigate how the nonsurvey regional input-output multipliers are affected by errors in the components from which they are computed.

Two basic structures of a regional economy particularly influence the characteristics of a nonsurvey regional input-output study. First, the structure of production in a particular region may be identical to or greatly different from that recorded in the national input-output table. Secondly, the trade structure of the economic area may be markedly different from that of the nation; the smaller the region, the more dependent that area's economy is on trade with "outside" areas both for sales of regional outputs and purchases of inputs needed for production.

Production functions in this model are, of course, of the Leontief type. This does not allow for input substitutions within a given sector in a region, but it is possible for the input mix used by a given sector to vary across regions. The output mix of a given sector may also be different from one region to the next. Although the term may be somewhat misleading, this structure is referred to as the technology of the region. A matrix of regional technical coefficients describes the technology of regional firms.[1] The trade structure, as the name implies, concerns the pattern of imports and exports for the region of study. What is produced and consumed within the region will be called an intraregional purchase (or shortly regional purchase).

Since the phrase "technical coefficient" is sometimes used rather loosely in the literature, a digression on terminology is in order. A matrix of regional coefficients is really not a technical coefficient matrix in the national sense.[2] Miller and Blair (1985, pp. 45-52 and 217-271) distinguish between a "regional technical coefficient" and a "regional input coefficient", denoted by a_{ij} and r_{ij} respectively. The former refers to regional technical requirements per unit of output of sector j, whereas the latter describes the proportion of required inputs supplied by firms located within the region. Thus $r_{ij} = a_{ij} - m_{ij}$, where m_{ij} denotes the proportion of sector j's inputs imported from other regions, as well as from abroad; it is called imports coefficient. Regional input coefficients provide more information on regional impacts than the region's technical coefficients do (see, for example, Afrasiabi and Casler, 1991).

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[1] Some authors (see, for example, Afrasiabi and Casler, 1990) use the term "regional technological coefficients" to stress the fact that these coefficients represent the technology of the region.

[2] This case only holds if the national economy approaches a closed, self-sufficient economy.

In using a non-survey technique, then, the regional analyst must exercise caution in adjusting either of these structures to the region under study. Such adjustments are done through the use of a matrix (a vector is also a matrix) of regional purchase coefficients. The matrix may be based on some limited surveys or on purely published data, or a mixture of both.

The accuracy of alternative adjustment methods have been the subject of evaluation in a number of studies (Czamanski and Malicia, 1969; Flegg et al., 1995; Gahart, 1985; Gerking, 1979; Harrigan et al., 1980; Jensen, 1990; Malizia and Bond 1974; Miernyk, 1976; McMenamin, and Haring, 1974; Morrison and Smith, 1974; Schaffer and Chu, 1969). Most authors seem to agree that the simple location quotient technique (which is a measure of the relative importance of each industry regionally compared to its national importance) is "the best" method for adapting the national input-output table although they concede that it is "grossly deficient" (Flegg et al., 1995; Harrigan et al., 1980; Heskelinen and Suorsa, 1980; Jensen, 1990; Morrison and Smith, 1974; Schaffer and Chu, 1969). The effects of its limitations are lessened by the choice of the basis upon which the simple location quotients are to be determined. Variables often used are earnings, wages and salaries, employment, payroll, number of establishments, etc.

The selection of a variable is still the major concern of most regional analysts who are striving to give accurate estimates of regional input-output multipliers. Nourse (1969), for example, argues that earnings-based location quotients take better account of regional productivity differences than do employment-based location quotients. Stevens and Trainer (1980) indicate that personal income-based location quotients are more appropriate in terms of regional self-sufficiency. The Bureau of Economic Analysis (thereafter referred to as BEA), in its series of studies of regional input-output multipliers, is still not confident on the use of a given basis. In 1981, BEA used a mixed regional purchase coefficients matrix, based on both employment and earnings data. Earnings data are used to estimate the location quotients for the agriculture, mining, and manufacturing industries while personal income data are used for the remaining industries (U.S. Department of Commerce-BEA, 1981). However, since 1992, BEA has used wages-and-salary data for regionalizing the national input-output table (U.S. Department of Commerce-BEA, 1992, and 1997).

To my knowledge, little has been done to empirically analyze the bias of regional input-output multipliers resulted from different specifications of the simple location quotients. This dissertation remedies the situation by comparing regional input-output multipliers originated from four sets of simple location quotients estimated from regional employment, earnings, number of establishments, or payroll data. It is now necessary to establish the framework for the empirical work to follow.

B. Errors in Regional Input-Output Models

1 - The Nature of Errors

The main tool in regional impact studies is the so-called regional Leontief inverse, $(I - A^{\mathrm{R}})^{-1}$, or the regional multiplier matrix. The matrix of regional input coefficients, A^{R}, is obtained by multiplying the national technical coefficients table, A, by the matrix of regional purchase coefficients, $\widehat{P}$. The regional Leontief inverse can, thus, be written as $(I - \widehat{P}A)^{-1}$. Errors in either the national technical coefficients matrix, A, or the matrix of regional purchase coefficients, $\widehat{P}$, will lead to errors in the regional matrix of multipliers.

The national input-output coefficients represent the input requirements per unit of output of the sectors; in other words, they express the amount of a particular input required by an industry to produce one dollar's worth of industry output. They are derived from a matrix of transactions by dividing each element of a column by its corresponding column total. The data used to construct the transactions matrix are often collected by a non-exhaustive sampling of firms in each sector. Enormous amounts of data are to be collected, separated, divided over sectors and aggregated to compose the transactions table (Bullard and Sebald, 1988; Viet, 1994).

It is, therefore, widely recognized that the obtained coefficients depend not only upon the original data, but to a large degree upon the way they are carried through each step of the construction process as well. Whether these transaction flows are determined by survey methods or from national statistics, the measurements are subject to errors (see, for example, Bullard and Sebald, 1988; Gerking, 1976). In fact, it is unlikely that any two input-output analysts, even with the same set of data, would come up with exactly the same model. Finally, since the table of technical coefficients available for the economy often reflects data from a much earlier year, changes in technology of production and the mix of products composing the sectors may be sources of errors for the A matrix (Afrasiabi and Casler, 1991; Conway, 1980; Lee and Schluter, 1993; Midmore and Harrison-Mayfield, 1996). Errors in the flow and column total of the transaction table will lead to errors in the resulting technical coefficients.

If $$a_{ij} = \frac{z_{ij} + e_{ij}}{X_j + e_j} \tag{1}$$

where,

z_{ij} is the flow of input from sector i to sector j,

X_j is the total (gross) output of sector j,

a_{ij} is the observed technical coefficient,

e_{ij} is an error associated with the measured flow from i to j,

e_j is an error associated with the measured total output for j, If a “*” denotes the true value of a variable,

then, in general, $a_{ij} \neq a^*_{ij}$,

with,

$$a^*_{ij} \equiv \frac{z^*_{ij}}{X^*_j}$$

being the true value of the technical coefficient.

Theil (1966) has shown that errors in the flow variables and column of the transactions table lead to additive errors in the matrix of technical coefficients. Thus,

$$A = A^* + \tilde{A} \tag{2}$$

where,

$A = [a_{ij}]$, the matrix of observed coefficients,

$A^* = [a^*_{ij}]$, the matrix of "true" coefficients,

$\tilde{A} = \left[\tilde{a}_{ij}\right]$, the matrix of errors.

The matrix $\widehat{P}$ of regional purchase coefficients, p^r_i, is also a potential source of error in non-survey regional input-output multipliers. The regional purchase coefficients, p^r_i, are estimates of regional percentages showing, for each supplying sector, the proportion of total regional requirements of that good that could be expected to originate within the region. They are usually evaluated from published national and regional data on output, employment, earnings, income, population, number of establishments, and so on. Generally, two kinds of information are used to compile these data: administrative records, and censuses. Then controls and allocation procedures follow. Hence, these data are also subject to collection and manipulation inaccuracies and can lead to errors in the $\widehat{P}$ matrix.

Most authors use a vector (rather than a full matrix) of regional purchase coefficients (see, for example, Alexandre, 1991; Stevens and Trainer, 1980; U.S. Dept. of Commerce, 1981, 1992, ans 1997). The elements in the i^{th} row of A are each multiplied by p_i^r. Thus, any error in a coefficient i is dispersed through the whole row i of the matrix of regional input coefficients.

2. The Measurement of Errors

Clearly, input-output coefficients obtained by any means (survey and nonsurvey) and regional purchase coefficients are subject to errors. These errors can occur as a result of the inevitable inaccuracies in data collection and manipulation, or because of violations of the input-output assumptions. Naturally, the analyst should be concerned with making his model as accurate as is feasible. But how does one go about determining the accuracy of a regional input-output model?

One way to approach the problems of errors in non-survey input-output models is to take for granted the stochastic assumptions on the input-output matrix and the regional purchase coefficients matrix and pose the question: How do the stochastic assumptions affect the evaluation of the resulted multipliers? As it is impossible to analyze all the effects of errors, the problem can be narrowed down to the economically important issue of the evaluation of the multipliers under stochastic assumptions. Literature on the subject often concentrates on this issue, known as the over- and under-estimation problem for multipliers (Dietzenbacher, 1995; Gahart, 1985; Kop Jensen, 1994; Simonovits, 1975; ten Raa and Steel, 1991; and West, 1986). A practical point of interest is to ask how large the bias will be when there is over- or under-estimation. The question arises whether the true multiplier values are under- or -overestimated by the observed ones.

This dissertation aims at analyzing the relative accuracy of regional input-output multipliers estimated from different specifications of the simple location quotients. The definition variables are: earnings, employment, number of establishments, and payroll data. The vectors of multiplier estimates are, first, compared with sets of "true" RIMS II[3] multipliers and, then, one with another for significant differences. To this end, the next chapter is concerned with the literature associated with the general input-output theory, the alternative adjustment techniques, as well as, the issues of errors of most relevance to regional input-output multipliers. Chapter 3 describes the model development. The statistical techniques appropriate for comparing multipliers, and the statistical analysis of the results are developed in Chapter 4. There, we explore a test routine that includes both non-parametric and parametric tests. Finally, Chapter 5 summarizes the results and presents the major conclusions of this dissertation.

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[3] The RIMS II model is maintained by the U.S. Department of Commerce, Bureau of Economic Analysis. BEA makes available sets of tables on input-output multipliers for the regions from the RIMS II model.

CHAPTER II

LITERATURE REVIEW

A. Introduction

As stated in the previous chapter, we want to empirically analyze the relative accuracy of regional input-output multipliers obtained from the simple location quotients estimated from four variables: earnings, employment, number of establishments, and payroll data. This chapter concentrates primarily on studies that will be used as a basis for setting up the model developed in the next chapter. It includes a short discussion of the traditional input-output methodology. Special attention is given to previous works in the adjustments of national I-O models to regional economic analysis, and the derivation of the regional input-output multipliers.

Regional models warrant a more complicated error analysis due to the additional information needed at the local level. Not only is one concerned with intersectoral flows of commodities but also with percentage of each flow which originates (or terminates) within the region under study. This requires a matrix of regional purchase coefficients in addition to technical coefficients. Section E reviews studies on the relative contributions of these components to multiplier accuracy. The chapter ends with a review of some statistical methods used for comparing regional input-output multipliers.

B. Input-Output Analysis: Theory

The input-output model, used to develop multipliers, may be considered as part of the vast spectrum of economic base analysis (Harmston, 1983). Developed by Wassily Leontief in the late 1930's, input-output analysis is directly concerned with economic interdependence, the structure of the economy and the way in which its individual sectors fit together. Also termed "Interindustry analysis", input-output methodology is defined by Leontief (1986, p. 4) as:

> *". . . essentially a method of analysis that takes advantage of the relatively stable patterns of the flow of goods and services among the elements of an economy to bring a much more detailed statistical picture of the system into the range of manipulation by economic theory."*

Table 2.1 depicts a simplified input-output transaction matrix. It presents an economy consisting of n industries. The number of sectors in an input-output table depends upon such factors as research objectives, and data and resource availability. It may vary from only a few to hundreds or even thousands. Isard and Landford (1971), and Miller and Blair (1985) note that the main criterion for delimiting a sector is homogeneity defined in the sense of industries having similar sales and purchase patterns.

To each of the n industries correspond a row and a column. Sectors of output origins or sellers are listed along the rows and the same sectors, now destinations or purchasers, are listed across the top of the table. Rows reveal the sales of a particular sector, i.e., z_{ij} is sales by industry i to industry j. Columns show the purchases made by a particular industry; hence, the element z_{ij} represents a purchase by industry j from industry i. There are two more columns to represent final demand and total output, and two more rows to represent value added and total inputs.

The final demand sector may be disaggregated into such components as household, capital formation, government purchases, and exports. Likewise, value added can be decomposed into labor and other value added items such as government services, interest payments, land (rental payments), profits, and so on. An import row may also be included.

If we denote by X_i the total output (production) of sector i and by Y_i the total final demand for sector i's product, we may write

$$X_i = z_{i1} + z_{i2} + \ldots + z_{ii} + z_{in} + Y_i \tag{3}$$

The z terms on the right-hand side represent the interindustry sales by sector i (z_{ii} represents intraindustry flows, that is, purchases by a sector of its own output as an input to production). The total output X_i is thus the sum of sector i's interindustry sales and its sales to final demand Y_i.

Input-output model transforms an accounting system to an analytical technique with the derivation of the input-output coefficients table from the input-output transactions table. By assuming that interindustry flows from i to j for a given period depends entirely and exclusively on the total (gross) output of sector j, the input-output coefficients are calculated as:

$$a_{ij} = \frac{z_{ij}}{X_j} \tag{4}$$

where,

a_{ij} = input-output coefficient,

z_{ij} = flow of products from sector i to sector j,

X_j = total output of sector j.

TABLE 2.1

SIMPLIFIED I-0 TRANSACTIONS TABLE

Selling Industries	Purchasing Industries					Final Demand	Total Output
	1	2	3	. . .	n		
1	z_{11}	z_{12}	z_{13}	. . .	z_{1n}	Y_1	X_1
2	z_{21}	z_{22}	z_{23}	. . .	z_{2n}	Y_2	X_2
3	z_{31}	z_{32}	z_{33}	. . .	z_{3n}	Y_3	X_3
.	.	.	.	. . .	.	.	.
.	.	.	.	. . .	.	.	.
.	.	.	.	. . .	.	.	.
.	.	.	.	. . .	.	.	.
n	z_{n1}	z_{n2}	z_{n3}	. . .	z_{nn}	Y_n	X_n
Value Added	V_1	V_2	V_3	. . .	V_n		
Total Inputs	X_1	X_2	X_3	. . .	X_n		

The input-output coefficients, a_{ij}'s, also termed (direct) input coefficients, technical input-output coefficients, or simply technical coefficients, are viewed as measuring fixed relationships between a sector's output and its inputs. Thus, an input-output coefficient expresses the amount of a particular input required by an industry to produce one dollar's worth of that industry's output.

In order to derive the input-output coefficients table, some assumptions about the nature of production functions of the economic sectors are necessary. Miller and Blair (1985) cite three categories. First, production is assumed to operate under conditions of constant returns to scale; second, each sector is assumed to use inputs in fixed proportions, that is, the amount of inputs purchased by a particular industry depends on the industry's output only; and, third, it is postulated that there is no substitution of production factors. These assumptions make explicit the dependence of interindustry flows on the total outputs of each sector (X_i).

The interdependence can be expressed by a system of equations:

$$\begin{array}{l} a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n + Y_1 = X_1 \\ a_{21}X_1 + a_{22}X_2 + \ldots + a_{2n}X_n + Y_2 = X_2 \\ \cdot \quad \cdot \quad \cdot\ \cdot\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ a_{n1}X_1 + a_{n2}X_2 + \ldots + a_{nn}X_n + Y_n = X_n \end{array} \tag{5}$$

or, in matrix notation:

$$AX + Y = X \tag{6}$$

Equation 6 can be written as:

$$X - AX = Y \tag{7}$$

or

$$(I - A)X = Y \tag{8}$$

Finally, premultiplying both sides of Equation 8 by $(I - A)^{-1}$ yields:

$$X = (I - A)^{-1}Y \tag{9}$$

where $(I - A)^{-1}$ is the Leontief inverse or matrix of multipliers, which is the form needed in impact analysis; I is an n^{th} order identity matrix.

The models described up to this point have relied on estimates of input-output relationships for a country as a whole. The consequences of certain economic events for specific regions are important, and input-output tables have been created for smaller areas in order to enable the effects of changes in the economy to be examined at a more local level. The analyst is faced with a choice, either to collect regional data to compile the tables, or to adjust national tables by mechanical methods which use regional published information; often, a compromise is sought between the two methods.

Compiling tables from survey data requires huge quantities of data that are often difficult, or sometimes even impossible to obtain at the regional level (Midmore and Harrison-Mayfield, 1996). In fact, tables that are viewed as "purely" survey-based often are based partially on extensive use of administrative records, especially for estimating control totals for industry-specific output (US Department of Commerce-BEA, 1981). Jensen (1980) argues that the pure survey component of some "survey-based" tables has not been sufficiently large to warrant their being considered as true survey-based tables.

The mixed approach of modifying a national table with limited survey or other region-specific data may require considerably less data gathering than a purely survey-based table, and therefore, may entail lower associated costs. However, in terms of the need for experienced research personnel, the costs of the two approaches are similar (US Dept. of Commerce-BEA, 1981). In application, the difference between "purely" survey-based and mixed-approach tables could be small. Non survey input-output methodology is extensively used at the regional level because of its low application cost, and its ability to be applied even at the county level (Stevens and Trainer, 1980; U.S. Dept. of Commerce-BEA, 1981, 1992, and 1997).

C. Nonsurvey Methods:

Regional Input-Output Analysis

The earliest attempts to produce regional input-output tables proceeded by simply applying the national input-output coefficients to a region economy by assuming that regional input patterns were identical to national input patterns. Isard (1960) recognizes that "these [unadjusted] input-output requirements are merely crude estimates."

Richardson (1972) identifies two major problems associated with the use of unadjusted coefficients: First, a much wider variety of products are produced by firms comprised in a given national industry than by those in the same industry in a region. Secondly, national input-output coefficients reflect the state of technology whereas the regional coefficients represent both technology and regional trade.

The need for a satisfactory alternative to the problems of unadjusted coefficients has forced the regional analysts to devise adjustment techniques in order to adopt the national input-output model to regional conditions. For a single region model, the national input-output coefficient is adjusted as follows:

$$A^R = \widehat{P}^R A \tag{10}$$

where,

$A^R = [a^r_{ij}]$ represents the regional input coefficients matrix,

$\widehat{P}^R = [p^r_i]$ is the matrix of regional purchase coefficients.

When a single vector is used, $\widehat{P}^R$ is a diagonal matrix where the "hat" symbol indicates that the elements of a the vector of regional purchase coefficients have been "strung out" along the main diagonal of the $\widehat{P}^R$ matrix.

The most common approach to estimate the regional purchase coefficients is the location quotients technique (Flegg et al., 1995; Jensen, 1990; Morrison and Smith, 1974; Richardson, 1972; and Schaffer and Chu, 1969). The location quotient techniques encompass the simple location quotient (SLQ), the purchase-only location quotient (PLQ), and the cross-industry location quotient (CLQ) approaches.

1. Simple Location Quotients

The simple location quotient (SLQ) compares the relative specialization or concentration of a region in the production of particular goods with the national average specialization.

Employing Miller and Blair's notation, the simple location quotient for sector i can be expressed as:

$$SLQ_i = \left(\frac{X_i^R / X^R}{X_i^N / X^N} \right) \tag{11}$$

where,

X_i^R and X^R denote output of sector i and total output in region R, respectively,

X_i^N and X^N are the corresponding quantities for the nation.

The simple location quotient can thus be viewed as a measure of the ability of regional industry i to supply the demands placed upon it by other industries in the region and by regional final demand.

The regional purchase coefficients are obtained as:

$$p_i^r = \begin{cases} 1 & \text{if } SLQ_i \geq 1.0 \\ SLQ_i & \text{if } SLQ_i < 1.0 \end{cases} \tag{12}$$

where,

$\widehat{P}^R = [p_i^r]$, is the matrix of regional purchase coefficients.

The interpretation is familiar from economic base studies. If SLQ_i is greater than 1.0, the region exports some of the output of industry i. Similarly, when SLQ_i is less than 1.0, the region imports some of the output of industry i from elsewhere in the nation. There are no exports or imports in the region when SLQ_i is equal to 1.0 (Isserman, 1980). But, the location quotients need not be stated in terms of output; other alternative economic variables include income, employment, sales, population, earnings, number of establishments, and value added.

There are several variants of the simple location quotient approach, all of which are used in the same general way in adjusting national to regional coefficients. The most commonly used are the purchase-only location quotients and the cross-industry location quotients.

2. Purchase-Only Location Quotients

The purchase-only location quotient (PLQ) for sector i relates regional to national ability to supply sector i inputs, but only to those sectors that use i as an input. That is,

$$PLQ_i = \frac{X_i^R / X^{*R}}{X_i^N / X^{*N}} \tag{13}$$

Where X_i^R and X_i^{N} are regional and national output of good i, as before, and where X^{*R} and $X^{*\mathrm{N}}$ represent total regional and national output of only those industries which purchase inputs i. The simple location quotient and the purchase-only location quotient for an industry will be equal only when X^R/X^{N} and $X^{*R}/X^{*\mathrm{N}}$ are equal. Hence, the difference depends on the relative sizes of the purchasing industries excluded from the computations of $X^{*R}/X^{*\mathrm{N}}$.

3. Cross-Industry Location Quotients

The cross-industry location quotient (CLQ) compares the proportion of national output by selling sector i in the region to that of purchasing sector j in the region. It is given by:

$$CLQ_i = \frac{X_i^R / X_i^N}{X_j^R / X_j^N} \tag{14}$$

The local industry i is assumed to be able to provide all the output required by local industry j. This method overcomes the problem of assuming that the demand patterns are the same, as it takes into account that the regional coefficients are not necessarily equal to the national coefficients, and that the trading potentials of each industry vary between regions. It does not, however, consider the weighting of the two industries relative to the total output of the region. Flegg et al. (1995), Harrison-Mayfield (1996), and Morrison and Smith (1974) have questioned this feature of the cross-industry location quotient on the basis that it takes no account of the relative size of the local industry. The regional purchase coefficients, $\widehat{P}^R$, is formed in a like manner to the simple location quotient technique above. Since these techniques will never increase a national coefficient (it is either left unchanged or made smaller), they are sometimes referred to as reduction techniques (Miller and Blair, 1985).

A fundamental assumption in all these regionalization techniques is that the national technical relationships hold at the regional level and that the regional trade coefficient differs from the national technical coefficient to the extent that goods and services are imported from other regions. Hence, the technique that takes better account of regional trade is expected to give the best results. Morrison and Smith (1974, p. 11) find that "the simple location quotient emerges, as a whole, as the best." Such results have also been obtained by Flegg et al. (1996); Heskelinen and Suorsa (1980); Jensen (1990); Schaffer and Chu (1969); and Sawyer and Miller (1983). In this study, the simple location quotients are employed to form the regional purchase coefficients matrix.

D. Regional Input-Output Multipliers

By analogy to the national model (see equation 6), the regional input-output model can be expressed in the following simplifying equations:

$$X^R = A^R X^R + Y^R \tag{15}$$

where,

X^R = a column vector of regional gross output

$A^R = [a^r_{ij}]$ a matrix of regional input coefficients

Y^R = a column vector of regional final demand.

Equation (15) states that total regional output (X^R) is equal to regional interindustry transactions ($A^R X^R$) plus final demand (Y^R). Y^R includes local final demand and net final demand by other regions.

The gross output effects of changes in final demand can be estimated by the regional multiplier matrix $\left(I - A^R\right)^{-1}$. This estimation can be represented as follows:

$$\Delta X^r = \left(I - A^R\right)^{-1} \Delta Y^r \tag{16}$$

For a given change in final demand (ΔY^r), the multiplier matrix $\left(I - A^R\right)^{-1}$ shows the total (direct and indirect) effects on output (ΔX^r) for each of the region's industries.

The regional Leontief inverse or regional multiplier matrix, $(I - A^R)^{-1}$, is derived as previously done from Equations (6) to (9). Each element of the regional Leontief inverse, $\left(I - A^R\right)^{-1}$, denoted thereafter by α^r_{ij}, represents the increase in output of the local industry i resulting directly and indirectly from an increase in the output of local industry j; in other words, each α_{ij} represents an individual output multiplier for industry i given a final demand change in industry j.

In the above model, changes in households demand are aggregated with the rest of final demand. Such input-output models are said to be open with respect to households and are referred to as "open models." One can move the household sector from the final demand column and place it inside the technically interrelated table, that is, make it one of the endogenous sectors. An household row of labor input coefficients will also be endogenous.

The input-output model is, thus, expanded by adding one row and one column to the matrix to represent household income and spending.[4] This is known as closing the model with respect to households; such models are referred to as "closed models."

The basis for closing an input-output model is that households earn incomes in payment for their labor inputs to production processes, and, as consumers they also spend their incomes. Hence, an increase in labor inputs due to increased output will lead to an increase in household demand for goods, a proportion of which will be purchased in the local economy and will consequently have a large created effect through the system. Such effects are called induced effects.

The regional matrices $\overline{A}^{R}$ and $\left(I - \overline{A}^{R}\right)^{-1}$ in a closed model are of order $n + 1$. The household row coefficient in the j^{th} column will be, hereafter, represented as $a^{r}_{n+1,\,j}$, and the household column as $a^{r}_{i,\,n+1}$; $a^{r}_{n+1,n+1}$ represents what households pay to domestic household workers for each one dollar of income received. Each entry in the regional Leontief inverse, represented by $\overline{\alpha}^{\,r}_{ij}$, gives the total increase (taking into account direct, indirect, and induced effects) in output of industry i resulted from a change in output of industry j. It should be noted that in multiplier calculation, if a regional household row is included in $\overline{A}^{R}$, but the household column is set equal to zero, the system is still considered an open model.[5]

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[4] The mechanics of closing an input-output model are described in more details, for example, by Bulmer-Thomas (1982), and Roberts (1991).

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[5] The overbar denotes a measure that is calculated from the Leontief inverse with an endegenous household sector.

Several types of aggregate multipliers, all derived from the Leontief inverse, are employed in regional impact analysis. The three most frequently used are the output, income, and employment multipliers.

1. Output Multipliers

The regional output multipliers estimate the effects of exogenous changes on outputs of the sectors in the region economy. The multipliers obtained from the open models are known as simple multipliers while those estimated from a closed model are called total multipliers.

The simple output multiplier for sector j is defined as the total value of the direct and indirect output effects in all sectors of the economy that are necessary to satisfy a dollar's worth of final demand for sector j's output. It is obtained by summing up the columns under industry j of the Leontief inverse or matrix of multipliers $\left(I - A^R\right)^{-1}$. If we denote each element of the Leontief inverse by α_{ij}^r, the simple output multiplier for each sector j is given by:

$$O_{\mathrm{j}} = \sum_{i=1}^{n} \alpha_{ij}^{r} \tag{17}$$

where,

O_{j} is the simple output multiplier for industry j.

The total output multiplier for a sector j can be expressed as:

$$\overline{O}_{\mathrm{j}} = \sum_{i=1}^{n+1} \overline{\alpha}_{ij}^{r} \tag{18}$$

where,

$\overline{O}_{\mathrm{j}}$ = total multiplier for sector j,

$\overline{\alpha}_{ij}$ = element of the regional Leontief inverse with an endogenous household sector.

The same interpretations for the simple output multipliers hold for the total output multipliers with the exception that induced effects are now included.

2. Income Multipliers

The regional analyst concerned with the income generating effects of a final demand change can estimate two measures: Income effects or Household Income Multipliers, and Type I and Type II Multipliers.

a) Income effects or Household Income Multipliers

The income received by household per dollar's worth of sectoral output is given by the coefficients that make up the $(n+1)^{st}$ household-row, H_R, which is used in closing the model with respect to household. In other words, the n-element row vector H_R is:

$$H_R = \left[a^r_{n+1,1},\ a^r_{n+1,2},\ \ldots,\ a^r_{n+1,n}\right] \tag{19}$$

In other words, each element of H_R represents the dollar value of labor inputs to each of the n sectors per dollar's worth of sectoral output. The simple household income multiplier (with an exogenous household sector) for sector j translates the direct and indirect effects for that sector in terms of dollars' worth of new household income; the initial effect is in terms of one dollar's worth of final demand output for sector j. The simple income effect or simple household income multiplier is given by:

$$H_{\mathrm{j}} = \sum_{i=1}^{n} a^r_{n+1,i}\alpha^r_{ij} \tag{20}$$

where,

H_{j} is the simple household income,

$a^r_{n+1,i}$ and α^r_{ij} are as defined previously.

Again using the overbar to denote the multiplier derived from the model in which households have been included in the matrix of regional input coefficients, the total (household) income effect or total (household) income multiplier for a given sector is expressed as follows:

$$\overline{H}_{\mathrm{j}} = \sum_{i=1}^{n} a^{r}_{n+1,i}\overline{\alpha}\,^{r}_{ij} \tag{21}$$

The elements $\overline{\alpha}\,^{r}_{ij}$ of the Loentief inverse $(I - \overline{A}\,^{R})^{-1}$, as we may recall, measures the total (direct, indirect, and induced) effect on sector i output of a dollar's worth of new demand for sector j output in the region. Thus, $\overline{\alpha}\,^{r}_{ij}$ is the total effect on the output of the local household sector, which is the total value of local labor services needed, when there is a dollar's worth of new final demand for goods of sector j in the region. This is exactly what we mean by the total household income effect or total household income multiplier. Hence, Equation (21) can also be expressed as:

$$\overline{H}_{\mathrm{j}} = \overline{\alpha}\,^{r}_{n+1,j} \tag{22}$$

b) Type I and Type II Income Multipliers

The Type I and Type II income multipliers consider the initial additional income payment of $a_{n+1,j}$ to workers in sector j as the initial income effect of the new demand for sector j's output. Then, the Type I income multipliers are estimated for the open model and the Type II for the closed model.

The Type I income multipliers take account of direct and indirect changes in income brought about by an increase in final demand for a given sector's output as well as the change in labor compensation by the industry or sector in the region.

For a regional industry j, it is calculated as:

$$Y_j = \sum_{i=1}^{n} \frac{a^r_{n+1,i}\alpha^r_{ij}}{a^r_{n+1,j}} \tag{23}$$

where,

Y_j = Type I income multiplier,

$a^r_{n+1,i}$= household input coefficient for sector i from vector H_R above,

α^r_{ij} = coefficients of the regional Leontief inverse for the open model,

$a^r_{n+1,j}$ = initial additional income payment to workers in sector j.

The Type II income multipliers, which include direct, indirect and induced effects, are estimated by using the closed model. The Leontief inverse coefficient α^r_{ij} (household exogenous) is substituted by $\overline{\alpha}\,^r_{ij}$ (household endogenous). The expression is:

$$\overline{Y}_j = \sum_{i=1}^{n} \frac{a^r_{n+1,i}\overline{\alpha}\,^r_{ij}}{a^r_{n+1,j}} \tag{24}$$

where $\overline{Y}_j$ is the Type II income multiplier.

The parallel between this measure and the Type I income multipliers is the same as that between the total ($\overline{H}_j$) and simple (H_j) household income multipliers in Eqs. (20) and (21). Thus, for exactly the same reason as in the case of $\overline{H}_j$, we can alternately define $\overline{Y}_j$ as:

$$\overline{Y}_j = \frac{\overline{\alpha}^r_{n+1,j}}{a^r_{n+1,j}} \tag{25}$$

where $\overline{\alpha}\,^r_{n+1,j}$ and $a^r_{n+1,j}$ are as defined above.

3. Employment Multipliers

When regional input-output analysts are preoccupied with the regional employment-creating effects of a particular industry j, they refer to number of jobs that regional industries provide in order for that industry to deliver its additional output to final demand.

The employment multipliers require information not found in the regional Leontief inverse, specifically, a measure of man-hours per unit of output produced for each sector. Let e_i be the number of employees in sector i, the physical labor input coefficients equal:

$$w_{n+1,i} = \frac{e_i}{X_i} \tag{26}$$

where,

$w_{n+1,i}$ = number of employees per dollar's worth of output for sector i,

X_i = total output of sector i.

For an n-sector regional input-output model, we could find:

$$W_R = [w_{n+1,1},\ w_{n+1,2},\ \ldots,\ w_{n+1,n}] \tag{27}$$

Then, it is a straightforward procedure to convert the conventional regional Leontief inverse (with or without households endogenous) to employment equivalents.

a) Employment Effects and Household Employment Multipliers

The procedure to estimate these measures is similar to that use for the income effects and household income multipliers described above. The physical labor input coefficients, $w_{n+1,j}$, is now used in place of the monetary labor input coefficients, $a_{n+1,j}$.

The simple employment effect or simple household employment multiplier gives the number of jobs created due to an additional dollar's worth of final demand for sector j. It is given by:

$$E_j = \sum_{i=1}^{n} w_{n+1,i}\alpha_{ij}^{r} \tag{28}$$

where E_j = the simple household employment multiplier.

If $\left(I - \overline{A}^{R}\right)^{-1}$ is used instead of $\left(I - A^{R}\right)^{-1}$, then we have the total employment effect or total household employment multiplier,

$$\overline{E}_j = \sum_{i=1}^{n} w_{n+1,i}\overline{\alpha}_{ij}^{r} \tag{29}$$

Again $\overline{E}_j$ gives the number of jobs created due to the additional dollar's of final demand for sector j, but now the effects of household spending in the region are included.

b) Type I and Type II Employment Multipliers

The procedures are essentially identical to those used to calculate the Type I and Type II income multipliers. Here, however, the initial effect is in employment. If we denote the Type I employment multiplier by W_j, the appropriate expression is:

$$W_j = \sum_{i=1}^{n} \frac{w_{n+1,i}\alpha_{ij}^{r}}{w_{n+1,j}} \tag{30}$$

where W_j represents job creation in the region due to total effects (direct and indirect) created for each additional new job in sector j.

The Type II multipliers (with households endogenous) are thus:

$$\overline{W}_j = \sum_{i=1}^{n} \frac{w_{n+1,i}\overline{\alpha}_{ij}^{r}}{w_{n+1,j}} \tag{31}$$

The Type II multiplier, $\overline{W}_j$, gives the total number of jobs in all the sectors in the economy for each job created in sector j (here total effects include induced effects).

As shown by Equations 18, 21, and 29 the total household employment multiplier for an industry j is a constant multiplier of either the total output multiplier or the total income multiplier of that industry. Morever, the vector of physical labor input coefficients, defined in Equation 27, does not enter into the calculation of the matrix of regional input-output coefficients. Hence, a study of the accuracy of the employment multipliers would not bring further detailed information to our goals.

Output, income multipliers are all defined in terms of the regional Leontief inverse whether or not the model is closed with respect to households. As described in the first chapter, both the national input-output coefficients and the regional purchase coefficients are subject to errors. The relative importance of errors in the technical coefficients table and the regional purchase coefficients matrix on regional multipliers has been studied to guide practitioners on how best to allocate scarce research funds (see, for example, Stevens and Trainer 1976). The next section covers this problem and should serve as an additional explanation why this dissertation concentrates on studying the relative accuracy of regional multipliers estimated from four variables (earnings, employment, number of establishments, payroll) used to specify the simple location quotients.

E. Sensitivity of Input-Output Multipliers

The literature dealing with the problem of errors in input-output multipliers analysis follows two distinct approaches. The first is to analytically introduce errors into various components of a general input-output model (see, for example, Burford and Katz, 1977; Dietzenbacher, 1990; Drake, 1976; Park, 1973), while the second involves shocking an actual set of coefficients (either empirically or randomly generated), as done by Dietzenbacher (1990), Conway (1980), Kop Jansen (1994), Roland-Holst (1989), Stevens and Trainer (1980), ten Raa (1994), and West (1986). One study, by Park, Mohtadi, and Kubursi (1981) uses both approaches.

1- Analytical Experiments

The main analytical work examining the effects of coefficients error on multipliers is that of Park (1973). Park derives type I and type II income multipliers by assuming additive errors in the input-output coefficients. He then tries to separate the error components from the "true" multipliers. The estimated vector of type I multipliers is found to be equal to the vector of actual multipliers plus a vector of errors comprising two additive components. The first component is an error vector obtained when errors are present only in the technical coefficients but, not in the vector of household consumption coefficients, the labor inputs, and the intrahousehold coefficient. The second component is a vector associated with the presence of errors in the household vector and in the technical coefficients matrix. Park also finds that the type II multipliers are a constant multiple $(1/\lambda)$ of the type I multipliers. He estimates that λ (as observed) is equal to its "actual" value plus an additive error term composed of two parts. The first part, again, is attributable to errors only in technical coefficients, while the second term occurs when there are errors in A as well as in the household consumption coefficients, the labor inputs, and the intrahousehold coefficient.

These errors in the multipliers are linear combinations of the error terms in the various components of the model. We can think of these linear combinations as "weightings" on the individual error terms. It may be possible, through determination of the size of the weights, to establish which components have the most "important" errors, in terms of their contribution to multiplier errors.

Park, Mohtadi, and Kubursi (1981) paper is the first in which the real problem of error in regional input-output multipliers is addressed in analytical form. In regional models, one is concerned with intersectoral flows of commodities as well as with the percentage of each flow which originates from the region. Park et al. use a diagonal matrix of regional purchase coefficients where each element represents the proportion of input i utilized by all industries and households in the region, which is purchased in the region. Park et al. derived error functions which contain both true values and errors of various coefficients in a complicated form, which prevents, except for few simple cases, the separation of the errors due to technical coefficients from those due to regional purchase coefficients.

The difficulty of analytically separating the importance of the technical coefficients from the regional purchase coefficients in contributing to regional multipliers bias has prompted Dietzenbacher (1990) to uses a totally different analytical approach. Dietzenbacher' analysis is based on the use of eigenvectors. He derives an eigensystem by rewriting the definition of the multipliers. The input-output multipliers are given by elements of the eigenvectors corresponding with the dominant eigenvalue. The effects of the errors in the data on the multipliers are examined by considering the effects of perturbations in a matrix of its Perron vector. The analysis is based on a simple lemma which states that "the largest relative increase and the largest relative decrease in the elements of the Perron vector are observed for elements corresponding to the perturbed columns." Hence, it is possible to indicate the sector for which the multiplier increases or decreases relatively and absolutely the most. In addition, the change in such sector constitutes an upper bound for the change in any sector. Dietzenbacher offers no other insights for the problem of separating the relative effects of components in multiplier accuracy as the nature of the expressions derived are of limited use.

Afrasiabi and Casler (1991) have studied how intertemporal differences in input-output coefficients due to technological change and mix of products composing the aggregate sectors of input-output model would affect the Leontief inverse. The model they develop was tested on four national input-output tables, five survey-based regional tables, and a semi-survey-based table. They find that the effects on the Leontief are negligible. Similar results were also obtained by Conway (1980).

2- Simulation Experiments

Two methods are used in simulation experiments. The traditional method is to specify the stochastic nature of the input-output coefficients directly. The practitioner's method consists of specifying the error structure in the transaction table. The implications for the coefficients may then follow as a consequence.

An important contribution using the traditional method is from Simonovits (1975). Simonovits was concerned with the connection between the A matrix and its Leontief inverse. He shows that if the coefficients of the A matrix are random variables and totally independent, the Leontief inverse is underestimated. His result states that the expected value of each observed multiplier exceeds the true multiplier. Several authors have shown this result to hold under various, different stochastic specifications (see, for example, Bullard and Sebald, 1988; Kop Jansen, 1994; ten Raa and Steel, 1994; West, 1986).

Conway (1980) also conducted Monte Carlo experiments to evaluate the effects of random errors in the A matrix, but rather concentrated on regional economies. He formed twenty random tables by drawing the input-output coefficients from a triangular distribution with the observed coefficient as the most likely estimate and minimum and maximum values determined subjectively. Then he calculated Type B multipliers (the numerator of Type II income multipliers). He felt that measurement errors in the A matrix contribute some, but not all of the inaccuracy in regional multipliers. Then, Conway lists five areas of concern for regional input-output analysts in descending order of importance: (1) misuse of multipliers, (2) behavioral specifications (e.g., the household purchase column), (3) measurement error in the direct purchase vector, (4) measurement error in the base-year input-output model (technical coefficient), and (5) temporal instability of the interindustry coefficients.

We have suggested in this dissertation that the specification of the regional purchase coefficients is the most important component of a regional input-output model in contributing to the accuracy of multiplier estimates. In that sense, the simulations work undertaken by Stevens and Trainer (1980), who were concerned exclusively with errors in the technical coefficients, A, and the regional purchase coefficients, $\widehat{P}$, needs a careful review.

Like Conway, Stevens and Trainer use a vector rather than a full matrix of regional purchase coefficients. However, they do not use an existing input-output table as a "true" table; rather, they generate "correct" technical coefficients, regional purchase coefficients, household purchase coefficients, and labor input coefficients. The first three matrices are subjected to errors. Then, simulation experiments concentrate on errors in the A matrix only, errors in the $\widehat{P}$ matrix only, and errors in both the A and $\widehat{P}$ matrices simultaneously. The statistical techniques are correlation analysis and stepwise regression. Multiplier errors are measured as : $\frac{M-M^*}{M^*}$ where M^* is the "actual" multiplier and M, the observed. Error in total output was measured by the Theil's inequality statistic as:

$$U = \left(\frac{\sum (X_i - X_i^*)^2}{\sum X_i^{*\,2}} \right)^{\frac{1}{2}} \tag{32}$$

Based on the statistical analysis, Stevens and Trainer make three important conclusions:

1- Errors in technical coefficients are relatively unimportant in impact analysis; emphasis should be placed on making the regional purchase coefficients as accurate as possible.

2- Priority should be given to estimating first round effects. Gathering data on the direct effects associated with the impacts of a final demand change to lessen the effects of multipliers errors have also been the conclusions of many recent studies (Beemiller, 1990; Grimes et al., 1992). One explanation is that the direct impact is often a large portion of the total impact and that much of the apparent multiplier differences between impact models can be due to how the direct impact is measured. The problem is how to make the transition from an actual event to specific exogenous effects.

West and Lenze (1994), in their study of the economic impacts of Hurricane Andrew develop a systematic framework approach of a regional economy to indicate which endogenous variables, exogenous variables, and linkages that are directly affected, which would minimize the multiplier error.

3-. Labor input coefficients should be given low priority, and the remaining technical coefficients the lowest priority. They go as far as to speculate that "system errors due to technical coefficients errors may be so small that it would be difficult to ever again justify constructing a regional table based entirely on survey data" (Stevens and Trainer, 1980, p. 83).

Stevens and Trainer do not examine individual components of the multipliers. They do not make reference to Jensen's types of accuracy, but they are clearly concerned with holistic accuracy.

In addition to analytical analysis, Park et al. (1981), in the same study, conducted simulation experiments to analyze the relative importance of different types of errors on the multiplier estimates. Levels of outputs and multipliers are estimated . Then errors are applied in additive form, as in Stevens and Trainer, to the technical coefficients, the regional purchase coefficients, the labor input coefficients, and the household consumption coefficients. The random numbers for the error matrix applied to the original input-output table are drawn from a normal distribution with mean zero and standard deviation equal to one half of the percentage error. Next they calculate new sectoral outputs and multipliers with the original final demand vector being unchanged. Finally, they evaluate the differences between sectoral outputs and multipliers for the two models.

Theil's inequality coefficient, used by Stevens and Trainer, is estimated to evaluate the differences and then regressed on a number of dummy variables representing presence or absence of error in the various components referred to above. Their results confirm the findings of Stevens and Trainer, and Park. They find that errors in multipliers calculated from the non-survey input-output table tend to be far more sensitive to errors in the regional purchase coefficients than to those in the technical coefficients. Moreover, the effect of errors in the technical coefficient matrix on the overall accuracy of the model is "surprisingly negligible." One explanation may be the mutual cancellation of errors in the individual input-output coefficients during interactions with each other. Such explanation was also given, implicitly, by Simonovits.

The simulation experiments in Stevens and Trainer and in Park et al. involve the application of error to various components of a "true" model (hypothetical in Stevens and Trainer) and comparison of the multipliers obtained with the "true" multipliers. Garhart (1985) argues that the use of a purely multiplicative error structure would bias the results in favor of the regional purchase coefficients. The reason is that, in general, the matrix of regional purchase coefficients contains larger coefficients that the A matrix; larger coefficients are subjected to larger errors than smaller coefficients. He thinks that regional purchase coefficients would generate larger multiplier errors than technical coefficients even when subjected to similar multiplicative errors. Similarly, if a given additive error (independent of the size of the coefficient) is applied to a small technical coefficient, it would result in a greater percentage of multiplier errors that would be the same error applied to regional purchase coefficients. Hence, additive error is biased toward the A matrix. Instead, he uses a mixed error structure combining a multiplicative and an additive component. Although his results are opposite for the open model, he found that the regional purchase coefficients errors generally cause greater errors in output multipliers that technical coefficient errors when he uses the closed model.

Two recent simulation studies based on the practitioner's method are worth noted to terminate this section. First, Roland-Holst (1989) conducted Monte Carlo simulations based on a variety of actual transaction tables. The elements of the tables are assumed to be random. The experiments show that the multiplier estimates are unbiased.

Like Roland-Holst, Dietzenbacher (1995) thinks that it is more appropriate to impose the stochastic assumption on the transactions table instead on the coefficients matrices. He finds that aggregate multipliers are unbiased. Moreover, he shows that, under certain conditions, the weighted average of the elements in any row of the multiplier matrix is unbiased. This result holds regardless of the bias of the original error terms. It was also shown that even the weighted averages of the stochastic errors (in the transactions table) themselves tend to be zero within each row and column.

In summary, few analytical studies have been conducted on input-output errors at the regional level. Other efforts to deal with this issue in a regional context have been of the second type, that is, simulation experiments. Regional models warrant a separate analysis due to the additional information needed to compile the matrix of regional input coefficients. Not only is one concerned with intersectoral flows of commodities but also with percentage of each flow which originates (or terminates) within the region under study. This requires a matrix of regional purchase coefficients in addition to technical coefficients.

The experiments show that the errors in technical coefficients contribute very little to the accuracy of the input-output multipliers (see, for example, Afrasiabi and Casler, 1991; Dietzenbacher, 1990; Kop Jansen, 1995; Park et al., 1981; ten Raa, 1994; Stevens and Trainer, 1980). Moreover, when the errors are originated from the transactions table (which is the practical case) the multiplier estimates are unbiased (Roland-Holst, 1989 and Dietzenbacher, 1995). In contrast, the above studies have shown that errors in the matrix of regional purchase coefficients are very important in contributing to multiplier accuracy. Hence, correct specification of the regional purchase coefficients is essential in improving regional multiplier accuracy. Before we develop the model, we present a summary of statistical tools used in comparing multipliers.

F. Comparing Multipliers

As evident from the previous descriptions, each author has chosen his own method in assessing the impact of errors in input-output analysis. This makes it difficult to compare the results obtained by different authors. The exception is the work by Park et al., who model their statistical analysis on that of Stevens and Trainer. The same problem of incomparable results has occurred in the literature evaluating non-survey techniques. In an attempt to remedy the situation in the latter case, Butterfield and Mules (1980) have suggested a multitude of tests to be used in comparing multipliers tables. First, one or more parametric tests should be performed to see how closely the observed matrix resembles the "true" one. Several such tests mentioned are: calculating the Mean Absolute Deviation (MAD), the Standardized Mean Absolute Deviation (SMAD), and/or the similarity index; using Czamanski and Malizia's information content approach; or simply constructing contingency tables based on frequency of coefficients falling in specific class intervals.

These non-parametric tests should be supplemented by analyses yielding testable hypotheses. Regression of the observed coefficients on the corresponding "true" multipliers enables one to test that the intercept term equals zero and the slope term equals one. If these hypotheses are true, then the observed coefficients are acceptable substitutes for the "true" ones. However, when one rejects either of the hypotheses "some ambiguity arises." The correlation between the two sets of multipliers can also be calculated and tested for significance. While Butterfield and Mules concentrate on cell by cell accuracy, the tests they suggest can also be used in developing a testing routine for comparing sets of multipliers. Theil's inequality approach, although not described by Butterifield and Mules, has also been widely used.

G. Summary of the Chapter

Regional input-output models differ from the more general (national level) models in that only intraregional intersectoral flows are considered, with a second, "rest-of-the world" region taken as exogenous. In these models, exports and imports are a much higher percentage of total output, due to greater degree of openness of regional economies relative to national economies.

In nonsurvey regional models, the national technical coefficients are adjusted to take into account the technology and trade structures of the region. This is done through a matrix of regional purchase coefficients. Location quotients are commonly used to estimate the regional purchase coefficients since they take better account of interregional trade (Flegg et al., 1995; Heskelinen and Suorsa, 1980; Jensen, 1990; Morrison and Smith, 1974).

Both the national technical coefficients and the regional purchase coefficients can be subject to errors because of inherent inaccuracies in data collection and manipulation and/or violations of input-output assumptions. Analytical studies are not conclusive, but simulation experiments have concluded that the regional purchase coefficients are more important to contributing to regional multiplier accuracy than the technical coefficients. Some studies have even shown that errors in the transaction tables (the practitioner's approach) generate unbiased multipliers.

These conclusions, coupled with the results regarding the simple location quotients (as stated earlier), show that the specifications of the simple location quotients must be a primary concern of the regional input-output analyst. The next chapter develops the model that leads to the calculation of the regional multipliers, which are, then, empirically analyzed.

CHAPTER III

MODEL DEVELOPMENT

A. Introduction

The works reviewed in the previous chapter have made it clear that correct specification of the simple location quotients is essential to the accuracy of nonsurvey regional input-output multipliers. The unanswered question stays: which of the four variables (earnings, employment, number of establishments, and payroll) under study gives the more (relative) accurate regional multipliers.

The model developed here uses the state of Florida as an example and estimates the multipliers needed for the empirical analysis. The procedure we follow starts with the definitions of the data and sectors of the model. The sectors are aggregated to conform to data availability in the state and to facilitate comparisons with other regional studies. We, then, continue with the derivation of the table of national industry-by-industry technical coefficients. This table is adjusted through the simple location quotients to reflect both the technology and trade structures of the state. Finally, total output and total income multipliers are calculated.

B. Data and Sectors Definitions

The regional input-output model in this study is derived essentially from two data sources:

(1) The two-digit 1987 BEA's national Input-Output tables which show the input and output structure of the US economy (Survey of Current Business, May 1994).

The 1987 Input-Output accounts are consistent with the definitions of the 1987 National Income and Product Accounts (NIPA) revisions. They are the most recent Input-Output benchmark for the United States economy. The 1992 Input-Output accounts benchmark is being developed and will be available soon.[6]

(2) BEA's two- and four-digit Standard Industrial Classification (thereafter, referred to as SIC) state of Florida employment, number of establishments, income, and earnings data for the period 1988-1992 (County Business Patterns-BEA, Various Issues of 1988-1992 period; Local Area Personal Income, 1987 to 1992-BEA, May 1994; the CD-ROM no. 55-92-30-599 of the Regional Economic Information System-BEA, June 1996).

Two basic assumptions of the input-output account should be noted here:

(a) that interindustry relationships established in the Input-Output accounts for a benchmark year will remain stable over time.

(b) that changes in interindustry relationships occur only gradually.

Hence, we assume that the interindustry relationships represented in the 1987 benchmark are applicable for a band of years surrounding 1987, namely for the period under study.

The 1987 input-output accounts differ from the traditional input-output models in several respects, most relatively minor. A major difference is the treatment of secondary products. The traditional input-output framework is an industry-by-industry analysis. The underlying assumption is that two different industries do not produce the same type of output. The 1987 input-output accounts relax this assumption by considering two classification schemes: Industry Accounts and Commodity Accounts.

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[6] Information obtained from conversation with the Regional Economic Analysis Division, Bureau of Economic Analysis, U.S. Department of Commerce. Washington, D.C.

The Industry Accounts is based on the SIC system, which classifies establishments into industries based on their primary products or services. Establishments are defined as economic units that are generally at a single physical location where business is conducted or where services are performed. The Commodity Accounts, however, compile data in terms of the characteristic products of the SIC code, whether the product is produced as a primary or secondary good or service. Both classification systems generally use the same input-output numbers and titles. Accounting for secondary production is the primary difference between Industry Accounts and Commodity Accounts, that is, if no secondary production exists, the two Accounts will be identical.

The traditional input-output framework summarizes an economy in three major tables: a transactions matrix, the matrix of direct requirements, and the total requirements matrix. The 1987 input-output accounts are presented in five tables: (1) The use (consumption) of commodities by industries, (2) the make (production) of commodities by industries, (3) commodity-by-industry direct requirements, (4) commodity-by-commodity total requirements, and (5) industry-by-commodity total requirements.

Two matrices are required in place of the transactions matrix: the Use table and the Make table. The relationship between these two tables is given in Figure 3.1.

The Use table gives an overall picture of the interrelationship between industries in the economy. It shows in each row the value of the commodity at the beginning of the row used in production by each industry or purchased by final users. Each column shows the value of the commodities utilized in production by the industry named at the head of the column and the value added generated in production. The final demand columns show the purchases of commodities by each final user, including net inventory change. The row sum equals total commodity output and the column sum equals total industry output.

Figure 3.1

The Use and Make Tables

Use Table

Industries

Commodities	Columns = value of commodities used by industry j Rows = value of commodity i used by industries	Final Demand
	Value added	

Make Table

Commodities

Industries	Rows = value of commodities produced by industry i Columns = value of commodity j produced by industries	Final Demand

The make table shows in each row the value of the commodities produced by industries in the economy. The columns describe the industry sources of commodity production. The main-diagonal elements of the make matrix define the interindustry relationship and represent the primary products of an industry. The off-diagonal elements give the secondary products.

The Use and Make tables show transactions among 95 industries. Ideally, this study would proceed by employing data available at the same level of aggregation as the 1987 national input-output tables. Unfortunately, it is very difficult to compile state data at that level of disaggregation. Moreover, the aggregated multipliers developed by BEA for the state of Florida, which are used to compare the multipliers estimated in this dissertation, comprise only 38 industries.

By assuming that aggregation bias is not a problem, we reduce the Use and Make tables from 95 to 38 industries. Various studies have shown that aggregation bias is negligible if the sectors have similar input structures (see, for example, Flegg et al., 1995; Hennigan et al., 1980; Miller and Blair, 1985; Morrison and Smith, 1974). Also, Monte Carlo experiments undertaken by Bullard and Sebald (1988) show that the level of aggregation has no impact on the sensitivity of input-output multipliers.

The necessary aggregation for the study is illustrated in Table 3.1. The first and second columns in the table represent the number and the code identifying the industry in the study. The third column shows the corresponding industry numbers as published in the 1987 input-output accounts. Column IV gives the titles of the industries. The last column gives the associated 1987 SIC codes.

The relationship between the 38-order and 95-order industry definitions and the SIC codes shown in Table 3.1 is somewhat approximate. The correspondence is quite close for the manufacturing sectors, but it is less close for agriculture, construction, and most of the services. Government (excluding U.S. postal service SIC code 43) and unclassified sectors have no corresponding codes in the SIC system.

After the necessary aggregation, the correspondence with the definitions of the regional data is very close. There are three fairly minor exceptions: (1) the 39-order input-output table includes mobile homes as a part of Fabmet (fabricated metals) while the regional data assign mobile homes to Lumber (lumber and wood products); (2) the input-output table assigns forgings to Primet (primary metal manufacturing) while regional data include forgings as a part of Fabmet; and (3) the input-output table places electrical measuring instruments in Elecquip (electrical equipment) while regional data appear in Instru (instruments).

These discrepancies, however, are not sufficiently critical to require further adjustment. A major discrepancy is found in the Reestate (real estate) sector, however. The input-output table includes the value of imputed rent for owner-occupied housing, while the regional data do not. This difference in definitions was considered important enough to require remedial action. This was accomplished by resorting to the more detailed table, the 480-order table, where imputed rent is separately listed. This information was used to subtract imputed rent from the Restate sector in the aggregated input-output table.

TABLE 3.1

SECTOR DEFINITIONS

No.	Code	I/O	Description	SIC Codes
01	Farms	1	Livestock & livestock products	01,02
		2	Other agricultural products	
		4	Agricultural, forestry, and fishery services	08
02	Forest	3	Forestry & fishery products	07
03	Coalmine	7	Caol mining	12
04	Gas	8	Crude petroleum & natural gas	13
05	Metalmine	5+6	Metallic ores mining	10,11
		9+10	Nonmetallic minerals mining	14
06	Construct	11	New construction	15,16
		12	Repair & maintenance construction	17
07	Foodtob	14	Food & kindred products	20
		15	Tobacco products	21
08	Textile	16	Broad & narrow fabrics, yarn and thread mills	22
		17	Miscellaneous textile goods & Floor coverings	
09	Apparel	18	Apparel	23
		19	Miscellaneous fabricated textile products	
10	Paper	24	Paper and allied products except containers	26
		25	Paperboard containers & boxes	
11	Printing	26	Printing and publishing	27
12	Chemicals	27A	Industrial and other chemicals	28
		27B	Agricultural fertilizers and chemicals	
		28	Plastics & synthetic materials	
		29	Drugs, cleaning & toilet preparations	
		30	Paints and allied products	
		31	Petroleum and refining related industries	29
13	Rubglas	32	Rubber and miscellaneous plastic products	30
		33	Leather tanning & finishing	31
		34	Footwear & other leather products	

TABLE 3.1 (Continued)

No.	Code	I/O	Description	SIC Codes
14	Lumber	20	Lumber and wood products, except containers	24
		21	Wood containers	
		22	Household furniture	25
		23	Other furniture & fixtures	
15	Glastone	35	Glass and glass products	32
		36	Stone & clay products	
16	Primet	37	Primary iron & steel manufacturing	33
		38	Primary nonferrous metals manufacturing.	
17	Fabmet	13	ordinances & accessories	34
		39	Metal containers	
		40	Heating plumbing & fabricated structural metal products	
		41	Screw machine products & stampings	
		42	Other fabricated metal products	
18	Machine	43	Engines & turbines	35
		44	Farm & garden machinery	
		45	Construction & mining machinery	
		46	Materials handling machinery	
		47	Metalworking machinery & equipment	
		48	Special industry machinery & equipment	
		49	General industrial machinery & equipment	
		50	Miscellaneous machinery, except electrical	
		51	Office, computing & accounting machines	
		52	Service industry machines	
19	Elecquip	53	Electric industrial equipment & apparatus	36
		54	Household appliances	
		55	Electric lighting & wiring equipment	
		56	Radio, TV, and communication equipment	
		57	Electronic components & accessories	
		58	Miscellaneous electrical machinery	
20	Motor	59	Motor vehicles & equipment	37
21	Transequip	60	Aircraft & parts	
		61	Other transportation equipment	

TABLE 3.1 (Continued)

No.	Code	I/O	Description	SIC Codes
22	Instru	62	Scientific & controlling instruments	38
		63	Optical, ophthalmic, & photographic equipment	
23	Misman	64	Miscellaneous manufacturing	39
24	Transport	65	Transportation & warehousing	40-48
25	Common	66	Communications, except radio & television broadcasting	48
		67	Radio & TV broadcasting	
26	Utility	68	Private electric, gas, water & sanitary services	49
27	Wholesale	69A	Wholesale trade	50,
28	Trades	69B	Retail trade	52-57
29	Finance	70A	Finance	60-62, 67
30	Insurance	70B	Insurance	63,64
31	Reestate	71	Real Estate & rental	65
32	Lodging	72A	Hotels & lodging places	70
		76	Amusements	78,79
33	Perserv	72B	Personal and repair services, except auto	72,76
34	Busserv	73	Business services	73
35	Eatdrink	74	Eating & drinking places	58
36	Health	77A	Health services	80
37	Miscserv	75	Automotive repair and services	75
		77B	Education & social services, & membership organizations	82
		78	Federal government enterprises	
		79	State & local government enterprises	
38	HHolds			
	- row	84	Household Industry	
		-	Labor	
	-column	91	Personal Consumption Expenditures	

C. Derivation of the National Industry-by-Industry Coefficients Table

To further accommodate the problem of secondary products the Use and Make tables can be combined according to either industry or commodity technology assumptions, or a mixture of both. The industry technology assumption is that commodities are produced using the technology of the producing industry, as opposed to the industry that produces the commodity as its principal product. The commodity technology assumption is that the commodity produced uses the technology of the industry that produces it as its principal product. It is also possible to create “hybrid” industry-by-industry and commodity-by-ommodity matrices. Roberts (1992) argues that the industry-by-industry matrix is more appropriate in regional impact studies. In fact, regional tables are typically constructed on an industry basis. This section focuses on indicating explicitly how the 1987 BEA's national input-output tables provide the basis for estimating regional industry-by-industry input-output tables.

The derivation of the industry-by-industry requirements account is partly taken from Miller and Blair (1985). It is done for the open model (with an exogenous household sector). Let's adopt the following notation with m $(m = 37)$ commodities and n $(n = 37)$ industries :

$V =$ $[v_{ij}]$ is the make matrix; that is, v_{ij} represents the amount of commodity j produced by industry i; V is of dimension n x m.

$U =$ $[u_{ij}]$ is the use matrix; that is, u_{ij} represents the amount of commodity i used by industry j; U is of dimension m x n.

$E =$ $[E_i]$ is the vector of commodity deliveries to final demand; E is of dimension m x 1.

$Q =$ $[Q_i]$ is the vector of commodity total output; Q is m x 1.

$W =$ $[W_j]$ is the vector of industry value-added inputs; W is 1 x n.

$X =$ $[X_j]$ is the vector of industry total outputs; X is 1 x n.

The column sums of the make matrix can be defined as the vector of total production of commodities, Q_j, in the economy, regardless of the industry that produced them. Thus, we can write:

$$Q_j = v_{1j} + v_{2j} + \ldots + v_{nj} \tag{33}$$

An industry-share requirements matrix is derived by dividing each entry in each column of the make matrix by the respective column total. It shows, for a given commodity, the proportion of the total output of that commodity produced in each industry. The expression is the following:

$$d_{ij} = \frac{v_{ij}}{Q_j} \tag{34}$$

where,

$D = [d_{ij}]$ is the market share matrix.

The total production of a commodity from the use table is the sum of all the amounts of that commodity consumed by industries in the economy plus any sales of that commodity to final users. The expression is:

$$Q_i = u_{i1} + u_{i2} + \ldots + u_{in} + E_i \tag{35}$$

The value of industry j total output from the use table is the sum of all commodity inputs plus any value added inputs. It is given by:

$$X_j = u_{1j} + u_{2j} + \ldots + u_{mj} + W_j \tag{36}$$

Let c_{ij} be the dollar's worth of commodity i required to produce one dollar's of industry j's output, we write:

$$c_{ij} = \frac{u_{ij}}{X_j} \tag{37}$$

where,

$C = [c_{ij}]$ is the aggregated commodity-by-industry direct requirements matrix.

The aggregated national industry-by-industry direct requirements table is formed by multiplying the industry-share matrix by the commodity-by-industry direct requirements matrix. The expression is:

$$A = DB \tag{38}$$

where,

A is the traditional national I-O technical coefficients table,

D is the industry-share matrix,

B is the commodity-by-industry direct requirements matrix.

D. Regionalization of the National Input-Output Coefficients

After the derivation of the aggregated national industry-by-industry I-O coefficients matrix, an important part of this research is the regionalization of the national coefficients. As indicated in Chapter 2, the location quotient technique is the most commonly used approach to adjust the national input-output coefficients. The simple location quotient approach, (SLQ_i), is the most straightforward form. It is based on the assumption that the needs for output in any regional industry i relative to the needs for output in the corresponding national industries are the same as the ratio of total regional to total national output. One technique, the purchase-only location quotients (PLQ_i)

technique defines the base of the location quotients to be the outputs of those industries purchasing inputs from industry i instead of total regional and national outputs. The cross-industry location quotients (CLQ_i) approach, however, allows the import proportions to vary within rows by comparing the proportion of national output of selling industry i in the region to that of purchasing industry j in the region. Studies of the accuracy of these alternative techniques indicate the relative superiority of the simple location quotient approach (Flegg et al., 1996; Heskelinen and Suorsa, 1980; Jensen 1990; Morrison and Smith, 1974; Schaffer and Chu, 1969; Sawyer and Miller, 1983).

We have selected the simple location quotient approach to regionalize the national input-output coefficients. Data on earnings, payroll, employment, and number of establishments are used to specify the variables defined in the simple location quotients, as expressed by Equation 11. The regional purchase coefficients are calculated as follows:

$$p_i^r = \begin{cases} 1 \text{ if } SLQ_i \geq 1.0 \\ SLQ_i \text{ if } SLQ_i < 1.0 \end{cases} \tag{39}$$

where:

p_i^r are the regional purchase coefficients,

$i = 1, 2, ..., 37$ intermediate sectors (with households exogenous).

The regional purchase coefficients are derived by assuming that any industry i in the state will be able to supply the demands placed on it both by itself and by all other industries in the region. According to these considerations and in setting up an upper bound equal to 1.0, it can be inferred that a SLQ_i greater than, or equal to, 1.0 means that it is very likely that the industry i will be able to meet all its requirements. However, if SLQ_i is less than 1.0, only a portion of the state demand will be fulfilled by the local industry; the remaining demand must be imported.

This study, as noted at the beginning of the chapter, covers a five-year period (1988-1992). For each of these years, data on earnings, employment, payroll, and number of establishments are used to estimate vectors of simple location quotients for the 37 aggregated industries of the open model. This gives four vectors of regional purchase coefficients per year , or a total of twenty vectors for the entire period. They are reported in Appendix I.

These vectors of regional purchase coefficients are used to regionalize the national input-output coefficients. The regional input-output coefficients are calculated as follows:

$$a^r_{ij} = p^r_i a_{ij} = \begin{cases} a_{ij}\ if\ SLQ_i \geq 1.0 \\ a_{ijSLQ_i}\ if\ SLQ_i < 1.0 \end{cases} \tag{40}$$

where:

$a^r_{ij} =$ regional input-output coefficients,

$a_{ij} =$ national technical coefficients.

Thus, in those cases where SLQ_i is less than one, a^r_{ij} is less than a_{ij} for all j industries. The positive difference between a_{ij} and a^r_{ij}, when SLQ_i is less than one, is a measure of the extent of importing the i^{th} industry's output. Similarly, if SLQ_i is greater than, or, equal to, one, then a_{ij} and a^r_{ij} are equal, and the region is assumed to be self-sufficient in producing the i^{th} industry's output. The set of regional input-output coefficients a_{ij} forms the regional input coefficients matrix, A^R, as in Equation 10. This gives a total of twenty matrices of input-output coefficients; each corresponds to a vector of regional purchase coefficients.

Each matrix of regional input-output coefficients gives the direct impact of any final demand changes in any sector of the Florida economy. However, our final goal in this chapter is to calculate the regional multipliers that take account of all the effects (direct, indirect, and induced) in the region. They are estimated through the regional multiplier matrix with an endogenous household sector.

E. Endogenization of the Regional Coefficients Matrix

The multipliers can be estimated from the regional multiplier matrix based on either an exogenous or an endogenous household sector. As discussed in Chapter 2, if the household sector is not included in A^R, then the Leontief inverse shows the direct and indirect effects on regional output. However, if the model is closed with respect with household sector, the Leontief inverse shows, in addition to the direct and indirect effects, the effects on regional output induced by households spending the additional income that arises because of the final demand change. If the regional input matrix, and therefore, the Leontief inverse is expanded to include both a household row and column, then values in the multiplier matrix are larger than those from the same matrix with an open model.

In impact studies, one is mostly interested in total effects which include the additional impacts induced by consumer spending as well the direct and indirect interindustry effects, following a change in final demand for output. Open input-output models (with household exogenous) tend to underestimate total effects. Moreover, multipliers estimated with an endogenous household sector are more useful in estimating potential impacts (see, for example, Bernat and Johnson, 1991; Miller and Blair, 1985). Also, nonsurvey and survey regional multipliers models, usually used as benchmark for comparison purposes, are in general estimated with closed models (see, for example, US Dept. of Commerce-BEA, 1981, 1992, and 1997). This dissertation uses the closed model to derive regional input-output multipliers.

To include the households sector in A^R, we need to specify households behavior. Accordingly, the regional household-payments row coefficients $(a^r_{38,j})$ and the regional household-expenditure column coefficients $(a^r_{i,38})$ will be developed. The cells of the household row $(a^r_{38,j})$ show the proportion of output of industry j that is used for payments to households in the form of labor earnings. Each cell of the household column $(a^r_{i,38})$ shows the expenditures per dollar of household earnings on the product of the row industry corresponding to the entry.

The estimation of the household column coefficients is based on personal consumption expenditures column from the 1987 national input-output accounts. Each column entry in the vector is expressed as a share of total personal consumption expenditures. We have:

$$s_i = \frac{PCE_i}{TPCE} \tag{41}$$

where,

s_i = sector i share of total personal consumption expenditure

PCE_i = household spending for sector i commodity.

$TPCE$ = total personal consumption expenditure.

The column vector $S = [s_i]$ is then premultiplied by the industry-share matrix derived from the make table (see Equation 34). To obtain the adjusted national household column coefficients $a_{i,38}$. The expression is the following:

$$PCES = DS \tag{42}$$

where,

$PCES = [a_{i,38}]$ vector of adjusted national household coefficients.

The results in the previous expression have to be adjusted further in order to reflect the regional leakages due to regional taxes and savings. The treatment of taxes and savings are not taken care of in the personal consumption expenditures column from the national input-output accounts since personal consumption expenditure is just a component of final demand. The additional adjustment is expressed in the following equation (see, for example, US Dept. of Commerce-BEA, 1981):

$$a_{i,38}^{r} = a_{i,38}(1 - T^{r})C^{r} \tag{43}$$

where,

$a_{i,38}^{r}$= the regional household column coefficients,

T^{r}= average state tax rate,

C^{r}= average regional after tax consumption rate.

The variable T^{r} is equal to the ratio of regional disposable income to total regional personal income; C^{r} is the ratio of regional personal consumption expenditures to regional disposable income. Data on personal consumption expenditures are not available at the regional level. National data are used to estimate C^{r} assuming that the national consumption pattern holds at the regional level. This is consistent with using national technology as a proxy for regional technology in adjusting the A^{R} matrix.

Another step in closing the model with respect to households is the calculation and regionalization of the household row-earnings coefficients, $(a_{38,\,j}^{r})$. From the (national) Use table, the value of sector j's purchase of labor (compensation for the employees of that sector) is divided by the value of total output of sector j, X_j, to give the earnings of employees per dollar's worth of j's output for the national economy. The expression is:

$$a_{38,j} = z_{38,j}/X_j \tag{44}$$

where,

$a_{38,j}$ = national earnings coefficient for workers of sector j,

$z_{38,j}$ = compensation for employees of sector j.

The household row coefficients are then adjusted to reflect the state's loss of income that results from individuals working in the state, but residing outside the region. Commuters' income is, thus, viewed as a leakage from the regional economy.

This additional adjustment is represented by:

$$a^r_{38,j} = h a_{38,j} \tag{45}$$

where,

h = total personal income plus residence adjustment divided by total personal income, if residence adjustment is negative,

$h = 1.0$, if residence adjustment is not negative.

The data source for residence adjustment for a given period is the REIS (U.S. Dept. of Commerce-BEA, 1996). During the study period (1988-1992), residence adjustment is positive for the state of Florida, hence, no adjustment of the coefficients was needed.

The final step in the process of closing the model with respect to household is to include the intrahousehold coefficient. It represents the part of the household spending that is paid to domestic household workers. It is obtained by dividing the personal consumption expenditure corresponding to the household industry row (industry no. 84 from the national I-O accounts) by the total personal consumption expenditure. Here again, no down adjustment of the coefficient was needed for the same reason that resident adjustment was positive for the state of Florida.

With the inclusion of the household sector, we now have:

$$i, j = 1, \ldots, 38$$

F. Estimation of Total Output and Total Income Multipliers

The closing of the model with respect to households in the previous section completes the calculation of the matrix of regional input coefficients $\overline{A}^{R}$. The Leontief inverse, $\left(I - \overline{A}^{R}\right)^{-1}$, also called (closed) regional multiplier matrix is straightforward. I is a 38-by-38 identity matrix and the matrix $\overline{A}^{R}$ now counts 38 sectors.

Jensen (1980) has defined two types of accuracy in input-output analysis: partitive (cell by cell) and holistic (overall) accuracy. Jensen thinks that partitive accuracy is an unrealistic goal, especially at the regional level. He adds that, although perfect accuracy cannot be obtained in the holistic sense, it is the type of accuracy the analyst should strive for. The rest of the chapter is devoted to procedures for estimating summary measures derived from $\left(I - \overline{A}^{R}\right)^{-1}$ and known, in impact analysis, as regional input-output multipliers. We use the ADOTMATR[7] input-output computer package to help estimate these multipliers.

1. Total Output Multipliers

Since we are dealing with closed models, the output multipliers derived from the Leontief inverse are total output multipliers. The total output multiplier for an industry j is obtained by summing up the rows under industry j of the regional Leontief matrix.

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[7] ADOTMATR is an input-output computer software written by Lamphear, F.C., and R. Konecny, 1991.

The total output multipliers are given by:

$$\overline{O}_j = \sum_{i=1}^{38} \overline{\alpha}_{ij}^{r} \tag{46}$$

where,

$\overline{O}_j$ = total output multiplier for industry j in the state,

$\overline{\alpha}_{ij}^{r}$ = individual multipliers of the Leontief inverse $\left(I - \overline{A}^{R}\right)^{-1}$.

For each given year of the period, we calculate four sets of total output multipliers. Each set corresponds to a vector of simple location quotients specified by either earnings, employment, number of establishments, or payroll data. The total output multipliers estimated for the state of Florida are given in Tables 3.2, 3.3, 3.4, and 3.5.

Table 3.2
Earnings-Based Output Multipliers

Sectors	1988	1989	1990	1991	1992
1	3.0467	2.5953	2.5674	2.5674	2.4711
2	3.0249	2.7273	2.7059	2.7059	2.6779
3	2.9905	2.6939	2.6931	2.6931	2.6872
4	2.7603	2.4989	2.4943	2.4943	2.4617
5	2.1213	1.9091	1.8974	1.8974	1.8796
6	2.3826	2.1268	2.1274	2.1274	2.1262
7	3.4472	3.0111	2.9951	2.9951	2.9859
8	2.0120	1.8698	1.8620	1.8620	1.8629
9	2.0655	1.9894	1.9861	1.9861	1.9838
10	3.9294	3.6715	3.6841	3.6841	3.6882
11	1.8006	1.7329	1.7307	1.7307	1.7275
12	1.7985	1.7215	1.7232	1.7232	1.7182
13	2.1382	2.0426	2.0387	2.0387	2.0469
14	1.4406	1.3959	1.4007	1.4007	1.4036
15	1.7081	1.6350	1.6381	1.6381	1.6328
16	3.2944	3.0672	3.0654	3.0654	3.0691
17	1.9438	1.8745	1.8719	1.8719	1.8452
18	1.6511	1.5846	1.5881	1.5881	1.5848
19	2.0182	1.9200	1.9260	1.9260	1.9226
20	2.0424	1.9494	1.9478	1.9478	1.9452
21	1.8513	1.7591	1.7557	1.7557	1.7572
22	1.6569	1.5965	1.5916	1.5916	1.5927
23	1.4295	1.3922	1.3867	1.3867	1.3873
24	1.7056	1.6401	1.6348	1.6348	1.6374
25	1.8739	1.7813	1.7689	1.7689	1.7625
26	2.5863	2.4450	2.4407	2.4407	2.4451
27	2.0103	1.9367	1.9342	1.9342	1.9363
28	2.5103	2.2764	2.2632	2.2632	2.2617
29	2.1907	1.7808	1.7801	1.7801	1.7943
30	2.0900	1.8279	1.8241	1.8241	1.8154
31	3.9915	3.3148	3.3104	3.3104	3.3155
32	3.7579	3.1174	3.1133	3.1133	3.1208
33	4.1465	3.1213	3.1196	3.1196	3.1684
34	4.6566	3.7033	3.6971	3.6971	3.7242
35	3.8897	2.9001	2.8901	2.8901	2.9090
36	4.7522	4.1045	4.0715	4.0715	4.0626
37	4.0146	3.4758	3.4525	3.4525	3.4501
38	3.1343	2.6192	2.6084	2.6084	2.6184

Table 3.3
Employment-Based Output Multipliers

Sectors	1988	1989	1990	1991	1992
1	2.8326	2.7651	2.6060	2.6293	2.5224
2	2.8639	2.8224	2.7260	2.7830	2.7535
3	2.7809	2.7696	2.7457	2.7911	2.7600
4	2.6311	2.6277	2.5846	2.5889	2.5537
5	1.9714	1.9735	1.9444	1.9315	1.9233
6	2.1967	2.1896	2.1798	2.1897	2.1777
7	3.0971	3.0699	3.0208	3.0255	2.9951
8	1.9079	1.8961	1.8781	1.8818	1.8677
9	2.0102	2.0074	1.9825	1.9893	1.9931
10	3.6564	3.6585	3.6187	3.6741	3.6631
11	1.7670	1.7622	1.7460	1.7590	1.7449
12	1.7536	1.7551	1.7332	1.7724	1.7498
13	2.0410	2.0407	2.0169	2.0367	2.0076
14	1.4305	1.4260	1.4228	1.4422	1.4452
15	1.6628	1.6657	1.6517	1.6821	1.6702
16	3.1855	3.1626	3.1378	3.1655	3.1611
17	1.9482	1.9372	1.9057	1.9114	1.8806
18	1.6330	1.6327	1.6253	1.6542	1.6370
19	1.9837	1.9827	1.9803	1.9953	1.9793
20	2.0062	1.9973	1.9866	1.9835	1.9769
21	1.8305	1.8265	1.8154	1.8176	1.8120
22	1.6636	1.6601	1.6482	1.6519	1.6463
23	1.4502	1.4434	1.4335	1.4453	1.4397
24	1.7038	1.6760	1.6667	1.6821	1.6807
25	1.9139	1.8886	1.8610	1.8908	1.8765
26	2.6306	2.6038	2.5670	2.6410	2.6089
27	2.0821	2.0618	2.0319	2.1057	2.1138
28	2.4666	2.4452	2.4099	2.4728	2.4451
29	1.8588	1.8438	1.8065	1.8463	1.8290
30	1.9393	1.9106	1.8774	1.9357	1.9172
31	3.4813	3.4387	3.4115	3.4583	3.4378
32	3.2704	3.2320	3.2052	3.2484	3.2264
33	3.3528	3.2707	3.2251	3.2941	3.2698
34	3.9572	3.8856	3.8196	3.9100	3.8780
35	3.1409	3.0774	3.0129	3.0955	3.0643
36	4.4425	4.3699	4.2748	4.3167	4.2716
37	3.6186	3.5598	3.4704	3.5493	3.5330
38	2.7862	2.7456	2.6980	2.7530	2.7352

Table 3.4
Establishment-Based Output Multipliers

Sectors	1988	1989	1990	1991	1992
1	2.6304	2.6209	2.5827	2.5220	2.4321
2	2.8002	2.8490	2.8295	2.8239	2.7823
3	2.7987	2.7735	2.7563	2.7997	2.7623
4	2.8518	2.8189	2.7779	2.7428	2.7388
5	2.1510	2.1322	2.1176	2.1124	2.1080
6	2.4202	2.4006	2.3763	2.3713	2.3658
7	3.1725	3.1573	3.1500	3.1409	3.1150
8	1.9696	1.9595	1.9573	1.9596	1.9479
9	2.1012	2.0913	2.0822	2.0898	2.0716
10	3.8711	3.8366	3.8507	3.9112	3.8497
11	1.8211	1.8147	1.8134	1.8127	1.7993
12	1.7338	1.7344	1.7294	1.7397	1.7228
13	2.1495	2.1403	2.1409	2.1499	2.1373
14	1.4952	1.4909	1.4979	1.5006	1.5001
15	1.6789	1.6714	1.6676	1.6696	1.6544
16	3.3200	3.3007	3.2896	3.2826	3.2680
17	1.9195	1.9134	1.9053	1.8884	1.8744
18	1.6517	1.6444	1.6405	1.6417	1.6228
19	2.4812	2.4399	2.4788	2.5463	2.3673
20	2.1296	2.1080	2.1125	2.1229	2.0854
21	1.9660	1.9412	1.9431	1.9532	1.9306
22	1.7595	1.7382	1.7376	1.7353	1.7211
23	1.5660	1.5509	1.5280	1.5593	1.5088
24	1.8909	1.8690	1.8376	1.8886	1.7040
25	2.1123	2.1031	2.0477	2.1104	1.9885
26	3.1550	3.1403	3.1280	3.2770	3.0851
27	2.4288	2.4091	2.2903	2.3977	2.2590
28	2.7370	2.7038	2.6231	2.7347	2.6058
29	1.8719	1.9150	1.8805	1.9187	1.8875
30	1.9718	2.0043	1.9269	2.0181	1.9695
31	3.7025	3.6635	3.6062	3.6872	3.5349
32	3.4438	3.4078	3.3612	3.4381	3.3392
33	3.5721	3.5641	3.5438	3.5984	3.4702
34	4.1931	4.1972	4.1623	4.2283	4.0927
35	3.3866	3.3964	3.3386	3.3964	3.2435
36	4.8595	4.8103	4.7640	4.7991	4.6264
37	3.6639	3.6860	3.6584	3.6749	3.5719
38	2.9690	2.9693	2.9441	2.9880	2.8844

Table 3.5
Payroll-Based Output Multipliers

Sectors	1988	1989	1990	1991	1992
1	3.0384	2.9264	2.8558	2.6835	2.6981
2	2.9052	2.8615	2.8154	2.7202	2.7747
3	2.8127	2.7944	2.7985	2.8043	2.7943
4	2.6735	2.6609	2.6317	2.6124	2.6006
5	1.9752	1.9843	1.9467	1.9214	1.9268
6	2.2018	2.1895	2.1900	2.1726	2.1777
7	3.1894	3.1513	3.1334	3.0727	3.0709
8	1.9491	1.9343	1.9294	1.9071	1.9009
9	2.0391	2.0249	2.0143	1.9991	2.0042
10	3.8402	3.7784	3.7849	3.7451	3.7601
11	1.8178	1.8058	1.8030	1.7961	1.7898
12	1.7908	1.7861	1.7812	1.8049	1.7978
13	2.0578	2.0495	2.0413	2.0592	2.0323
14	1.4448	1.4374	1.4399	1.4515	1.4586
15	1.6838	1.6805	1.6810	1.7008	1.6963
16	3.2495	3.2160	3.2177	3.1953	3.2020
17	2.0051	1.9811	1.9745	1.9574	1.9432
18	1.6494	1.6467	1.6567	1.6754	1.6641
19	1.9809	1.9801	2.0232	2.0110	1.9954
20	2.0160	2.0012	2.0049	1.9902	1.9865
21	1.8400	1.8308	1.8289	1.8200	1.8125
22	1.6731	1.6648	1.6583	1.6506	1.6356
23	1.4689	1.4543	1.4510	1.4498	1.4484
24	1.7439	1.6863	1.6919	1.6873	1.6937
25	1.9496	1.9064	1.8992	1.8941	1.8897
26	2.6543	2.6249	2.6264	2.6391	2.6205
27	2.1844	2.1274	2.1405	2.1341	2.1421
28	2.5190	2.4812	2.4681	2.4729	2.4679
29	1.8812	1.8613	1.8597	1.8480	1.8466
30	1.9749	1.9471	1.9510	1.9419	1.9459
31	3.5654	3.4999	3.5137	3.4897	3.5052
32	3.3492	3.2953	3.3078	3.2820	3.2963
33	3.5292	3.4389	3.4632	3.4103	3.4521
34	4.0952	4.0086	4.0201	3.9657	4.0039
35	3.2546	3.1757	3.1784	3.1378	3.1552
36	4.6212	4.4990	4.4984	4.4119	4.4214
37	3.6807	3.6118	3.5769	3.4730	3.5928
38	2.8641	2.8148	2.8050	2.7756	2.7981

The direct application of output multipliers is appropriate in cases where a change in final demand has occurred (or, is expected to occur in the future). If the change in final demand is known (or, has been estimated) then with the use of the appropriate output multiplier the total economic impact can be estimated. In short, output multipliers are appropriate in any case that is characterized by some initial change in final demand.

Output multipliers are helpful in deciding in which sector of the state economy to increase spending. The industry with the largest multiplier would generate the greatest impact in the state economy in terms of total dollar value of output. If the maximum total output effect is the exclusive goal, a government agency that wants to spend an additional dollar (or one hundred dollars, or whatever amount) would spend all the money in that sector. Even with big anticipated expenditures, there would be no reason, on the basis of output multipliers alone, to divide that spending between the sectors of the state economy.

2. Total Household Income Multipliers

In impact analysis, the analyst is usually concerned with income generating effects. Income multipliers translate, in one way or another, the impacts of final-demand spending changes into changes in income received by households, rather than translating the final-demand changes into total value of sectoral output. From the closed regional multiplier matrix $\left(I - \overline{A}^{R}\right)^{-1}$, we can derive two types of income multipliers. These are the total household income multipliers and the Type II income multipliers.

As explained in Chapter 2, the difference between the total household income multipliers and the Type II income multipliers resides in the initial effect. In the former, the initial effect on income is in terms of dollars' worth of final demand, and hence output, for sector j. The Type II income multipliers, on the other hand, are developed on the idea that the initial dollar's worth of new output from sector j means an initial additional income payment to workers in sector j. This initial income effect of the new demand for sector j output is the earnings coefficient for workers of sector j, $a^{r}_{38,j}$.

In general, the choice between total household income multipliers and Type II income multipliers depends on the nature of the exogenous change whose impact is being studied. Final demand change is more readily available as estimation of total economic impacts in output also require information on final demand change. We estimate total household income multipliers (we use, for short, total income multipliers in the next chapters). Hence, the total household income multipliers are calculated as:

$$\overline{H}_{\mathrm{j}} = \overline{\alpha}\,^{r}_{n+1,j} \tag{47}$$

As for the total output multipliers in the previous section, four sets of total income multipliers are estimated for each year. The total income multipliers for the whole period are given in Tables 3.6, 3.7, 3.8, 3.9.

Table 3.6
Earnings-Based Total Income Multipliers

Sectors	1988	1989	1990	1991	1992
1	0.3126	0.3083	0.2955	0.2963	0.2740
2	0.1684	0.1662	0.1605	0.1636	0.1511
3	0.1209	0.1204	0.1185	0.1234	0.1116
4	0.1046	0.1044	0.1010	0.1027	0.0925
5	0.0559	0.0560	0.0546	0.0541	0.0494
6	0.0688	0.0684	0.0678	0.0688	0.0612
7	0.1255	0.1241	0.1203	0.1205	0.1147
8	0.0662	0.0656	0.0643	0.0646	0.0621
9	0.1422	0.1422	0.1403	0.1408	0.1388
10	0.2670	0.2670	0.2636	0.2676	0.2607
11	0.0801	0.0800	0.0790	0.0798	0.0767
12	0.0779	0.0779	0.0763	0.0785	0.0743
13	0.0899	0.0895	0.0885	0.0898	0.0849
14	0.0358	0.0355	0.0353	0.0363	0.0330
15	0.0377	0.0377	0.0368	0.0380	0.0346
16	0.1589	0.1576	0.1561	0.1586	0.1469
17	0.0484	0.0477	0.0460	0.0465	0.0413
18	0.0356	0.0354	0.0349	0.0363	0.0316
19	0.0570	0.0569	0.0567	0.0583	0.0508
20	0.0955	0.0950	0.0942	0.0948	0.0903
21	0.0393	0.0390	0.0382	0.0388	0.0340
22	0.0424	0.0422	0.0414	0.0417	0.0377
23	0.0191	0.0188	0.0182	0.0190	0.0154
24	0.0509	0.0495	0.0490	0.0500	0.0464
25	0.0462	0.0448	0.0430	0.0449	0.0367
26	0.1938	0.1921	0.1896	0.1945	0.1821
27	0.0987	0.0974	0.0938	0.1021	0.0779
28	0.1008	0.0991	0.0957	0.1030	0.0790
29	0.0807	0.0795	0.0763	0.0801	0.0743
30	0.0918	0.0896	0.0862	0.0923	0.0774
31	0.1999	0.1971	0.1940	0.2004	0.1760
32	0.1984	0.1960	0.1931	0.1988	0.1764
33	0.6254	0.6204	0.6174	0.6234	0.6039
34	0.7858	0.7817	0.7772	0.7850	0.7593
35	0.6665	0.6630	0.6587	0.6655	0.6412
36	0.8600	0.8561	0.8492	0.8534	0.8222
37	0.5737	0.5708	0.5655	0.5719	0.5564
38	0.1756	0.1734	0.1702	0.1750	0.1577

Table 3.7
Employment-Based Total Income Multipliers

Sectors	1988	1989	1990	1991	1992
1	0.3328	0.3241	0.3182	0.3056	0.3070
2	0.1727	0.1699	0.1665	0.1604	0.1646
3	0.1237	0.1229	0.1234	0.1249	0.1240
4	0.1106	0.1093	0.1079	0.1077	0.1062
5	0.0558	0.0560	0.0545	0.0530	0.0535
6	0.0684	0.0677	0.0680	0.0668	0.0673
7	0.1326	0.1299	0.1286	0.1243	0.1246
8	0.0690	0.0680	0.0677	0.0662	0.0660
9	0.1445	0.1437	0.1428	0.1416	0.1422
10	0.2778	0.2742	0.2741	0.2717	0.2728
11	0.0829	0.0823	0.0821	0.0816	0.0814
12	0.0800	0.0798	0.0792	0.0801	0.0797
13	0.0918	0.0911	0.0907	0.0910	0.0905
14	0.0369	0.0364	0.0365	0.0369	0.0372
15	0.0389	0.0385	0.0385	0.0388	0.0387
16	0.1645	0.1622	0.1626	0.1613	0.1620
17	0.0515	0.0502	0.0498	0.0485	0.0479
18	0.0367	0.0363	0.0366	0.0371	0.0365
19	0.0567	0.0567	0.0592	0.0589	0.0579
20	0.0964	0.0956	0.0958	0.0953	0.0949
21	0.0399	0.0394	0.0393	0.0390	0.0382
22	0.0429	0.0424	0.0421	0.0416	0.0399
23	0.0203	0.0196	0.0195	0.0194	0.0192
24	0.0530	0.0502	0.0505	0.0504	0.0506
25	0.0481	0.0461	0.0457	0.0453	0.0448
26	0.1958	0.1943	0.1943	0.1948	0.1940
27	0.1071	0.1038	0.1048	0.1044	0.1049
28	0.1065	0.1038	0.1035	0.1037	0.1035
29	0.0826	0.0814	0.0813	0.0806	0.0804
30	0.0950	0.0935	0.0937	0.0932	0.0933
31	0.2074	0.2033	0.2040	0.2028	0.2037
32	0.2052	0.2021	0.2027	0.2014	0.2022
33	0.6389	0.6337	0.6353	0.6325	0.6351
34	0.7972	0.7922	0.7930	0.7903	0.7927
35	0.6751	0.6709	0.6707	0.6687	0.6699
36	0.8724	0.8653	0.8648	0.8596	0.8600
37	0.5797	0.5760	0.5742	0.5697	0.5763
38	0.1818	0.1791	0.1785	0.1773	0.1787

Table 3.8
Establishment-Based Total Income Multipliers

Sectors	1988	1989	1990	1991	1992
1	0.2945	0.2903	0.2823	0.2816	0.2778
2	0.1678	0.1664	0.1621	0.1644	0.1621
3	0.1222	0.1206	0.1172	0.1220	0.1200
4	0.1062	0.1044	0.1011	0.1007	0.0996
5	0.0714	0.0696	0.0677	0.0680	0.0685
6	0.0888	0.0867	0.0832	0.0840	0.0848
7	0.1284	0.1264	0.1241	0.1250	0.1240
8	0.0699	0.0690	0.0681	0.0688	0.0683
9	0.1474	0.1464	0.1449	0.1461	0.1454
10	0.2790	0.2758	0.2721	0.2797	0.2767
11	0.0850	0.0842	0.0832	0.0839	0.0833
12	0.0779	0.0777	0.0764	0.0780	0.0772
13	0.0936	0.0927	0.0916	0.0931	0.0927
14	0.0394	0.0390	0.0388	0.0394	0.0396
15	0.0392	0.0385	0.0375	0.0384	0.0375
16	0.1665	0.1642	0.1615	0.1631	0.1632
17	0.0476	0.0466	0.0451	0.0454	0.0445
18	0.0363	0.0355	0.0345	0.0355	0.0345
19	0.0923	0.0889	0.0896	0.0962	0.0819
20	0.0967	0.0947	0.0938	0.0964	0.0928
21	0.0467	0.0450	0.0439	0.0455	0.0436
22	0.0481	0.0463	0.0455	0.0456	0.0440
23	0.0254	0.0245	0.0229	0.0248	0.0220
24	0.0626	0.0611	0.0590	0.0621	0.0520
25	0.0552	0.0553	0.0519	0.0554	0.0505
26	0.2160	0.2160	0.2136	0.2223	0.2138
27	0.1210	0.1195	0.1028	0.1193	0.1121
28	0.1143	0.1122	0.0989	0.1149	0.1072
29	0.0788	0.0829	0.0793	0.0836	0.0825
30	0.0914	0.0944	0.0850	0.0961	0.0945
31	0.2113	0.2068	0.1936	0.2096	0.2013
32	0.2079	0.2035	0.1918	0.2068	0.2017
33	0.6400	0.6358	0.6282	0.6385	0.6325
34	0.8006	0.7969	0.7875	0.7997	0.7932
35	0.6844	0.6811	0.6707	0.6809	0.6731
36	0.8877	0.8803	0.8697	0.8800	0.8711
37	0.5781	0.5767	0.5716	0.5761	0.5707
38	0.1898	0.1876	0.1821	0.1891	0.1838

Table 3.9
Payroll-Based Total Income Multipliers

Sectors	1988	1989	1990	1991	1992
1	0.3576	0.2870	0.2847	0.2847	0.2740
2	0.2070	0.1559	0.1543	0.1543	0.1511
3	0.4134	0.1122	0.1124	0.1124	0.1116
4	0.1545	0.0954	0.0953	0.0953	0.0925
5	0.1010	0.0506	0.0502	0.0502	0.0494
6	0.1184	0.0614	0.0616	0.0616	0.0612
7	0.2122	0.1174	0.1164	0.1164	0.1147
8	0.2720	0.0628	0.0624	0.0624	0.0621
9	0.1517	0.1395	0.1393	0.1393	0.1388
10	0.2992	0.2613	0.2616	0.2616	0.2607
11	0.0896	0.0772	0.0770	0.0770	0.0767
12	0.0857	0.0750	0.0749	0.0749	0.0743
13	0.1010	0.0849	0.0849	0.0849	0.0849
14	0.0404	0.0327	0.0329	0.0329	0.0330
15	0.0481	0.0351	0.0351	0.0351	0.0346
16	0.1876	0.1465	0.1644	0.1644	0.1469
17	0.0562	0.0430	0.0428	0.0428	0.0413
18	0.0424	0.0318	0.0319	0.0319	0.0316
19	0.0677	0.0511	0.0515	0.0515	0.0508
20	0.1070	0.0909	0.0908	0.0908	0.0903
21	0.0509	0.0345	0.0343	0.0343	0.0340
22	0.0510	0.0384	0.0381	0.0381	0.0377
23	0.0233	0.0158	0.0155	0.0155	0.0154
24	0.0600	0.0468	0.0466	0.0466	0.0464
25	0.0558	0.0380	0.0373	0.0373	0.0367
26	0.2092	0.1824	0.1822	0.1822	0.1821
27	0.0938	0.0797	0.0793	0.0793	0.0779
28	0.1223	0.0814	0.0805	0.0805	0.0790
29	0.1046	0.0735	0.0735	0.0735	0.0743
30	0.1031	0.0792	0.0788	0.0788	0.0774
31	0.2608	0.1784	0.1777	0.1777	0.1760
32	0.2584	0.1784	0.1778	0.1778	0.1764
33	0.7737	0.6023	0.6022	0.6022	0.6039
34	0.9083	0.7594	0.7590	0.7590	0.7593
35	0.8073	0.6425	0.6417	0.6417	0.6412
36	0.8392	0.8277	0.8251	0.8251	0.8222
37	0.6552	0.5584	0.5572	0.5572	0.5564
38	0.2524	0.1586	0.1579	0.1579	0.1577

CHAPTER IV

STATISTICAL TESTS

A. Introduction

In this chapter the results of the statistical tests conducted for comparing the multipliers derived in the previous chapter are reported. There exist a variety of alternative standard measures in determining the accuracy of input-output multipliers. The next section (Section B) describes the most common ones and explains the basis for selecting the tests we use.

The accuracy analysis per se starts with Section C. For a given multiplier type, the vectors of multiplier estimates are compared with a vector of RIMS II multipliers (U.S. Department of Commerce-BEA, 1997). Details on the RIMS II model are also given in that section. Then, Section D compares the sets of multiplier estimates one with another in order to study their statistical differences, both in terms of size and ranking distributions.

The statistical tests performed would not hold unless the multiplier estimates are stable during the period (1988-1992) under study. Section E studies the stability of these multipliers. The final section summarizes the chapter and offers some preliminary observations of the results.

B. Statistical Analysis

Regional analysts have used a number of tests for comparing multipliers. Determination of which techniques should be used is often difficult, as each statistical test yields a different type of information. Butterfield and Mules (1980) suggest a battery of complementary tests that can be used to compare two matrices in order to assess how closely they resemble each other. Their suggestions can be helpful in comparing regional input-output multipliers.

A first step in the testing routine suggested by Butterfield and Mules is the use of non-parametric tests to check for consistent over- or under-estimation of the multipliers. The test used is the error sign test. For each comparison, we count the number of sectors that are overestimated in the vector of “true” multipliers as well as the number of sectors that are underestimated.

The other non-parametric test is to calculate a measure of distance such as the Mean Absolute Deviation (MAD) or the Standardized Mean Absolute Deviation (SMAD). Butterfield and Mules feel that the MAD statistic is useful for purposes of comparison, but that the SMAD is even more powerful. The SMAD is a refinement of the MAD; it standardizes the error with respect to the size of the true coefficient. A problem arises in using the SMAD statistic to compare input-output tables, though, when one of the "true" coefficients is zero. They, therefore, suggest calculating the SMAD statistic only for non zero entries, and to use that in conjunction with the MAD statistic. When comparing two vectors of multipliers the problem of zero elements in the "true" vector does not arise since all the multipliers will be nonzero.

An advantage of the SMAD statistic is that the mean values may be converted to percentages that may be compared to percentage errors found in similar studies elsewhere.

The SMAD test statistic is defined as:

$$SMAD = \frac{1}{n}\sum_{i=1}^{n} \left| \frac{m_i - m_i^*}{m_i^*} \right| \tag{48}$$

where,

m_i = the calculated multiplier for sector i,

m_i^* = the "true" multiplier for sector i, and

n = 38 sectors (closed model).

The SMAD statistic has no parametric properties; it is not possible to test its significance, either from zero or from any other number. Yet, we can have some guidance by reviewing a few studies. Schaffer and Chu (1969), for example, evaluated the non-survey input-output techniques at the regional level. They derived total income multipliers and found that, "the mean multiplier under the location quotient technique is 47 percent higher than for the survey ..." (Schaffer and Chu, p. 26). Morrison and Smith (1974) conducted a similar study and found that, on average, the total income multiplier estimates under the simple location quotient technique overestimated the survey multipliers by 27.4 percent. They thought that the "distance was quite large in absolute terms".

Another relevant study is by Burford and Katz (1981) who conducted experiments to test a short-cut multiplier based on column total of the direct requirements table. They calculated output multipliers for the state of Louisiana and compared them with survey-based output multipliers. Burford and Katz found an "average absolute error of 3.81 percent" and concluded that "the multipliers estimates ... are fairly close" (Burford and Katz, p. 155-156). Katz and Burford (1980) also used six regional tables to test their short-cut formulas and found that the original multipliers are within 5 percent of the actual multipliers. They qualified these estimates as "reasonable." Finally, we should note the conclusions of Garnick (1970) for comparing survey-based input-output Type II income multipliers with nonsurvey counterpart multipliers. He found an absolute mean difference of 10 percent and concluded that the two estimates appeared to be "within tolerable limits."

The parametric tests which Butterfield and Mules suggest are regression of the estimated coefficients on the "true" coefficients, and calculation of the Pearson's r correlation coefficient. The estimated regression equation is:

$$m_i = b_0 + b_1 m_i^*, \qquad i = 1, \ldots, 38 \text{ and } b_1 > 0, \tag{49}$$

where b_0 and b_1 are estimates of the parameters β_0 and β_1. If $b_0 = 0$ and $b_1 = 1$, the two sets of multipliers are in fact identical. The hypotheses

$$\beta_0 = 0$$

$$\beta_1 = 0$$

and

$$\beta_1 = 1$$

can be tested using the usual t-test.

Butterfield and Mules think that an intercept not significantly different from zero and a slope coefficient not significantly different from unity indicate the two sets of multipliers are good estimates of each other. However, for any other cases "some ambiguity may arise". In these cases some under- or overestimation or both occur. "This makes it difficult to reach a judgment, particularly when comparing or attempting to rank two or more techniques for estimating benchmark coefficients" (Butterfield and Mules, p. 298). The regression analysis is not performed in this study.

The final step in the routine is to calculate the Spearman-rank correlation coefficient. It measures the degree of association between two distributions of rankings; if the rankings were the same, the coefficient would equal one.

The Spearman-rank correlation coefficient is calculated as:

$$r_s = 1 - \frac{6\sum_{i=1}^{n} D_i^2}{n(n^2-1)} \tag{50}$$

where D_i = difference between the size rankings of m_i and m_i^*, as defined before.

In implementing this statistic, the multiplier values for the rows in each column are ranked from highest to lowest. For each multiplier type, Spearman correlation coefficients are then calculated between the single vector of RIMS II multipliers and each vector of earnings-, employment-, establishments-, and payroll-based multiplier estimates for the period 1988-1992. This gives five (5) correlation coefficients per variable under study, or a total of twenty (20) for the period.

The major advantage of the Spearman-rank correlation is that, contrary to the Pearson r correlation, hypothesis testing does not require any assumption (Glenberg, 1996). The null hypothesis $H_0 : \rho = 0$ that the two vectors being compared have similar rank-ordering is tested at the .05 level of significance against the alternative hypothesis that the null is wrong $H_1 : \rho > 0$. The appropriate test is the t-statistic calculated as:

$$t = \frac{r_s}{S_{r_s}} \tag{51}$$

having $n - 2$ degrees of freedom. The standard deviation, S_{r_s}, is given by:

$$S_{r_s} = \sqrt{\frac{1-r_s^2}{n-2}} \tag{52}$$

We report the number of times the correlation is significant

An alternative procedure, Theil's inequality coefficient (U), which was used in both the Stevens and Trainer (1980) and Park et al. (1981) studies, was not chosen here. The use of a number of tests, as suggested by Butterfield and Mules (1980), and Miernyck (1976), seems to be more informative than a single test. Also, the property of the Theil U statistic which caused the other authors to use it, i.e., that it can be decomposed into three sources of prediction error, actually yields little additional information. In case U is not equal to zero, we can look for errors of central tendency (U^m), unequal variation (U^s), or incomplete covariation (U^c) (Theil, 1966).

The bias proportion U^m is an indication of systematic error, since it measures the extent to which the average values of the "true" multipliers and actual multipliers deviate from each other. To take the average value of a set of sectoral multipliers is not particularly meaningful. The SMAD statistic, described earlier, takes into account the mean of the differences between each pair of multipliers. It is far more useful for comparing multipliers.

The variance proportion U^s indicates differences in standard deviations between the two sets of multipliers. Once again, it is not clear what useful additional information the analyst can obtain by looking at deviations from the mean since the mean of sectoral multipliers is not a very useful measure.

Finally, the covariance proportion U^c measures what we may call unsystematic error. It represents the remaining error after deviations from average value and average variability have been accounted for. This value is calculated using the correlation coefficient between the two sets of multipliers. It is obviously the most useful proportion. The SMAD and the Spearman-rank correlation analysis, are, above all, better tools.

Before we conduct the statistical tests, a word of caution is necessary. The comparison analysis is concerned with forecast errors, that is, with the difference between “expectations” and “outcomes”. As such, it deals with the degree to which the forecasts are imperfect. In multiplier analysis, as we have indicated above, the average value of a series of sectoral multipliers is of little analytical meaning. Hence, most of the statistical tools used for comparing groups cannot be used in their typical way.

The tests that follow utilize little in the way of initial assumptions which might distort their performance. The comparison analysis is mainly descriptive and significance tests play only a complementary role. For each test we perform, we report only the average (or total) statistics. The average is taken over the five-year period for each variable category and multiplier type. The tests performed in a section are reported, first, for the output multipliers and, then, for the income multipliers.

C. Results of the Comparisons with the RIMS II Multipliers

Richardson (1985), and Rickman and Schwer (1995) have already pointed out the pitfalls of comparing regional input-output multipliers. The actual values against which multiplier estimates are compared are usually derived from survey-based or other non-survey-based models. The comparisons assume that these models generate "true" values. Such assumption is certainly questionable since measurement errors may be associated with both survey and non-survey estimates of multipliers. Yet, it is necessary to adopt some norm against which to compare the multipliers we estimated. The RIMS II multipliers for the state of Florida are used as basis for comparison in this section.

The RIMS II model is maintained by the U.S. Department of Commerce, BEA. Statistical tests such as Spearman-rank correlation coefficients, Theil statistic, and Chi-square statistic, used to investigate the validity of the RIMS II model, have found a percent error non-significant (U.S. Dept. of Commerce-BEA, 1981; Brucker et al., 1990). "According to empirical tests, the estimates based on RIMS II are similar in magnitude to the estimates based on relatively expensive surveys" (U.S. Department of Commerce-BEA, 1997, p. 1).

The RIMS II multipliers are based on two main data sources:

(1) BEA's 1987 benchmark input-output accounts for the U.S. economy, and

(2) BEA's 1992 SIC regional wage-and-salary data.

We have a vector of RIMS II output multipliers and a vector of RIMS II income multipliers. For each year and variable type (earnings, employment, number of establishments, and payroll), the same and only vector of RIMS II output multipliers is compared with a vector of output multiplier estimates. In other words, for each year, the vector of RIMS II output multipliers is compared with the vector of earnings-, employment-, establishment-, and payroll-based output multiplier estimates successively. This gives a total of 190 sector by sector comparisons over the entire period (1988-1992) for each variable-based output multiplier vector; or a grand total of 760 sectoral comparisons.

The same procedure is followed for comparing the estimated income multipliers with the vector of RIMS II income multipliers. The RIMS II model, rather, uses the term “final-demand earnings multipliers" to denote total (household) income multipliers. We use the term “total income multipliers” to avoid any confusion.

Three statistical tests follow. The error sign test is searching whether or not the calculated multipliers of the model overestimate or underestimate the “true” RIMS II multipliers. The SMAD gives the average percentages by which the calculated multipliers deviate from the RIMS II multipliers. Finally, the Spearman-rank correlation analysis tests for statistical differences in the rank-ordering of row elements of two sets. Each test is conducted for both the total output multipliers and the total income multipliers.

1. Error Sign Test

The error sign test starts with the calculation of the sectoral deviations between the observed multipliers and the "true" RIMS II multipliers. The expression is:

$$D_i = m_i - m_i^* \tag{53}$$

where,

D_i = deviations between sectors i for the two multipliers vectors,

m_i = calculated multiplier for sector i,

m_i^*= RIMS II multiplier for sector i.

A positive D_i indicates that the observed multiplier of sector i overestimates the corresponding RIMS II multiplier while a negative D_i indicates an underestimation.

a) Total Output Multipliers

The results indicate that the calculated output multipliers overestimate the RIMS II output multipliers for all the variables under study. The overestimation occurs 100 percent of the time, that is, for all the 760 sectoral comparisons.

b) Total Income Multipliers

The results of the error sign test for the total income multipliers are opposite to those obtained for the total output multipliers. The observed income multipliers underestimate the RIMS II multipliers in all the cases, that is, for all the variables and the whole period.

2. SMAD Statistics

As outlined in the previous section, one method for comparing observed multipliers with "true" multipliers is to calculate the Standardized Mean Absolute Deviation (SMAD) between the two sets of multipliers. For each multiplier type and given year, SMAD statistics are calculated between the vector of RIMS II multipliers and that of the earnings-, employment-, establishment-, and payroll-based multipliers successively. The results for the total output and income multipliers are presented next.

a) Total Output Multipliers

Table 4.1 presents the results of the SMAD statistics for the comparison between the estimated output multipliers and the RIMS II output multipliers. The average SMAD statistic between the RIMS II output multipliers and the earnings-based output multipliers is similar to that estimated for the RIMS II output multipliers and the employment-based multipliers, that is, 0.6744 and 0.6722 respectively. The average SMADs between the vector of RIMS II output multipliers and the other sets are: establishment-based multipliers 0.7854 and payroll-based multipliers 0.7018.

In terms of percentages, we could say when the simple location quotients are specified by the earnings, employment, number of establishments, and payroll data, the total output multipliers respectively deviate from the RIMS II multipliers by about 67.44%, 67.22%, 78.54%, and 70.18%.

b) Total Income Multipliers

The average SMAD statistics for the total income multipliers are also given in Table 4.1. The analysis is done the same way as for the total output multipliers. Here, the RIMS II total income multipliers deviate from the earnings-based income multipliers by 68.78%; from the employment-, establishment-, and payroll-based income multipliers by 67.76%, 66.76% and 67.22% respectively.

Table 4.1

SMAD Statistics for Comparing Estimated Total Output and Income Multipliers with RIMS II Multipliers

	Output Multipliers	Income Multipliers
Earnings	0.6744	0.6878
Employment	0.6722	0.6776
Number of Establishments	0.7854	0.6676
Payroll	0.7018	0.6722

3. Spearman-rank Correlation Analysis

As outlined earlier, the Spearman-rank correlation coefficient measures the strength of the association of the ranking of the row-industries in two vectors of multipliers.

a) Total Output Multipliers

The Spearman-rank correlation coefficients between the vectors of output multiplier estimates and the vector of RIMS II output multipliers are very low, ranging from 0.02 to 0.07. We fail to reject the null hypothesis $H_0 : \rho = 0$ in all the comparisons, indicating statistical significant differences in the rank-ordering of the row-industries forming the vectors of output multiplier estimates and those making the vector of RIMS II output multipliers.

b) Total Income Multipliers

As for the analysis of the output multipliers, the Spearman-rank correlation coefficients between the vectors of income multiplier estimates and the vector of RIMS II income multipliers are low, ranging from 0.01 to 0.07. Also, the null hypothesis that the correlation coefficient equals zero is not rejected in any of the comparisons. This indicates statistical significant differences in the rank-ordering of the row-industries of these vectors.

D. Tests of Equality of the Vectors of Multiplier Estimates

The accuracy tests performed in this section deals with whether or not the earnings-, employment-, establishment-, and payroll-based location quotients generate equal multipliers. The tests follow the same routine as the previous section. Here, however, we undertake a multiple-comparison analysis, as described by Kenkel (1989). It involves performing a series of vector-paired comparisons sequentially.

The total number of comparisons is given by $k(k-1)/2$; $k = 4$ represents the number of variables. For each year, we have, thus, six comparisons. Again, average results for the entire period 1988-1992 are reported.

1. Error Sign Test

a) Total Output Multipliers

When we compare the vectors of earnings-based output multipliers with the other sets of output multipliers, we find that they are lower than the employment-, establishment-, and payroll-based output multipliers, respectively, in 98%, 99%, and 98% of the cases. The employment-based output multipliers are, respectively, 92 percent, and 85 percent of the time lower than the payroll- and establishment-based output multipliers. Finally, the results indicate that 75 percent of the output multipliers from the payroll data are lower than those estimated with the number of establishments.

A summary of the results of the sign test is presented in Table 4.2. Multipliers listed across the top of the table are subtracted from those listed at the left. A plus (+) sign indicates that the multiplier across the top of the table overestimates that from the left in at least 51 percent of the cases.

We find that the earnings-based location quotients generate the lowest set of multipliers, followed by the employment-, payroll-, and establishment-based location quotients.

b) Total Income Multipliers

A summary of the error sign test conducted for the total income multipliers is given in Table 4.3. Again a plus (+) sign indicates that there is overestimation by the multipliers resulted from the variables across the top; a negative (–) sign indicates an underestimation.

Table 4.2

Sign Test for Comparing Total Output Multipliers[a]

	Earnings	Employment	Establishment	Payroll
Earnings		+	+	+
Employment	−		+	+
Establishment	−	−		−
Payroll	−	−	+	

Table 4.3

Sign Test for Comparing Total Income Multipliers[a]

	Earnings	Employment	Establishment	Payroll
Earnings		+	+	+
Employment	−		+	+
Establishment	−	−		−
Payroll	−	−	+	

[a] A (+) sign indicates an overestimation by the multiplier across the top of the table while a (−) sign indicates an underestimation.

Apart some minor differences, the results for the income multipliers are quite similar to those obtained for the output multipliers. The total count of the signs gives the following percentage results. The earnings-based income multipliers underestimated the employment-, establishment-, and payroll-based income multipliers in 98%, 81%, and 99% of the cases respectively. The employment-based income multipliers are, respectively, lower than the establishment-, and payroll-based income multipliers in 96% and 68% of the cases. Finally, we find that the payroll-based income multipliers underestimated the establishment-based income multipliers in 92% of the cases.

The results show the same ranking as for the output multiplier estimates, In overall, the earnings-based income multipliers are the lowest, followed by the employment- and the payroll-based income multipliers. The establishment-based income multiplier estimates have the highest values.

2. SMAD Statistics

a) Total Output Multipliers

This stage of the test routine concerns the analysis of measures of absolute distances between the vectors of output multiplier estimates. Average SMADs over the five-year period are presented in Table 4.4. The multipliers that originate from the variables specified in the far left of Table 4.4 are assumed the "true" multipliers. Based on the SMAD statistic, the employment- and the payroll-based location quotients techniques generate the closest multiplier values; the average SMAD is 0.0147. With the earnings-based output multipliers as the “true” values, the average SMADs for the employment-, establishment-, and payroll-based multipliers are, respectively, 0.0284, 0.0842, and 0.0419. The average SMAD between the employment- and the establishment-based output multiplier estimates equals 0.0568, and that between the establishment- and the payroll-based output multipliers is 0.0236.

In terms of percentages, for example, we could say that, on average, the earnings-based output multipliers deviate from the employment-based output multipliers by almost 3 percent, from the establishment-based output multipliers by 8.4 percent, and from the payroll-based output multipliers by about 4.2 percent.

b) Total Income Multipliers

The results of the SMADs for the sets of total income multipliers are also given in Table 4.4. They indicate the following. Once again, starting with the earnings-based income multipliers as the "true" values, we find that the average SMADs distance from the employment-, establishment-, and payroll-based income multipliers by 8.2 percent, 16.78 percent, and 11.03 percent, respectively. The employment-based income multipliers deviate from the establishment- and the payroll-based income multipliers by 8.22 percent and 2.78 percent, respectively. Finally, the deviation between the establishment- and the payroll-based income multipliers is, on average, 3.52 percent.

A very obvious result for Table 4.4 is that, for a given variable, the average SMADs for the vectors of income multiplier estimates are higher, in all the cases, than the average SMADs obtained for the sets of output multiplier estimates.

Table 4.4

SMAD Statistics for Comparing the Vectors of Observed Multipliers

	Output Multipliers	Income Multipliers
Earnings-Employment	0.0284	0.0820
Earnings-Establishment	0.0842	0.1678
Earnings-Payroll	0.0419	0.1103
Employment-Establishment	0.0568	0.0822
Employment-Payroll	0.0147	0.0278
Establishment-Payroll	0.0236	0.0352

3. Spearman-rank Correlation Coefficient

This part of the test routine compares the ranking of the row-industries in the estimated vectors of multipliers. Again, the vectors are compared with each other, based on the multiple comparison approach. The Spearman-rank correlation coefficients are calculated for the six paired-vector comparisons. The null hypothesis that there is no rank-ordering association is tested at the 0.05 level of significance, using the t-statistic defined in Equation 51.

a) Total Output Multipliers

The range of the estimated Spearman-rank correlation coefficients is from 0.984 to 0.998. The coefficients were all significant at 0.05 level of significance for a one-tailed test, indicating that the rank-ordering of the vectors of output multiplier estimates are statistically similar.

b) Total Income Multipliers

Spearman correlation coefficients are also calculated for the income multiplier estimates. The results are almost similar to those of the output multiplier estimates. The values of the coefficients range from 0.0987 to 0.999 and the null hypothesis ($H_0 : \rho = 0$) for the one-tailed test is rejected in all the cases. Again the indication is that the vectors of income multiplier estimates have the same industry-specific rank-size distributions.

The results of the Spearman-rank correlation coefficients confirm the findings of the SMAD statistics which showed that, for a given multiplier type, the sets of multipliers estimated with our input-output model, are good estimates of each other. In the last section, we present a summary of the statistical tests and results.

Most of the results reported above would be meaningless unless the multipliers are stable over the period under study. Because of the crucial aspect of this assumption, we test the stability of the multiplier estimates in the next section. We perform the error sign test and the SMAD statistic.

E. Tests of Stability of the Multiplier Estimates: A Sensitivity Analysis

The question here is: what set of multipliers would have been expected if, in fact, the multipliers are stable over the period 1988-1992. If we can answer this question, a comparison can be made between the actual observed set of multipliers and what would have been expected. The 1988 multipliers are considered the "expected" and are compared, successively, with the 1989, 1990, 1991, and 1992 multiplier estimates.

1. Error Sign Test

a) Total Output Multipliers

Table 4.5 presents the number of cases for which the output multipliers calculated for 1989, 1990, 1991, and 1992 under- or overestimate the "expected" 1988 output multipliers. The tendency is an underestimation throughout the five-year period. We have noted many cases having deviations equal to zero at three- and four-digit decimals; we define them as borderline cases. They are also reported in Table 4.5.

b) Total Income Multipliers

The results of the error sign test for the stability of the income multiplier estimates are reported in Table 4.6. The deviations are again estimated, successively, between the 1989, 1990, 1991, and 1992 multipliers sets and the "predicted" 1988 vectors. The general pattern here is similar to that found for the output multipliers, with the exception that we now have a much higher number of borderline cases.

Table 4.5

Results of Error Signs for Stability

of Output Multipliers*

	Earnings	Employment	Number of Establishments	Payroll
Overestimated Cases	0	29	23	14
Underestimated Cases	130	121	126	138
Borderline cases[1]	22	2	3	0
Total Cases for the Period	152	152	152	152

[1] Borderline cases are those with deviations equal zero at three- and four-digit decimal level.

* 1988 Multipliers are the "expected" estimates for all the comparisons.

Table 4.6

Results of Error Signs for Stability of Income Multipliers*

	Earnings	Employment	Number of Establishments	Payroll
Overestimated Cases	3	5	8	3
Underestimated Cases	30	89	115	113
Borderline cases[1]	119	58	29	36
Total cases for the Period	152	152	152	152

[1] Borderline cases are those with deviations equal zero at three- and four-digit decimal level.

* 1988 Multipliers are the "expected" estimates for all the comparisons.

2. SMAD Statistics

a) Total Output Multipliers

The results of the SMAD statistics for the period differences during the five-year period and the overall average SMAD are given in Table 4.7. In most cases, sectoral deviations are increasing with time, which is consistent with theoretical settings since the multipliers are expected to be less stable as the time period widens.

The smallest average SMAD is obtained for the earnings-based output multipliers (0.0030) while establishment-based output multipliers record the highest average SMAD (0.0152). The other average SMADs are 0.0119 and 0.0133 for the employment- and payroll-based output multipliers, respectively.

b) Total Income Multipliers

Table 4.8 presents the SMAD statistics obtained for the differences between the "expected" 1988 vector of income multipliers and the 1989, 1990, 1991, and 1992 vectors. The five-year average SMAD for the earnings data is the lowest (0.0077), followed by that of the payroll-based income multiplier estimates (0.0215). The SMADs for the payroll-based income multipliers present historical consistencies. They tend to increase with time. Such consistent increases are theoretically expected since the multipliers tend to be less stable as time passes. The five-year period average SMADs for the employment- and establishment-based income multipliers are, respectively, 0.0182 and 0.0312. However, there was no historical pattern for these multipliers.

Table 4.7

SMAD Statistics

for the Stability of the Output Multipliers.

The table reports Standardized Measures of Absolute Deviations for the Output Multipliers for 1988-89,88-90, 88-91, 88-92.

Periods	Earnings	Employment	Establishments	Payroll
1988-89	0.0023	0.0063	0.0104	0.0072
1988-90	0.0025	0.0171	0.0127	0.0127
1988-91	0.0026	0.0099	0.0193	0.0097
1988-92	0.0048	0.0143	0.0182	0.0236
Average	0.0030	0.0119	0.0152	0.0133

Table 4.8

SMAD Statistics

for the Stability of the Income Multipliers.

The table reports Standardized Measures of Absolute Deviations

for the Income Multipliers for 1988-89,88-90, 88-91, 88-92.

Periods	Earnings	Employment	Establish-ment	Payroll
1988-89	0.0075	0.0090	0.0169	0.0147
1988-90	0.0077	0.0283	0.0443	0.0184
1988-91	0.0077	0.0140	0.0200	0.0264
1988-92	0.0078	0.0182	0.0435	0.0215
Average	0.0077	0.0182	0.0312	0.0215

F. Summary of the Chapter

Three statistical tools were used for comparing the multipliers: the error sign test, the Standardized Absolute Mean Deviation (SMAD), and the Spearman-rank correlation analysis. These tests are mainly complementary as each gives a different type of information.

We started with the comparison between the estimated multipliers and the "true" RIMS II multipliers. The results of the error sign test, coupled with the average SMAD statistics indicate that the earnings-, employment-, establishment-, and payroll-based estimated output multipliers overestimate the "true" RIMS II output multipliers by 67.44%, 67.22%, 78.54%, and 70.18% respectively.

The scenario was different for the income multipliers. The earnings-, employment-establishment-, and payroll-based estimated income multipliers underestimate the "true" RIMS II income multipliers, respectively, by 68.78%, 67.76%, 66.76%, and 67.22%.

To terminate the comparison with the RIMS II multipliers, we calculated the Spearman-rank correlation coefficient that we tested at the 0.05 level of significance. We failed to reject the null hypothesis in all the cases for both the output multipliers and the income multipliers. This indicated that, for each multiplier type, the vectors of multiplier estimates have different sectoral ranking distributions from the vectors of RIMS II multipliers.

We, then, turned to the comparison of the vectors of multiplier estimates among themselves. We could use the previous results to deduct information about differences among the vectors of multiplier estimates, namely by analyzing the differences between the percentage over- and under-estimation reported above. However, more information is obtained with the multiple comparison analysis.

The results of the multiple comparison analysis for the vectors of estimated output multipliers and the vectors of income multipliers showed that the relationship worsens among the estimated vectors of income multipliers. The SMAD, estimated for any two vectors of income multiplier estimates, is larger than that of the counterpart output multipliers. The results were reported in Table 4.4.

The final test performed was the Spearman-rank correlation analysis. We rejected the null hypothesis at 0.05 significance level for all the multiple comparisons. This showed that the vectors of estimated output multipliers have similar row-industry ranking distributions. The findings also showed no difference in the rank-ordering of the vectors of income multiplier estimates. Tests of stability of the multiplier estimates also indicated that both the output and income multiplier estimates are stable over the period under study although the income multipliers appear less stable.

CHAPTER V

SUMMARY AND CONCLUSIONS

A. Introduction

The matrix of regional purchase coefficients, commonly estimated through the simple location quotients, is important to the accuracy of regional input-output multipliers. We studied the relative accuracy of total output and income multipliers when the simple location quotients are specified by earnings, employment, number of establishments, and payroll data.

We present, in this final chapter, the major steps followed to estimate and, then, evaluate these multipliers. The last section presents the major conclusions of this dissertation and the policy implications.

B. Model Development

Three major tasks were required for developing an appropriate non-survey regional input-output model and estimating its multipliers. First, we derived the national industry-by-industry direct requirements table. Second, we regionalized the national table by means of vectors of simple location quotients to reflect the state of Florida's industrial structure and trading patterns. Data on earnings, employment, number of establishments, and payroll specified the simple location quotients; a regional table was developed for each vector of simple location quotients. Then, the industry-by-industry tables of regional input-output coefficients were closed with respect to households and, then, used to derive total output and income multipliers.

1. The Adjusted National Coefficients Table

The first task in preparing the national direct requirements table was to aggregate the two most important tables (at least for this research) in BEA's 1987 benchmark I-O accounts for the U.S. economy: the Use table and the Make table. The aggregation was made on the basis of regional data availability and, primarily, for comparison suitability with the 38 industries of the vector of RIMS II multipliers. The 95 input-output industries in the Use and Make tables were aggregated into 38 industries (37 intermediate industries and 1 household sector).

The next step was to derive the 37-order industry-share matrix. It showed each industry's share of the production of a commodity, and was formed by dividing each entry in each column of the Make table by the respective column total. We also calculated a commodity-by-industry direct requirements table by dividing each entry in each column of the Use table by the respective column total. Then, the industry-share matrix premultiplied the commodity-by-industry requirements table to form the national industry-by-industry direct requirements table.

Because it is customary in regional impact analysis to account for the effects of changes in household income and expenditure, the model included households as both suppliers of labor inputs to regional industries and as purchasers of regional output. In other words, we closed the model with respect to households.

The closing of the model started with the derivation of a household row of labor earnings. We divided each entry of the employee compensation row in the Use table by the total output of industry j. The entries in the household row showed the earnings received by households per dollar of output of industry j.

Next, we estimated a household-expenditure column by expressing each entry in the personal consumption expenditures column of the I-O accounts as a share of total personal consumption expenditures. Each entry in the household column showed the expenditures per dollar of household income on the product of the row industry corresponding to the entry. This column was then multiplied by the industry-share matrix for an initial adjustment.

2. The Regional Industry-by-Industry Coefficients Tables

The national direct requirements table, now closed with respect to household, was regionalized using the simple location quotient technique. Data on earnings, employment, number of establishments, and payroll specified the location quotients and, thus, formed the vectors of regional purchase coefficients. Four vectors were constructed for each year. We had a total of twenty vectors of regional purchase coefficients for the five-year period under study (1988-1992).

The simple location quotient was used here as a measure of the extent to which regional supply of an industry's output has been sufficient to meet regional demand. If the simple location quotient for a row industry in the matrix of regional coefficients was greater than, or equal to, one, we assumed that the region's demand for the output of the row industry was met entirely from regional production. In this instance, the entries in the row industry of the matrix of regional coefficients were equal to the corresponding entries in the table of national technical coefficients.

Conversely, if the simple location quotient was less than one, the assumption was that regional supply of the industry's output has not been sufficient to meet regional demand. Hence, the row entries for the industry in the table of regional coefficients were to the product of the corresponding entries in the table of national technical coefficients and the simple location quotient for the industry.

The household row and the household column that we added to the table of national technical coefficients were also adjusted regionally. We adjusted the household row entries to reflect the loss of income due to individuals working in the state but residing outside the state. We adjusted the household-column entries down to account for the leakage effects of taxes and savings on expenditures.

3. The Regional Leontief Inverse and the Multipliers

The Leontief inverse $(I - A^R)^{-1}$, also called a regional output multiplier table, was calculated from the matrix of regional coefficients. In the Leontief inverse, each column entry indicated the change in output in each row industry that resulted from a $1 change in final demand in industry j. The multipliers accounted for the sum of direct, indirect, and induced effects of a change in final demand. The total output multiplier of an industry was given by the sum of all the multipliers for each row except the household row. The total impact on regional output can be calculated by multiplying the final demand change in industry j by the total output multiplier.

Income multipliers, which showed the effects of regional final demand changes on regional earnings, were also calculated. Total income multipliers are the sums of the multiplication of the individual output multipliers in the regional Leontief inverse by the household-row entry in the direct requirements table that corresponds to the row industry for the output multiplier. The sum of these i industry-specific income multipliers for an industry j also equals the entry in the household row of the Leontief inverse for that column j. We estimated the total income multipliers by the entries in the household-row of the Leontief inverse. The total impact on regional income can be calculated by multiplying the final demand change in that industry by the total income multiplier of the industry j.

C. Model Evaluation

1. Procedure

We performed a comparative evaluation of the sets of total output and income multipliers estimated by the model. First, for each multiplier type, we compared the vectors of multiplier estimates with a set of BEA's RIMS II multipliers. The goal was to establish how close these vectors resemble each other. Then, we proceeded by comparing the vectors of multiplier estimates one with another. We used the multiple comparison approach; one set of multiplier estimates was assumed the "true" vector and matched with another set, sequentially. A Total of six vector comparisons were performed.

The comparison of the multiplier estimates, first with the "true" RIMS II multipliers and, then, among themselves, proceeded in a number of ways, rather than reliance on a single statistical procedure. The testing routine followed the steps suggested by Butterfield and Mules (1980), with a few exceptions.

The first test was the non-parametric error sign test for consistent overestimation or underestimation. We estimated the deviations between the multipliers and, then, counted the number of under- and over-estimated cases.

Then, we calculated the Standardized Mean Absolute Deviation (SMAD) statistic, which measured the average percent absolute difference between two vectors of multipliers. We could, thus, determine the average percentage by which a vector of multipliers deviated from the vector of RIMS II multipliers or from another vector of multiplier estimates.

The last step in the test routine was to calculate the Spearman-rank correlation coefficients. The null hypothesis, $H_0 : \rho = 0$, that there is no association in the rank-ordering of the two vectors of multipliers was, then, tested at 0.05 level of significance. The appropriate test was the t-statistic with $n-2$ or 36 degrees of freedom (the aggregated input-output model counted 38 industries).

2. Results

a) Comparison with BEA's RIMS II multipliers

An obvious result from the error sign test was that all the output multiplier estimates overestimated the RIMS II output multipliers while all the income multiplier estimates underestimated the RIMS II income multipliers.

To get more insight, we matched these results with the average SMADs of Table 4.1. We found that the earnings-, employment-, establishment-, and payroll-based output multipliers overestimated the RIMS II output multipliers by 67.44%, 67.22%, 78.54%, and 70.18% respectively. Similar analyses also indicated that the earnings-, employment, establishment-, and payroll-based income multiplier estimates underestimated the RIMS II income multipliers, respectively, by 68.78%, 67.76%, 66.76%, and 67.22 %.

The Spearman-rank correlation coefficients between the vectors of multiplier estimates and those of RIMS II multipliers were in general low. We failed to reject the null hypothesis at 0.05 level of significance in all the cases, indicating that the rank-ordering of the vectors of multiplier estimates differed from that of the vector of RIMS II output multipliers.

The above statistical tests revealed that, for each multiplier type and independently of the specification, the vectors of multipliers are poor estimates of the vectors of RIMS II multipliers, both in sizes and rank-ordering. It was shown by the literature reported in chapter II that, contrary to the matrix of regional purchase coefficients, the matrix of technical coefficients has only negligible effects on the accuracy of multipliers (Conway, 1980; Dietzenbacher, 1995; Dietzenbacher, 1990; Park et al., 1981; Roland-Holst, 1989; Steven and Trainer, 1980). Hence, a potential explanation may be the difference in the specification of the simple location quotients. The RIMS II model used wages and salary data to specify the simple location quotients while our model used earnings, employment, number of establishments, and payroll data.

It is important to recognize that the RIMS II multipliers are derived from non-survey tables, which, themselves, are estimates of the "true" input-output relationships in the economy. Therefore, since measurement errors may also be associated with the RIMS II estimates, it would be incorrect to ascribe the entire difference between our multiplier estimates and the RIMS II multipliers to our model estimation error.

b) Multiple Comparison Analysis of the Multiplier Estimates

The error sign test allowed us to rank the multiplier estimates in terms of their sizes. The ranking was the same for both the output and income multiplier estimates. The earnings-based multiplier estimates had the lowest multiplier values, followed by the employment-, the payroll- and, finally, the establishment-based multiplier estimates.

The average SMAD statistics for the comparisons among the vectors of output multiplier estimates are all in the single digit percentages (see Table 4.4). Based on the conclusions of Burford and Katz (1980), Katz and Burford (1981), and Garking (1970), reported in Chapter 4 Section B, the results suggest that the calculated output multipliers are "acceptable" estimates of each other. Except for the earnings-establishment comparison, we can make similar suggestions for the income multiplier estimates.

The SMAD statistics also indicated that the income multiplier estimates deviated more from each other than the output multiplier estimates did. For example, the SMAD between the earnings- and the employment-based income multipliers was 189 percent larger than that estimated for the counterpart output multipliers. Such patterns (at a lesser degree) were also found for all the other comparisons.

The high Spearman-rank correlation coefficients and rejection of the null hypotheses $(H_0 : \rho = 0)$ indicated that the rank distributions of the vectors of output multipliers are indistinguishable from each other. The results were similar for the income multiplier estimates.

c) Tests of Stability of Multiplier Estimates

We performed the error sign test and the SMAD statistic to test the assumption that the multiplier estimates are stable during the period under study. Both the output and income multiplier estimates for 1989, 1990, 1991, and 1992 slightly underestimated the assumed "expected" 1988 multipliers.

SMADs statistics calculated for the output multipliers indicated that the observed multipliers differed only slightly from the "expected" 1988 ones. These results coupled with the error sign test indicated the following. On average, the earnings-based output multipliers underestimated the "expected" 1988 output multipliers by 0.33 percent. The underestimations by the employment-, payroll-, and establishment-based output multipliers are, respectively, 1.19 %, 1.33 %, and 1.52%.

The patterns for the income multipliers are similar. The earnings-, employment-, payroll-, and establishment-generated income multipliers would decrease by 0.77 percent, 1.82 percent, 2.15 percent, and 3.12 percent respectively.

Again based on the studies by Burford and Katz (1980) and Katz and Burford (1981), reported in Chapter 4, Section B, the results suggest that both the output and income multiplier estimates are stable over the period (1988-1992) under study. We should also note that, although stable, the income multiplier estimates showed greater variability than the output multiplier estimates.

D. Conclusions

Two major findings have come from the analysis of the results of this dissertation. First, for each multiplier type, the vectors of multipliers originated from earnings, employment, number of establishments, and payroll data are "acceptable" estimates of each other. These vectors also have similar rank-ordering of row industries. The second conclusion is that, the output multiplier estimates are more accurate (lowest errors) and more stable than the income multiplier estimates. A number of interesting conclusions can also be drawn, but these are the two most important.

Error sign tests and SMAD statistics have shown that the earnings-, employment-, establishment-, and payroll-based output multiplier estimates overestimated the RIMS II output multipliers. They also revealed the ranking of these multiplier estimates as follow. The earnings-based output multipliers have the lowest multiplier values, followed by the employment-, payroll-, and establishment-based output multipliers. Statistical tests have shown that the RIMS II output multipliers, in general, tend to overestimate the survey-based multipliers (U.S. Dept. of Commerce-BEA, 1981); this is also expected in the literature (see, for example, Flegg et al., 1990; Morrison and Smith, 1974; Ralston et al., 1986; and Schaffer and Chu 1969). A corollary would be that the earnings-based output multipliers are relatively the closest to survey multipliers while the establishment-based output multipliers are the less accurate.

Another interesting result concerns the income multiplier estimates. They all underestimated the RIMS II income multipliers. The earnings-based income multiplier estimates were the closest to the RIMS II income multipliers, followed by the employment-, the payroll-, and the establishment-based income multiplier estimates. No general conclusion on the accuracy of these estimates can be drawn.

We have also found that the deviations among the vectors of income multiplier estimates are larger than those associated with the vectors of output multipliers estimates. The labor input coefficients do not enter directly into the calculation of output multipliers, but are used in determining income multipliers. From the definitions of the multipliers, the only difference between total output and income multipliers is that, in calculating the total income multipliers, each element in a column of the Leontief inverse is multiplied by the corresponding element in the household row of the original matrix before summing the column (see Equation 21). In fact, the total income multipliers for any sector j are precisely equal to the bottom-row element of the Leontief inverse of the closed model. It corresponds to the $(n + 1)^{th}$ household sector used to close the table of regional input coefficients in Chapter III, Section E. Therefore, errors in these coefficients are causing higher errors in income multipliers.

The differences in the labor input coefficients between the RIMS II model and the model of this dissertation may explain the underestimation of the income multiplier estimates. The RIMS II model defines earnings as the incomes that are received by households from the production of regional goods and services and available for spending on these goods and services. Thus, earnings is calculated as the sum of wages and salaries, proprietors' income, directors' fee, and employer contributions for health insurance less personal contributions for social insurance. The RIMS II model derives the household row as follows:

$$HR_j = (W\&S_j + PI_j + DF_j + EHj{-}PC_j)/X_j \tag{54}$$

where,

HR = the household row,

$W\&S$ = wages and salaries,

PI = proprietors' income,

DF = directors' fees,

EH = employer contributions for health insurance,

PC = personal contributions for social insurance, and

X_j = total industry output.

Both models use the same dividend, that is, the total industry output (X_j). However, we derived the household row by dividing each entry in the compensation of employees row by X_j (see Equation 4.4). Since compensation of employees is smaller than earnings, coefficients based on compensation of employees are smaller than those based on an earnings definition. Moreover, the RIMS II model in its 38^{th} footnote states that after incorporating the household-row into the direct requirements, the sum of the entries in each column was more than one. Downward adjustments were, then, needed to stay within the limit of input-output theory, that is, the sums of the entries are less than, or equal to, one. Such adjustments were not required in our model. This ascertains that the labor input coefficients in the model we developed were smaller. The smaller labor input coefficients will correspond to smaller income multiplier estimates.

One implication of this dissertation is a careful review of the recommendation offered by most authors; specifically that, in conducting a regional input-output study, scarce funds should be allocated to estimating regional purchase coefficients as accurately as possible. This may be true for those interesting only in output multipliers. In impact analysis, however, the analyst is more usually concerned with income generating effects. Hence, the regional analyst should allocate as much resource to accurately estimate the vector of labor input coefficients.

Moreover, the results of this research question the conclusion of Stevens and Trainer (1980) that the labor input coefficients should be given low priority. The results, rather, acknowledge the findings of Garhart (1985) who think that "both the amount of labor required per dollar of output and the percentage of that labor provided intraregionally should be estimated as accurately as possible for each sector and that knowing these coefficients would greatly increase the accuracy of income multipliers."

In summary, one must be cautious in employing non-survey input-output techniques. Specifically, when the analyst is interested in the income multipliers, labor inputs should be estimated carefully, including the intrahousehold coefficient.

Another important implication from this study concerns impact studies at the county or smaller area levels. It is widely accepted that the simple location quotients perform better than the other nonsurvey techniques. The results of this study have shown that the earnings-, employment-, establishment-, and payroll-based multipliers are not significantly different from each other.

At the county level, it is very difficult to obtain a single type of data to specify the whole vector of simple location quotients, primarily because of disclosure policies (see, for example, Alexandre, 1991; US Dept. of Commerce-BEA, 1994). BEA would not report information when data for an establishment are identifiable. These results suggest greater flexibility in constructing the vector of simple location quotients to regionalize the table of national technical coefficients. We suggest further studies on the accuracy of multipliers originated from vectors of mixed simple location quotients at the small area levels.

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Appendix I

Location Quotients for the State of Florida

Appendix 1A
Earnings-Based Location Quotients

Sectors	1988	1989	1990	1991	1992
1	1.7766	1.8150	1.7934	1.8067	1.8255
2	0.8856	0.8869	0.8899	0.8701	0.7732
3	0.0050	0.0060	0.0056	0.0060	0.0004
4	0.0461	0.0302	0.0325	0.0434	0.0663
5	0.9277	0.8727	0.8212	0.7900	0.7957
6	1.4956	1.1407	1.0748	1.0105	1.0144
7	0.6057	0.6313	0.6284	0.6088	0.5894
8	0.1289	0.1416	0.1495	0.1595	0.1514
9	0.5744	0.6128	0.6221	0.6330	0.6440
10	0.4509	0.4597	0.4354	0.4329	0.4529
11	0.8079	0.8222	0.8182	0.8217	0.8130
12	0.3474	0.3507	0.3373	0.3332	0.3333
13	0.3927	0.4150	0.4256	0.4221	0.4202
14	0.6069	0.5860	0.5515	0.5212	0.4982
15	0.8573	0.8679	0.8118	0.7451	0.7185
16	0.1205	0.1211	0.1270	0.1269	0.1274
17	0.4587	0.4428	0.4355	0.4247	0.3984
18	0.4350	0.4230	0.4151	0.4387	0.4341
19	0.7076	0.7446	0.7649	0.7983	0.8450
20	0.0873	0.0983	0.1084	0.1017	0.1108
21	1.0269	1.0102	0.9756	0.9798	0.9932
22	0.5676	0.5925	0.6191	0.6331	0.6699
23	0.4618	0.4327	0.4385	0.4350	0.4183
24	0.9552	0.9357	0.9468	0.9539	0.9662
25	1.0346	1.0328	1.0055	1.0430	1.0986
26	0.8024	0.7933	0.8136	0.8235	0.8263
27	0.9455	0.9675	0.9675	0.9701	0.9890
28	1.1737	1.1923	1.1966	1.1946	1.2013
29	1.0367	1.0920	1.0602	1.0538	1.0016
30	0.9448	0.9720	0.9863	0.9967	1.0050
31	2.0221	2.1839	2.0514	1.9897	1.5853
32	1.5213	1.5555	1.5140	1.4993	1.5181
33	1.1158	1.1515	1.1598	1.1723	1.1748
34	0.9559	1.0164	1.0502	1.0882	1.1173
35	1.3206	1.3873	1.3747	1.3323	1.3247
36	1.1755	1.2395	1.2530	1.2624	1.2556
37	0.5912	0.6062	0.5917	0.5654	0.5325

Appendix 1B
Employment-Based Location Quotients

Sector	1988	1989	1900	1991	1992
1	1.7518	1.7887	1.7723	1.8498	1.7422
2	0.7751	0.8506	0.6507	0.6298	0.8421
3	0.0087	0.0214	0.0246	0.0258	0.0130
4	0.0607	0.0767	0.0579	0.0526	0.0372
5	0.6946	0.6334	0.5576	0.5583	0.6168
6	1.3644	1.3707	1.2180	1.1267	1.0973
7	0.6736	0.6687	0.6400	0.6119	0.5796
8	0.1632	0.1594	0.1669	0.1891	0.1779
9	0.6093	0.6307	0.6355	0.6502	0.6984
10	0.4785	0.4670	0.4581	0.4518	0.4297
11	0.7829	0.7567	0.7631	0.7596	0.7610
12	0.4485	0.4533	0.4428	0.4593	0.4559
13	0.4460	0.4493	0.4616	0.4887	0.4439
14	0.6806	0.6798	0.6415	0.5883	0.5708
15	0.9290	0.9596	0.8666	0.7792	0.7679
16	0.1402	0.1308	0.1345	0.1298	0.1523
17	0.5166	0.5072	0.4991	0.4607	0.4475
18	0.3827	0.2974	0.3094	0.3095	0.3372
19	0.7902	0.7588	0.7854	0.7828	0.7899
20	0.1891	0.1921	0.2048	0.1898	0.2061
21	0.7440	0.7645	0.7144	0.6899	0.6063
22	0.9188	0.8898	0.9198	0.9574	0.9949
23	0.4909	0.4919	0.4931	0.4797	0.5155
24	1.0343	0.9697	0.8937	1.0074	1.0204
25	1.0779	1.0592	1.0894	1.0016	1.0542
26	0.7970	0.8287	0.8202	0.9391	0.8923
27	0.9374	0.9479	0.9399	0.9121	0.9168
28	1.1847	1.1738	1.1776	1.1843	1.1796
29	1.0440	1.0552	1.0537	1.0417	0.9854
30	0.9163	0.9231	0.9422	0.9693	0.9444
31	1.5192	1.4972	1.5067	1.5092	1.4698
32	1.6306	1.7211	1.6544	1.6644	1.6096
33	1.1584	1.1651	1.1930	1.2203	1.2088
34	1.1191	1.1453	1.1724	1.2049	1.2672
35	1.2451	1.2323	1.2384	1.2242	1.2050
36	1.0092	1.0143	1.0277	21.7322	1.0726
37	0.9460	0.9367	0.8859	10.0610	0.9344

Appendix 1C
Establishment-Based Location Quotients

Sectors	1988	1989	1990	1991	1992
1	1.2869	1.2477	1.2762	1.3130	1.2869
2	0.8789	0.8362	0.8077	0.8025	0.8789
3	0.0665	0.0782	0.0722	0.0656	0.0665
4	0.1164	0.1140	0.1032	0.0957	0.1164
5	0.4640	0.4555	0.4449	0.3827	0.4640
6	1.0390	0.9996	0.9496	0.8983	1.0390
7	0.5828	0.5810	0.5772	0.5475	0.5828
8	0.5096	0.4825	0.5351	0.6030	0.5096
9	0.9421	0.9175	0.9068	0.8643	0.9421
10	0.5127	0.5036	0.4869	0.4891	0.5127
11	0.8829	0.8557	0.8633	0.8530	0.8829
12	0.6784	0.6595	0.6606	0.6623	0.6784
13	0.6850	0.6871	0.6957	0.6691	0.6850
14	0.8619	0.8286	0.8045	0.7375	0.8619
15	0.9880	0.9819	0.9828	0.9568	0.9880
16	0.3117	0.3102	0.3338	0.3245	0.3117
17	0.6681	0.6579	0.6590	0.6181	0.6681
18	0.4700	0.4627	0.4600	0.4487	0.4700
19	0.6951	0.7059	0.7473	0.7214	0.6951
20	0.6334	0.6007	0.5599	0.5178	0.6334
21	1.9737	1.8947	1.9126	1.8585	1.9737
22	0.7202	0.7147	0.7177	0.7275	0.7202
23	0.9012	0.8698	0.8492	0.8639	0.9012
24	0.6053	0.8408	0.8558	0.8979	0.6053
25	0.7674	0.7198	0.7483	0.8292	0.7674
26	0.6106	0.6148	0.6206	0.6349	0.6106
27	0.9634	0.9527	0.9742	0.9768	0.9634
28	1.0190	1.0092	1.0198	1.0208	1.0190
29	0.9891	0.9561	0.9561	0 9409	0.9891
30	0.9554	0.9518	0.9822	1.0162	0.9554
31	1.3295	1.3148	1.3243	1.3218	1.3295
32	0.9914	0.9715	0.9743	0.9898	0.9914
33	1.0133	0.9982	1.0229	1.0274	1.0133
34	1 1414	1.1431	1.2024	1.2068	1.1414
35	0.8901	0.8796	0.8830	0.8952	0.8901
36	1.0337	1.0469	1.0759	1.0977	1.0337
37	1.0224	0.9771	0.6656	0.9958	1.0224

Appendix 1D
Payroll-Based Location Quotients

Sectors	1988	1989	1990	1991	1992
1	1.7877	1.7691	1.7194	1.7557	1.7273
2	0.9063	0.8568	0.7442	0.6652	0.7019
3	0.0060	0.0222	0.0672	0.0473	0.0393
4	0.0643	0.0633	0.0574	0.0550	0.0388
5	0.5432	0.5089	0.4045	0.0937	0.4931
6	1.2495	1.2194	1.1904	1.1195	1.1097
7	0.7409	0.7180	0.7072	0.6817	0.6612
8	0.1398	0.1464	0.1608	0.1825	0.1632
9	0.6511	0.6586	0.6770	0.6753	0.6798
10	0.5448	0.5501	0.5406	0.5275	0.4842
11	0.7939	0.7870	0.7889	0.7840	0.7758
12	0.4332	0.4480	0.4220	0.4413	0.4289
13	0.3982	0.3984	0.4309	0.4404	0.4085
14	0.6718	0.6454	0.6287	0.5863	0.5654
15	0.9120	6.5450	0.8305	0.7710	0.7692
16	0.1331	0.1210	0.1243	0.1180	0.1407
17	0.4758	0.4671	0.4719	0.4454	0.4273
18	0.4552	0.2824	0.2986	0.3042	0.3239
19	0.9161	0.9017	0.9439	0.9370	0.9768
20	0.1270	0.1284	0.1324	0.1170	0.1384
21	0.6968	0.7031	0.6764	0.7004	0.5980
22	0.9959	0.9555	0.9766	1.0437	1.0646
23	0.4874	0.4753	0.4734	0.4664	0.5072
24	1.1367	1.0707	1.1032	1.0791	1.0895
25	1.2262	1.1485	1.1647	1.0455	1.1624
26	0.8376	0.8647	0.8759	1.0117	0.9811
27	0.9558	0.9489	0.9533	0.9284	0.9394
28	1.3455	1.3275	1.3303	1.3274	1.3087
29	1.0047	1.0457	1.0398	1.0219	0.9356
30	0.9908	0.9794	1.0257	1.0469	1.0214
31	1.4302	1.4031	1.3949	1.3944	1.4235
32	1.5669	1.6415	1.6163	1.5982	1.5621
33	1.3034	1.2887	1.2928	1.3018	1.2874
34	1.0822	1.1016	1.1264	1.1948	1.2156
35	1.4397	1.4435	1.4466	1.4269	1.4174
36	1.2807	1.2781	1.2878	1.3098	1.3061
37	1.2130	1.1749	1.1722	1.1565	1.1675

Appendix II

The National Industry-by-Industry Coefficients Table

Appendix II
National Industry-by-Industry
Direct Requirements Table

	1	2	3	4	5
1	0.3058	0.1816	0.0001	0.0000	0.0002
2	0.0001	0.0177	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.1072	0.0000	0.0036
4	0.0012	0.0006	0.0017	0.0388	0.0051
5	0.0015	0.0002	0.0013	0.0001	0.0481
6	0.0074	0.0111	0.0077	0.0219	0.0103
7	0.0584	0.0405	0.0001	0.0001	0.0002
8	0.0013	0.0097	0.0008	0.0001	0.0004
9	0.0008	0.0041	0.0003	0.0000	0.0002
10	0.0017	0.0000	0.0025	0.0000	0.0021
11	0.0040	0.0004	0.0005	0.0001	0.0023
12	0.0014	0.0106	0.0018	0.0025	0.0044
13	0.0489	0.0460	0.0204	0.0132	0.0373
14	0.0030	0.0004	0.0095	0.0004	0.0101
15	0.0007	0.0003	0.0032	0.0032	0.0026
16	0.0002	0.0002	0.0016	0.0032	0.0134
17	0.0016	0.0135	0.0116	0.0049	0.0110
18	0.0073	0.0064	0.0681	0.0062	0.0460
19	0.0034	0.0004	0.0055	0.0022	0.0062
20	0.0018	0.0008	0.0009	0.0002	0.0012
21	0.0001	0.0200	0.0004	0.0001	0.0005
22	0.0002	0.0023	0.0007	0.0003	0.0009
23	0.0003	0.0004	0.0002	0.0001	0.0005
24	0.0271	0.0086	0.0351	0.0049	0.0205
25	0.0029	0.0032	0.0015	0.0025	0.0029
26	0.0105	0.0014	0.0251	0.0220	0.0824
27	0.0452	0.0250	0.0283	0.0062	0.0199
28	0.0019	0.0011	0.0004	0.0001	0.0006
29	0.0092	0.0108	0.0067	0.0027	0.0153
30	0.0115	0.0134	0.0012	0.0002	0.0015
31	0.0522	0.0000	0.0244	0.1736	0.0121
32	0.0021	0.0018	0.0003	0.0006	0.0061
33	0.0014	0.0009	0.0002	0.0001	0.0011
34	0.0095	0.0456	0.0112	0.0180	0.0227
35	0.0006	0.0015	0.0007	0.0008	0.0015
36	0.0038	0.0000	0.0000	0.0000	0.0000
37	0.0051	0.0220	0.0097	0.0027	0.0136
38	0.0959	0.1045	0.3294	0.1389	0.2955

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	6	7	8	9	10
1	0.0058	0.2246	0.0644	0.0013	0.0120
2	0.0000	0.0042	0.0000	0.0029	0.0421
3	0.0000	0.0003	0.0007	0.0001	0.0003
4	0.0005	0.0007	0.0040	0.0009	0.0013
5	0.0079	0.0001	0.0007	0.0001	0.0001
6	0.0006	0.0022	0.0042	0.0021	0.0065
7	0.0001	0.1507	0.0008	0.0001	0.0003
8	0.0030	0.0001	0.2636	0.2241	0.0212
9	0.0006	0.0002	0.0018	0.1722	0.0011
10	0.0560	0.0003	0.0001	0.0008	0.2206
11	0.0023	0.0261	0.0076	0.0078	0.0090
12	0.0084	0.0092	0.0030	0.0036	0.0041
13	0.0276	0.0089	0.1957	0.0333	0.0269
14	0.0108	0.0135	0.0064	0.0165	0.0179
15	0.0509	0.0102	0.0043	0.0003	0.0082
16	0.0270	0.0005	0.0002	0.0000	0.0193
17	0.0612	0.0262	0.0004	0.0004	0.0416
18	0.0192	0.0017	0.0073	0.0029	0.0079
19	0.0268	0.0002	0.0003	0.0002	0.0038
20	0.0015	0.0003	0.0002	0.0001	0.0023
21	0.0005	0.0002	0.0000	0.0001	0.0004
22	0.0035	0.0005	0.0009	0.0008	0.0011
23	0.0018	0.0002	0.0003	0.0052	0.0013
24	0.0178	0.0213	0.0134	0.0073	0.0231
25	0.0079	0.0029	0.0026	0.0027	0.0036
26	0.0025	0.0114	0.0296	0.0098	0.0176
27	0.0428	0.0455	0.0413	0.0385	0.0533
28	0.0390	0.0002	0.0002	0.0002	0.0008
29	0.0118	0.0029	0.0032	0.0052	0.0077
30	0.0031	0.0010	0.0012	0.0012	0.0023
31	0.0044	0.0025	0.0023	0.0060	0.0051
32	0.0012	0.0006	0.0001	0.0004	0.0006
33	0.0002	0.0005	0.0045	0.0026	0.0005
34	0.0701	0.0273	0.0202	0.0198	0.0284
35	0.0023	0.0010	0.0020	0.0030	0.0035
36	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0106	0.0033	0.0045	0.0076	0.0100
38	0.3070	0.1220	0.2055	0.2655	0.2515

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	11	12	13	14	15
1	0.0005	0.0001	0.0008	0.0002	0.0002
2	0.0008	0.0000	0.0002	0.0000	0.0000
3	0.0040	0.0001	0.0012	0.0003	0.0067
4	0.0032	0.0007	0.2207	0.0049	0.0034
5	0.0031	0.0001	0.0080	0.0012	0.0612
6	0.0045	0.0031	0.0056	0.0045	0.0077
7	0.0034	0.0002	0.0040	0.0100	0.0005
8	0.0099	0.0013	0.0014	0.0234	0.0024
9	0.0002	0.0001	0.0001	0.0006	0.0002
10	0.0444	0.0001	0.0004	0.0024	0.0058
11	0.2360	0.1539	0.0109	0.0203	0.0233
12	0.0044	0.0860	0.0059	0.0039	0.0044
13	0.0720	0.0233	0.1813	0.2132	0.0483
14	0.0199	0.0125	0.0160	0.0605	0.0052
15	0.0014	0.0003	0.0037	0.0076	0.1127
16	0.0017	0.0014	0.0011	0.0047	0.0056
17	0.0064	0.0011	0.0099	0.0146	0.0071
18	0.0066	0.0044	0.0029	0.0078	0.0048
19	0.0003	0.0008	0.0003	0.0025	0.0017
20	0.0005	0.0004	0.0003	0.0004	0.0003
21	0.0001	0.0001	0.0001	0.0001	0.0001
22	0.0013	0.0064	0.0010	0.0014	0.0011
23	0.0003	0.0014	0.0004	0.0013	0.0009
24	0.0365	0.0240	0.0384	0.0354	0.0652
25	0.0030	0.0059	0.0040	0.0042	0.0087
26	0.0414	0.0081	0.0329	0.0263	0.0494
27	0.0431	0.0282	0.0429	0.0489	0.0326
28	0.0009	0.0007	0.0002	0.0003	0.0006
29	0.0033	0.0053	0.0061	0.0047	0.0061
30	0.0024	0.0019	0.0019	0.0020	0.0019
31	0.0032	0.0123	0.0045	0.0062	0.0051
32	0.0016	0.0033	0.0005	0.0008	0.0006
33	0.0013	0.0007	0.0007	0.0014	0.0011
34	0.0158	0.0441	0.0310	0.0223	0.0292
35	0.0017	0.0054	0.0014	0.0029	0.0027
36	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0115	0.0191	0.0039	0.0084	0.0075
38	0.2130	0.3128	0.1315	0.2736	0.2813

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	16	17	18	19	20
1	0.0001	0.0001	0.0001	0.0001	0.0001
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0119	0.0003	0.0001	0.0001	0.0004
4	0.0041	0.0011	0.0008	0.0010	0.0007
5	0.0481	0.0003	0.0001	0.0006	0.0001
6	0.0126	0.0100	0.0075	0.0068	0.0044
7	0.0002	0.0001	0.0001	0.0002	0.0001
8	0.0005	0.0002	0.0008	0.0005	0.0033
9	0.0001	0.0008	0.0001	0.0002	0.0172
10	0.0026	0.0025	0.0014	0.0042	0.0095
11	0.0018	0.0052	0.0038	0.0087	0.0023
12	0.0043	0.0053	0.0041	0.0051	0.0033
13	0.0317	0.0171	0.0065	0.0200	0.0174
14	0.0063	0.0097	0.0156	0.0368	0.0504
15	0.0114	0.0057	0.0040	0.0098	0.0098
16	0.2343	0.2075	0.0881	0.0569	0.0417
17	0.0137	0.0584	0.0346	0.0371	0.0781
18	0.0227	0.0203	0.1277	0.0140	0.0585
19	0.0073	0.0143	0.0589	0.1239	0.0401
20	0.0006	0.0011	0.0020	0.0011	0.2345
21	0.0002	0.0190	0.0010	0.0007	0.0013
22	0.0008	0.0041	0.0040	0.0061	0.0077
23	0.0003	0.0005	0.0006	0.0014	0.0007
24	0.0382	0.0184	0.0139	0.0148	0.0237
25	0.0040	0.0049	0.0052	0.0058	0.0038
26	0.0647	0.0163	0.0119	0.0137	0.0092
27	0.0618	0.0477	0.0580	0.0551	0.0701
28	0.0004	0.0004	0.0003	0.0002	0.0008
29	0.0043	0.0050	0.0054	0.0083	0.0034
30	0.0020	0.0017	0.0016	0.0016	0.0023
31	0.0027	0.0059	0.0067	0.0068	0.0014
32	0.0004	0.0018	0.0027	0.0037	0.0006
33	0.0013	0.0008	0.0009	0.0018	0.0009
34	0.0327	0.0280	0.0258	0.0321	0.0245
35	0.0017	0.0027	0.0033	0.0033	0.0017
36	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0052	0.0063	0.0055	0.0058	0.0169
38	0.2277	0.3246	0.3283	0.3215	0.1688

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	21	22	23	24	25
1	0.0001	0.0001	0.0008	0.0005	0.0001
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0001	0.0002	0.0001	0.0000	0.0000
4	0.0006	0.0008	0.0012	0.0017	0.0005
5	0.0001	0.0002	0.0007	0.0002	0.0000
6	0.0091	0.0047	0.0057	0.0199	0.0365
7	0.0001	0.0008	0.0021	0.0014	0.0001
8	0.0030	0.0069	0.0112	0.0006	0.0000
9	0.0033	0.0004	0.0044	0.0012	0.0004
10	0.0056	0.0024	0.0221	0.0002	0.0000
11	0.0006	0.0189	0.0221	0.0011	0.0008
12	0.0043	0.0063	0.0101	0.0066	0.0068
13	0.0078	0.0158	0.0377	0.0601	0.0021
14	0.0092	0.0172	0.0307	0.0049	0.0021
15	0.0049	0.0041	0.0053	0.0003	0.0001
16	0.0589	0.0270	0.0715	0.0011	0.0003
17	0.0388	0.0290	0.0127	0.0046	0.0027
18	0.0386	0.0151	0.0086	0.0074	0.0038
19	0.0295	0.1033	0.0157	0.0028	0.0265
20	0.0094	0.0010	0.0006	0.0021	0.0002
21	0.1489	0.0006	0.0003	0.0153	0.0002
22	0.0219	0.0269	0.0013	0.0008	0.0019
23	0.0005	0.0008	0.0361	0.0007	0.0007
24	0.0168	0.0103	0.0206	0.1456	0.0041
25	0.0061	0.0068	0.0057	0.0125	0.1791
26	0.0097	0.0105	0.0132	0.0108	0.0083
27	0.0271	0.0374	0.0523	0.0194	0.0054
28	0.0003	0.0003	0.0006	0.0123	0.0002
29	0.0089	0.0065	0.0081	0.0187	0.0116
30	0.0013	0.0019	0.0021	0.0070	0.0003
31	0.0076	0.0082	0.0073	0.0182	0.0229
32	0.0076	0.0014	0.0011	0.0016	0.0535
33	0.0006	0.0009	0.0010	0.0022	0.0039
34	0.0320	0.0396	0.0609	0.0339	0.0251
35	0.0017	0.0035	0.0071	0.0124	0.0039
36	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0046	0.0100	0.0141	0.0226	0.0066
38	0.3645	0.3591	0.2610	0.3368	0.2448

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	26	27	28	29	30
1	0.0002	0.0004	0.0002	0.0002	0.0001
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0629	0.0001	0.0000	0.0000	0.0000
4	0.0851	0.0008	0.0015	0.0004	0.0001
5	0.0001	0.0000	0.0000	0.0000	0.0000
6	0.0487	0.0066	0.0136	0.0069	0.0030
7	0.0001	0.0002	0.0022	0.0000	0.0000
8	0.0001	0.0002	0.0001	0.0000	0.0000
9	0.0000	0.0005	0.0002	0.0004	0.0001
10	0.0007	0.0031	0.0002	0.0000	0.0000
11	0.0006	0.0139	0.0081	0.0029	0.0009
12	0.0021	0.0169	0.0108	0.0259	0.0125
13	0.0213	0.0066	0.0051	0.0016	0.0006
14	0.0018	0.0029	0.0011	0.0004	0.0002
15	0.0003	0.0007	0.0001	0.0002	0.0000
16	0.0006	0.0001	0.0000	0.0000	0.0000
17	0.0021	0.0022	0.0014	0.0001	0.0001
18	0.0043	0.0022	0.0010	0.0010	0.0003
19	0.0033	0.0007	0.0005	0.0023	0.0012
20	0.0035	0.0008	0.0006	0.0002	0.0002
21	0.0001	0.0000	0.0000	0.0003	0.0000
22	0.0026	0.0007	0.0004	0.0036	0.0014
23	0.0002	0.0012	0.0013	0.0018	0.0010
24	0.0267	0.0150	0.0068	0.0278	0.0076
25	0.0021	0.0172	0.0161	0.0244	0.0162
26	0.1255	0.0120	0.0259	0.0069	0.0022
27	0.0094	0.0235	0.0040	0.0043	0.0016
28	0.0006	0.0018	0.0021	0.0005	0.0003
29	0.0104	0.0139	0.0091	0.1692	0.0410
30	0.0096	0.0011	0.0012	0.0112	0.3059
31	0.0034	0.0233	0.0577	0.0331	0.0279
32	0.0005	0.0095	0.0020	0.0033	0.0065
33	0.0021	0.0042	0.0047	0.0015	0.0011
34	0.0117	0.0686	0.0892	0.1068	0.0388
35	0.0011	0.0137	0.0131	0.0117	0.0165
36	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0076	0.0259	0.0219	0.0332	0.0092
38	0.1496	0.4123	0.4466	0.3820	0.3606

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	31	32	33	34	35
1	0.0065	0.0072	0.0002	0.0003	0.0130
2	0.0000	0.0000	0.0000	0.0000	0.0063
3	0.0000	0.0001	0.0001	0.0000	0.0000
4	0.0000	0.0017	0.0017	0.0004	0.0013
5	0.0000	0.0001	0.0001	0.0000	0.0000
6	0.0533	0.0210	0.0097	0.0043	0.0088
7	0.0000	0.0063	0.0004	0.0003	0.2218
8	0.0000	0.0013	0.0035	0.0001	0.0001
9	0.0000	0.0070	0.0103	0.0002	0.0001
10	0.0001	0.0019	0.0005	0.0002	0.0002
11	0.0007	0.0040	0.0054	0.0044	0.0076
12	0.0044	0.0169	0.0207	0.0311	0.0066
13	0.0012	0.0083	0.0221	0.0070	0.0018
14	0.0009	0.0098	0.0261	0.0063	0.0070
15	0.0001	0.0042	0.0037	0.0006	0.0018
16	0.0000	0.0003	0.0007	0.0001	0.0002
17	0.0003	0.0011	0.0041	0.0022	0.0004
18	0.0005	0.0014	0.0112	0.0103	0.0015
19	0.0004	0.0021	0.0347	0.0154	0.0005
20	0.0001	0.0003	0.0007	0.0008	0.0001
21	0.0000	0.0009	0.0002	0.0006	0.0000
22	0.0001	0.0021	0.0097	0.0050	0.0001
23	0.0003	0.0029	0.0211	0.0022	0.0016
24	0.0023	0.0082	0.0092	0.0155	0.0106
25	0.0035	0.0159	0.0200	0.0247	0.0065
26	0.0006	0.0290	0.0256	0.0057	0.0229
27	0.0009	0.0089	0.0229	0.0110	0.0444
28	0.0007	0.0008	0.0012	0.0011	0.0001
29	0.0118	0.0226	0.0131	0.0103	0.0108
30	0.0222	0.0010	0.0011	0.0023	0.0002
31	0.0630	0.0475	0.0567	0.0385	0.0424
32	0.0015	0.1359	0.0016	0.0103	0.0048
33	0.0011	0.0092	0.0217	0.0020	0.0027
34	0.0226	0.0915	0.0872	0.1389	0.0451
35	0.0047	0.0053	0.0070	0.0092	0.0038
36	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0031	0.0202	0.0332	0.0256	0.0049
38	0.0386	0.2968	0.3187	0.4291	0.3912

Appendix II
(continued)
National Industry-by-Industry
Direct Requirements Table

	36	37	38
1	0.0011	0.0023	0.0075
2	0.0001	0.0001	0.0010
3	0.0000	0.0054	0.0000
4	0.0013	0.0021	0.0022
5	0.0002	0.0002	0.0002
6	0.0081	0.0614	0.0000
7	0.0090	0.0084	0.0721
8	0.0004	0.0005	0.0028
9	0.0033	0.0015	0.0259
10	0.0002	0.0006	0.0070
11	0.0052	0.0051	0.0042
12	0.0132	0.0329	0.0089
13	0.0427	0.0303	0.0357
14	0.0222	0.0064	0.0082
15	0.0032	0.0032	0.0014
16	0.0001	0.0004	0.0002
17	0.0017	0.0210	0.0025
18	0.0006	0.0086	0.0024
19	0.0023	0.0086	0.0123
20	0.0004	0.0264	0.0342
21	0.0002	0.0007	0.0036
22	0.0208	0.0022	0.0032
23	0.0010	0.0025	0.0088
24	0.0068	0.0253	0.0238
25	0.0108	0.0107	0.0216
26	0.0137	0.0310	0.0319
27	0.0195	0.0229	0.0367
28	0.0008	0.0126	0.1229
29	0.0045	0.0173	0.0453
30	0.0035	0.0086	0.0262
31	0.0643	0.0555	0.1469
32	0.0017	0.0059	0.0224
33	0.0029	0.0056	0.0158
34	0.0435	0.0474	0.0127
35	0.0057	0.0056	0.0558
36	0.0200	0.0000	0.1194
37	0.0183	0.0222	0.0223
38	0.5263	0.3703	0.0025

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