AGGREGATION BIAS, INFORMATION LOSS, AND TRADE-COEFFICIENT STABILITY IN THE MULTIREGIONAL INPUT-OUTPUT MODEL

by

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ABSTRACT

The impacts of aggregation on estimation bias and questions concerning the stability of technical coefficients in single-region input-output models received a great deal of attention in the literature throughout the 1950s and 1960s. The comparatively recent development of several multiregional models requires that concerns about the problems related to aggregation be reconsidered from a multiregional perspective. Furthermore, because of the spatial characteristics of multiregional models, the importance of interregional trade for accurate output estimates and the issue of trade-coefficient stability also need to be given more attention.

In this thesis, a theoretical framework is developed to analyze the importance of trade, aggregation bias, and information loss that builds upon research conducted by previous analysts. In the case of aggregation bias and information loss, this theoretical work represents an extension from single-region analyses to multiple regions. This extension requires explicit treatment of interregional trade. The theoretical work concerning the importance of trade for accurate output estimates deals with clarifying the issue of when it is necessary to include detailed state-to-state trade data in the multiregional input-output (MRIO) model. It is shown that by correctly adjusting regional final demands by the amount of net-trade balances, accurate output estimates can be obtained without detailed interregional trade data. This is true, however, only when accurate regional production and consumption data are available with which to obtain the net-trade balance estimates. Furthermore, interregional trade data are necessary for several other reasons: (1) for ensuring the accuracy of detailed multipliers; (2) for their usefulness in balancing the MRIO accounts; and (3) for conducting transportation studies.

An analysis of the effects of aggregation on estimation bias in the MRIO model is also conducted. This analysis indicates that aggregation of the base-year accounts results in very little estimation bias. However, introducing a different final demand structure can result in substantially different conclusions concerning the size of the aggregation bias.

The fact that aggregation may lead to loss of information content in the model is investigated as well. In these tests, it is found that the information content falls dramatically with increasing aggregation. This suggests that regional analysts, who often use input-output models for purposes other than impact analysis, need to be very careful about the aggregation of data. This is particularly true in multiregional input-output models, where the quantity of data often requires aggregation to allow meaningful interpretation of the results.

Finally, if interregional trade data are to be used in a multiregional model, it is also necessary to be concerned about the stability of trade patterns over time. Including obsolete trade data in a model may introduce considerable error into the estimates obtained. To shed some light on this topic, an analysis of trade coefficient stability is carried out using 1967 and 1972 Census of Transportation data with detail for three transportation modes and twenty commodity classifications on a state-to-state basis. The results show that the stability of the trade data decreases with disaggregation. Whether or not interregional trade data are sufficiently stable for use by regional analysts is a topic requiring further study, however. It seems likely that the data may be stable enough for some types of studies but not for others.

Thesis Supervisor: Karen R. Polenske

Title: Professor

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TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGMENTS	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	viii
LIST OF FIGURES	x

CHAPTER 1

TRADE RELATIONSHIPS IN MULTIREGIONAL MODELS 1

CHAPTER 2

A METHODOLOGY FOR ANALYZING THE ROLE OF TRADE IN THE MRIO MODEL 6

TOTAL INTERREGIONAL TRADE EFFECTS 9
MRIO Accounts and Model 9
Interregional Trade Effects in the MRIO model 15

AGGREGATION BIAS AND INFORMATION LOSS IN THE MRIO MODEL 20
Aggregation Bias in the MRIO Model 21
Aggregation and Information Loss 31
Underlying Principles of Information Theory 34
Quantifying Information Loss in the MRIO Model 38

INTERTEMPORAL TRADE-COEFFICIENT STABILITY 41
Definition of Trade-Coefficient Stability 43
Effects of Trade-Coefficient Instability 47

CONCLUSIONS 48

CHAPTER 3

EMPIRICAL EVIDENCE REGARDING THE ROLE OF TRADE IN THE MRIO MODEL 50

INTERREGIONAL TRADE EFFECTS 51

AGGREGATION BIAS AND INFORMATION LOSS 57

Page

Chapter 3 (continued)

TRADE-COEFFICIENT STABILITY 69
Consistency Between 1967 and 1972 Industry Definitions 71
Aggregate Intermodel Substitution 72
Analysis of Trade-Coefficient Stability 76

CONCLUSIONS 89

CHAPTER 4

CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH 93

INTERREGIONAL TRADE EFFECTS 93

AGGREGATION BIAS AND INFORMATION LOSS 96

TRADE-COEFFICIENT STABILITY 99

DIRECTIONS FOR FUTURE RESEARCH 100

APPENDIX A: MATRIX STRUCTURE OF THE MRIO MODEL 103
The MRIO Accounting Framework 104
The MRIO Accounts and Model 109
Matrix Structure of the MRIO Model 112

APPENDIX B: MATHEMATICAL FORMULATION OF INTERREGIONAL FEEDBACK EFFECTS 117
Feedback Effects in an Interregional Input-Output Model 118
Feedback Effects in the Multiregional Input-Output Model 121

APPENDIX C: MRIO CLASSIFICATION SCHEMES 124

APPENDIX D: ADDITIONAL RESULTS RELATED TO INTERREGIONAL TRADE EFFECTS 128

APPENDIX E: TRANSPORTATION COMMODITY CLASSIFICATION CODES 131

APPENDIX F: ADDITIONAL RESULTS RELATED TO TRADE-COEFFICIENT STABILITY 137

BIBLIOGRAPHY 174

LIST OF TABLES

Table	Title	Page
3.1	PERCENTAGE DIFFERENCE BETWEEN BASE CASE AND 1963 REGIONAL OUTPUTS RESULTING FROM OMISSION OF INTERREGIONAL TRADE	53
3.2	PERCENTAGE DIFFERENCE BETWEEN BASE CASE AND 1963 REGIONAL OUTPUTS RESULTING FROM OMISSION OF INTERREGIONAL TRADE (WITH NET-TRADE BALANCE ADJUSTMENT)	55
3.3	AGGREGATION BIAS: 1963 ESTIMATED OUTPUTS, 19-INDUSTRY, 9-REGION CASE	58
3.4	AGGREGATION BIAS: 1963 ESTIMATED OUTPUTS, 79-INDUSTRY, 51-REGION CASE	61
3.5	AGGREGATION BIAS: 1980 ESTIMATED OUTPUTS, 19-INDUSTRY, 9-REGION CASE	63
3.6	AGGREGATION BIAS: 1980 ESTIMATED OUTPUTS, 79-INDUSTRY, 51-REGION CASE	64
3.7	INFORMATION LOSS DUE TO AGGREGATION	67
3.8	PERCENT DISTRIBUTION OF COMMODITIES SHIPPED IN THE UNITED STATES BY TRANSPORTATION MODE	73
3.9	MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION FOR TRADE-COEFFICIENT CHANGES, 1967-1972	79
3.10	MEANS, STANDARD DEVIATIONS, ZERO ENTRIES, AND COEFFICIENTS OF VARIATION FOR TRADE-COEFFICIENT CHANGES: NONZERO ENTRIES, 1967-1972	81
3.11	DISTRIBUTION OF RAIL TRADE-COEFFICIENT CHANGES	83
3.12	DISTRIBUTION OF TRUCK TRADE-COEFFICIENT CHANGES	84
3.13	DISTRIBUTION OF OTHER TRADE-COEFFICIENT CHANGES	85
3.14	DISTRIBUTION OF PERCENTAGE TRADE-COEFFICIENT CHANGES FOR RAIL	86
3.15	DISTRIBUTION OF PERCENTAGE TRADE-COEFFICIENT CHANGES FOR TRUCK	87
3.16	DISTRIBUTION OF PERCENTAGE TRADE-COEFFICIENT CHANGES FOR OTHER	88

Table	Title	Page
C.1	MULTIREGIONAL INPUT-OUTPUT CLASSIFICATION FOR NINETEEN INDUSTRIES	125
C.2	INDUSTRIAL CLASSIFICATION SCHEME (79 to 3 Industries)	126
C.3	REGIONAL CLASSIFICATION SCHEME (51, 9, and 3 Regions)	127
D.1	PERCENTAGE DIFFERENCE BETWEEN BASE CASE AND 1963 REGIONAL OUTPUTS RESULTING FROM OMISSION OF INTERREGIONAL TRADE FOR SERVICE INDUSTRIES (WITH NET-TRADE BALANCE ADJUSTMENT)	129
D.2	1963 CALCULATED BASE CASE OUTPUTS, 19 INDUSTRIES, 9 REGIONS	130
F.1	AGGREGATE TRADE COEFFICIENT DIFFERENCES 1967 to 1972	138
F.2	PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS, 1967-1972	150
F.3	AGGREGATE 1967 TRADE COEFFICIENTS	162

LIST OF FIGURES

Figure	Title	Page
2.1	RELATIONSHIP OF PROBABILITY SIZE TO INFORMATION CONTRIBUTION	36
A.1	IRIO ACCOUNTING FRAMEWORK	105
A.2	MRIO OUTPUT AND FINAL DEMAND VECTORS	113
A.3	EXPANDED TECHNICAL COEFFICIENT MATRIX	114
A.4	EXPANDED TRADE COEFFICIENT MATRIX	115
A.5	DETAILED MATRIX BALANCE EQUATIONS (REARRANGED)	116

CHAPTER 1

TRADE RELATIONSHIPS IN MULTIREGIONAL MODELS

Economics is sometimes defined as the study of the allocation of scarce resources among competing ends. When a spatial dimension is added to this statement, it becomes a definition of regional economics. Because trade is inevitably the process by which resources are allocated, the study of trade would seem to be of particular interest to regional analysts. In actuality, the amount of interregional trade research that has been done is quite limited. Part of the reason for this lack of research stems from the amount of work that has been done in the field of international trade. In fact, most of the theoretical work that has been done on interregional trade has borrowed its conceptual framework directly from the international literature. There is, however, another reason for the lack of interregional trade research--paucity of data. Only recently, with data for several years available from the U.S. Census of Transportation, have regional analysts been provided with a significant database of interregional trade information. Even this information has severe drawbacks, however, some of which are noted in Chapter 3.

Partly because of the difficulty in assembling interregional trade data, several issues related to the role of trade in multiregional and interregional input-output models have not been adequately resolved. Among the most important of these issues are the significance of interregional trade data for accurate industrial output estimates, the impact of aggregation on estimation bias and information loss, and trade-coefficient stability. In this thesis, these three issues are studied with an explicit recognition of their interrelated nature. Although by dealing with all three, it was difficult to study any one of the issues in great detail, this approach was considered to be necessary because of the complex interrelationships among the three areas. These interrelationships have not been clearly delineated in the literature. As a result, the literature related to the importance of interregional trade data in multiregional and interregional input-output models and trade-coefficient stability has been largely inconclusive.(1) In fact, only the literature with respect to aggregation bias in single-region input-output models appears to have been very definitive.

The issue of aggregation in single-region input-output tables was of great interest to analysts in the late 1950s and early 1960s, but was found by these analysts to have negligible impacts on estimated outputs. Recently, Miller and Blair (1980, 1981) have conducted studies to determine whether aggregation is a serious problem in interregional and multiregional input-output models. The authors presented results, however, only for total regional outputs. Because it would be expected that the output for each industry in a region would be more sensitive to aggregation bias than total regional outputs, additional work needs to be done before the empirical significance of the aggregation problem can be resolved.

Of course, regional analysts employ interregional and multiregional input-output models for purposes other than conducting impact analyses. A major attribute of these models is the detail that they provide in terms of interregional, interindustry transactions. In

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(1) For a brief review of the literature, see Richardson (1972, pp. 76-82), and Crown (1981).

the late 1960s several analysts recognized that, in addition to estimation bias, aggregation may result in a loss of information in input-output models. To measure the loss of information from aggregation, quantitative methods were developed using concepts from information theory. The extent of this research has been very limited, however, and no studies have been conducted to assess the impacts of aggregation on a multiregional input-output system.

Although the literature has focused primarily on aggregation bias and technical coefficient stability in single-region models, the recent growth in multiregional modeling requires that the topics of aggregation bias and information loss be reconsidered from a multiregional perspective. Because of the difficulty of collecting interregional trade data, several studies have been conducted concerning the size of interregional trade effects in interregional and multiregional models. These studies have sought to determine whether interregional trade data are necessary for making accurate estimates of regional industrial outputs with multiregional or interregional input-output models. A similar type of study is carried out in this thesis. However, the research presented in this dissertation differs from previous studies for reasons that are discussed in Chapter 2.

The final topic dealt with in the thesis, is an investigation of the stability of interregional trade patterns. Such a study is important for both empirical and theoretical reasons. The empirical reasons include errors introduced into multiplier and output calculations with multiregional and interregional input-output models, as well as the implications for how often interregional trade data must be assembled. A study of trade stability is important for theoretical reasons because there is no a priori reason to expect interregional trade patterns to be either stable or unstable over time (Richardson, 1972, pp. 76-82). This is an issue that can only be resolved by a comprehensive analysis of trade-coefficient stability. The research presented in this dissertation is a first step towards understanding changes in trade patterns over time.

The current assembly of the 1977 MRIO accounts provides an illustration of the need for a study combining an analysis of the importance of interregional trade in the MRIO model with a study of trade-coefficient stability and the impacts of aggregation on estimation bias and information loss. The 1977 MRIO accounts are being assembled to form the business component of the Multiregional Policy Impact Simulation (MRPIS) model.(1) The issues dealt with in this thesis are important to the MRPIS research for a number of reasons: (a) the MRPIS model is being designed to investigate the impact of different federal programs on income distribution, and interregional trade is the mechanism by which these impacts are distributed to the different sectors in each region; (b) for various reasons related to data availability and model development, certain segments of the MRPIS model must be run at an aggregate level. This will have implications for aggregation bias and information loss in the model; and (c) the stability of the trade coefficients will have implications for the resources that must be committed to the periodic assembly or estimation of trade coefficients, as well as the reliability of the results produced by the model.

In the following chapters, an analysis of the importance of

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(1) For a description of the MRPIS model, see The Social Welfare Research Institute (1981).

interregional trade in the MRIO model will be coupled with a study of trade-coefficient stability and the impacts of aggregation on estimation bias and information loss in the MRIO model. The MRIO model developed by Polenske (1980) was chosen for this analysis because it is based upon the only consistent set of multiregional input-output accounts for the United States that is presently available. It is not possible, at this time, to use the MRIO model for the analysis of trade-coefficient stability because the trade data are available only for the base-year 1963. Comparable data for 1977 will not become available until the summer of 1982. Therefore, data from the 1967 and 1972 Census of Transportation are used instead.

In Chapter 2, a methodology is developed that can be implemented to study each of the issues outlined above in detail. This methodology is used in Chapter 3 to conduct an empirical analysis of each issue. The methodology and results presented in Chapters 2 and 3 are not as rigorous or definitive as they might have been if only one of the three issues had been investigated. Nevertheless, the approach taken does allow the interrelationships between the different areas to be better understood. As such, this study provides the groundwork for further theoretical and empirical developments concerning the use of the MRIO model. In Chapter 4, a summary of the thesis is provided, along with some possibilities for future research.

CHAPTER 2

A METHODOLOGY FOR ANALYZING THE ROLE OF TRADE IN THE MRIO MODEL

As noted in the previous chapter, the assembly of interregional trade data is a formidable and difficult task. As a result, interregional trade data are seldom collected for use in multiregional models. Instead, a regional model is often used, or estimation methods are employed to approximate the interregional trade flows with incomplete data. In a recent test, Harrigan, McGilvray, and McNicoll (1981) compared the accuracy of several alternative methods frequently used for estimating interregional trade flows. All of the techniques were found to perform poorly. From these initial findings, it appears that if a multiregional model incorporating trade flows is to be built, the trade data must be assembled and not estimated. If this is true, it has serious implications for the construction of multiregional models requiring detailed trade data.

The importance of specifying detailed interregional trade relationships in interregional and multiregional input-output models has concerned regional analysts for many years. Empirical studies have been conducted by Miller (1966, 1969), Riefler and Tiebout (1970), and Greytak (1970). In each of these studies, the importance of interregional trade for accurate output estimates was measured by calculating the size of the interregional feedback effects. These were defined by Miller (1966) to be the increases in the outputs of a particular region brought about by increases in the demands of the sectors in other regions, which themselves resulted from an initial increase in production in the region of origin. The interregional feedback approach is outlined for interregional and multiregional input-output model's in Appendix B. However, the measure provided by the traditional definition of interregional feedbacks was not considered to be appropriate for this study. This is because it does not take account of the total effects of interregional trade in the model. A methodology that does measure the total effects of interregional trade in the MRIO model is presented in this chapter.

Of course, if interregional trade data are necessary for accurate output or detailed multiplier estimates, and a decision is made to assemble interregional trade data for a particular project, the stability of the trade coefficients calculated from the data becomes important. This stability will determine how often new trade-coefficient estimates must be constructed.

As with the studies of interregional feedback effects, the literature concerning the stability of trade coefficients has been inconclusive. One problem that has affected the results of studies concerning interregional feedback effects and trade-coefficient stability is the aggregation level of the data used for the analyses. For example, in trade-coefficient stability analyses it would be expected that regional and industrial aggregation would smooth much of the variation in the data, thus giving the impression of greater stability than actually exists. Yet, most studies have been carried out with detail for only a few industries and two or three regions, therefore building in a bias towards stability. The level of industrial and regional aggregation in the studies of interregional feedbacks by Miller (1966, 1969), for instance, no doubt contributed to his conclusions that interregional trade data may not be necessary for some types of analyses. Because of their interrelationships, interregional trade effects and the stability of trade coefficients should not be studied in isolation of the aggregation problem.

In addition to its impact on the results of empirical studies, aggregation may create estimation bias and information loss in a model. An increase in estimation bias may be brought about by aggregating regions and industries with heterogeneous production and trade technologies. Furthermore, Theil (1967) showed that a loss of information may be brought about by the reduction of interindustry detail that results when an input-output model is aggregated. An extension of Theil's information approach will be made to multiregional input-output models in this chapter.

In the past ten years, the number of U.S. multiregional models has expanded rapidly (Polenske, 1980, p. 87). This increase in multiregional modeling does not seem to have been accompanied by a corresponding increase in concern about the specification of trade relationships. A methodology for investigating each of the issues discussed above is presented in this chapter. The chapter is divided into three principal sections. In the first section, a methodology for measuring the size of the total interregional trade effects in multiregional input-output models is presented. The second section provides a methodology for analyzing the impacts of aggregation upon estimation bias and information loss. Finally, in the third section, a methodology is presented for measuring the stability of interregional trade coefficients, and a discussion is provided of the implications of instabilities on the detailed output estimates.

TOTAL INTERREGIONAL TRADE EFFECTS

In this section, a methodology for analyzing the total effects of interregional trade on the regional industry output estimates produced by the MRIO model is presented. To provide some background for this presentation, a summary of the MRIO accounts and model described by Polenske (1980) is given first.

MRIO Accounts and Model

The MRIO model is comprised of the most comprehensive set of multiregional economic accounts currently in existence for the United States. These accounts trace in detail the supply and demand relationships in the U.S. economy. The supply of output produced by each industry in each region is equal to the amount of output demanded by all intermediate and final users in all regions, including foreign demand. The complete system of equations for m industries and n regions is shown in Appendix A. Before discussing the model further, a set of notations is provided.

- m — designates the number of industries, with the subscript i indicating the producing industry and the subscript j the purchasing industry.
- n — designates the number of regions, with the superscript g indicating the shipping region and the superscript h the receiving region.
- o — as a subscript indicates a summation over all industries; as a superscript indicates a summation over all regions.

^ indicates a block-diagonal matrix.

t as a superscript indicates a transposed matrix.

-1 as a superscript indicates the inverse of a matrix.

X = vector, mnx1, of commodity outputs. Each element, x_j^h, describes the total output of commodity j produced in region h.

Y = vector, mnx1, of final demands. Each element, y_i^h, describes the total amount of commodity i purchased by the final users in region h regardless of where the good was produced.

V = vector, 1xmn of value added components. Each element, v_j^h, describes the payment made by industry j in region h to factors of production regardless of where the factors are located.

$\hat{G}$ = square matrix, mnxmn, of intermediate demands. Each element, g_{ij}^{oh}, shows the output purchased by industry j in region h from industry i regardless of where industry i is located.

$\hat{A}$ = block diagonal square matrix, mnxmn, of technical input coefficients for each region, with the direct input coefficients for each region appearing as n square matrices, mxm, on the diagonal blocks. Each technical coefficient, $a_{ij}^{oh} = g_{ij}^{oh}/x_j^h$, describes the amount of commodity i purchased by industry j in region h, g_{ij}^{oh}, per dollar of industry j's output in that region, x_j^h.

C = square matrix, mnxmn, of expanded trade coefficient matrices, with the trade coefficients arrayed along the principle diagonal of each of the n blocks and zeros for the off-diagonal elements. Each block in the expanded matrix has an mxm dimension. Each trade coefficient, $c_{oi}^{gh} = t_{oi}^{gh}/t_i^h$, describes the amount of commodity i shipped from region g to region h, t_{oi}^{gh}, per dollar of consumption in region h of commodity i, t_i^h.

With these definitions, it is possible to discuss the transformation of the MRIO accounts into the MRIO model. The MRIO accounts require transformation because the MRIO accounting system contains more variables than equations. It cannot be used to solve for regional outputs, given a set of regional final demands, without introducing (mxmxn) technical coefficients and (nxnxm) trade coefficients. By introducing these two sets of structural coefficients, the basic accounting balance between supply and demand in the MRIO system can be represented by the following matrix equation:

$$X = C(\hat{A}X + Y) \qquad (2.1)$$

Because the structure of these matrices may not be apparent, the expanded matrices for m industries and n regions are presented in Appendix A.

An example for two regions and two industries will help to illustrate the structure of the model. Following the notational conventions of Polenske (1980), the technical coefficient matrices for regions 1 and 2 and industries 1 and 2 are given by:

$$\begin{bmatrix} a_{11}^{01} & a_{12}^{01} \\ a_{21}^{01} & a_{22}^{01} \end{bmatrix} \qquad \begin{bmatrix} a_{11}^{02} & a_{12}^{02} \\ a_{21}^{02} & a_{22}^{02} \end{bmatrix} \tag{2.2}$$

Region 1   Region 2

The expanded $\hat{A}$ is thus:

$$\hat{A} = \begin{bmatrix} a_{11}^{01} & a_{12}^{01} & & \\ a_{21}^{01} & a_{22}^{01} & \multicolumn{2}{c}{0} \\ & & a_{11}^{02} & a_{12}^{02} \\ \multicolumn{2}{c}{0} & a_{21}^{02} & a_{22}^{02} \end{bmatrix} \tag{2.3}$$

Similarly, the trade coefficient matrices for commodities 1 and 2 are given by:

$$\begin{bmatrix} c_1^{11} & c_1^{12} \\ c_1^{21} & c_1^{22} \end{bmatrix} \qquad \begin{bmatrix} c_2^{11} & c_2^{12} \\ c_2^{21} & c_2^{22} \end{bmatrix} \qquad (2.4)$$

Commodity 1 Commodity 2

and the expanded C by:

$$C = \begin{bmatrix} c_1^{11} & 0 & c_1^{12} & 0 \\ 0 & c_2^{11} & 0 & c_2^{12} \\ c_1^{21} & 0 & c_1^{22} & 0 \\ 0 & c_2^{21} & 0 & c_2^{22} \end{bmatrix} \qquad (2.5)$$

Substituting matrices (2.3) and (2.5) into the balance equation (2.1) for the MRIO model and carrying out the multiplication yields equation (2.6). Equation (2.6), which is given on the next page, illustrates how the different components of the system interact. The trade coefficients

$$
\begin{bmatrix} x_1^1 \\ x_2^1 \\ x_1^2 \\ x_2^2 \end{bmatrix}
=
\begin{bmatrix}
c_1^{11} a_{11}^{01} x_1^1 + c_1^{11} a_{12}^{01} x_2^1 + c_1^{12} a_{11}^{02} x_1^2 + c_1^{12} a_{12}^{02} x_2^2 \\
c_2^{11} a_{21}^{01} x_1^1 + c_2^{11} a_{22}^{01} x_2^1 + c_2^{12} a_{21}^{02} x_1^2 + c_2^{12} a_{22}^{02} x_2^2 \\
c_1^{21} a_{11}^{01} x_1^1 + c_1^{21} a_{12}^{01} x_2^1 + c_1^{22} a_{11}^{02} x_1^2 + c_1^{22} a_{12}^{02} x_2^2 \\
c_2^{21} a_{21}^{01} x_1^1 + c_2^{21} a_{22}^{01} x_2^1 + c_2^{22} a_{21}^{02} x_1^2 + c_2^{22} a_{22}^{02} x_2^2
\end{bmatrix}
+
\begin{bmatrix}
c_1^{11} y_1^1 + c_1^{12} y_1^2 \\
c_2^{11} y_2^1 + c_2^{12} y_2^2 \\
c_1^{21} y_1^1 + c_1^{22} y_1^2 \\
c_2^{21} y_2^1 + c_2^{22} y_2^2
\end{bmatrix}
$$

Equation System (2.6)

act as a set of weights to allocate regional outputs to meet intermediate and final demands in each region. As a result, they provide the linkages between demand and supply of each industry's output among all regions. Solving equation (2.1) for X yields:

$$X = (I - C\hat{A})^{-1} CY \qquad (2.7)$$

It would appear from equations (2.1), (2.6), and (2.7) that interregional trade relationships play an important role in determining regional industrial outputs. But how large is this role empirically? A methodology for testing the empirical significance of interregional trade data in the MRIO model is presented in the next section.

Interregional Trade Effects in the MRIO Model

The most obvious indicator of the empirical significance of interregional trade in the MRIO model in terms of the detailed output estimates is an estimate of the outputs without trade in the model. These outputs can then be compared to those obtained with trade in the model; the difference between the two vectors of outputs being the error introduced by completely omitting trade. If the interregional trade relationships are omitted from equation (2.7), it simplifies to:

$$X' = (I - \hat{A})^{-1} Y \qquad (2.8)$$

where X' indicates that the outputs were calculated without interregional trade relationships in the model.

The total size of the interregional trade effects can then be found as the difference between the outputs calculated with (2.7) and (2.8):

$$X - X' = [(I - C\hat{A})^{-1} C - (I - \hat{A})^{-1}] Y \qquad (2.9)$$

From equation (2.9), it can be seen that as the number of regions approaches one, the error introduced by omitting trade goes to zero. This is because the effects of interregional trade will become smaller and smaller as the regions are aggregated. Although the MRIO model is admittedly mispecified when the interregional trade data are omitted in this manner, this test does provide a measure of the maximum error introduced into the MRIO model by neglecting trade completely.

However, equation (2.9) overstates the size of the interregional trade effects because no adjustment has been made to the accounts for the omission of trade. When the trade relationships are taken out of equation (2.7), the economic accounts underlying the model will no longer balance. This is because the outputs in the X vector are a function of demands in all regions, while the X' vector assumes that the intermediate and final demands in each region are satisfied solely from regional production. Before an accurate assessment of the interregional trade effects can be made, the accounts must therefore be balanced. Most regional analysts would not neglect trade completely, but would attempt to make an adjustment for its omission. A simple correction is presented below that can be made to the regional final demands to balance the accounts. This correction is known as the net-trade balance and is defined as the difference between regional production and regional consumption of the output in each industry.

It can be shown that the net-trade balance will properly augment the accounts for the omission of interregional trade. First, however, it is necessary to define some additional notations.

Q = a vector, mnx1, of total regional consumption. Each element, $q_i^h = \sum_j g_{ij}^{oh} + y_i^h$, is the sum of intermediate and final demands for the output of industry i in region h.

Z = a matrix, mnxmn, of interregional interindustry transactions. The matrix, Z, is equal to the product of the expanded interregional trade coefficient matrix, C, and the expanded interindustry transactions matrix, $\hat{G}$.

H = a vector, mnx1. Each element, $h_i^h = \sum_j Z_{ij}$, is the sum of all intermediate demand for the output of industry i produced in region h.

With these notations, the outputs in equation (2.1) can be expressed by:

$$X = H + CY \tag{2.10}$$

Because equation (2.10) shows that regional production is equal to the sum of regional consumption plus the demands from other regions, it follows that the amount of output shipped to other regions is equal to total regional output minus total regional consumption. As noted above, this is termed the net-trade balance and is found by:

$$N = X - Q \tag{2.11}$$

Rearranging equation (2.11), regional outputs are the sum of regional intermediate and final demands, Q, and the net-trade balance.

$$X = Q + N \tag{2.12}$$

Equation (2.12) is equivalent to (2.10). Thus, the accounting system is still balanced. A final demand vector, adjusted for the net-trade balances can be defined by:

$$Y' = Y + N \tag{2.13}$$

Substituting $a_{ij}^{oh} x_j^{h}$ for g_{ij}^{oh} in the definition of Q, an adjusted set of accounts is given by:

$$X = \hat{A}X + Y' \tag{2.14}$$

Solving for X:

$$X = (I - \hat{A})^{-1} Y' \tag{2.15}$$

It is thus possible to solve for the detailed regional outputs without interregional trade data by making a net-trade balance adjustment to final demands. Of course, it must be stressed that an accurate net-trade balance adjustment is possible only if reliable data on regional production and consumption exist. Polenske (1980) points out that the trade data play a crucial role in the MRIO accounts by helping to ensure consistency of production and consumption totals between the various regions. Without the interregional trade data, these consistency checks would not be possible. Furthermore, if the model is to be used for detailed multiplier analyses (one of the strong advantages of using a multiregional or interregional input-output framework), the trade data are necessary for the determination of the detailed multipliers. Also, the transportation flows are useful as data in and of themselves, for conducting transportation studies.

A final clarification should be made regarding the treatment of foreign imports and exports in the net-trade balance analysis presented above. In the MRIO accounts, foreign imports and exports are usually combined to form a net foreign exports column in each regional input-output table. This column forms one component of the regional final demands. Thus, the treatment of foreign imports and exports is handled in the net-trade balance adjustment within the final demands of each region.

The result shown in equation (2.15) will be investigated empirically in Chapter 3 for the 19-industry, 9-region MRIO accounts. This will be done by calculating the outputs using the net-trade balance approach for all industries. The value of using the MRIO model for these calculations is twofold: (a) the model contains actual data on interregional trade, and (b) the data in the model are organized in a strict accounting framework. This means that the data are consistent within each region, among all regions, and with national control totals.

It was pointed out in the preceding discussion that the importance of interregional trade for accurate output estimates was a function of the level of regional aggregation. In particular, as the number of regions approaches one, the MRIO model becomes a national input-output model and the error from omitting trade goes to zero. On the other hand, aggregation may lead to estimation bias because of the combination of industries with heterogeneous technical and trade structures. Furthermore, it would be expected that aggregation would lead to a loss of information in the model. The impacts of aggregation on estimation bias and information loss are considered in the following section.

AGGREGATION BIAS AND INFORMATION LOSS IN THE MRIO MODEL

Williamson (1970), Doeksen and Little (1968), and Hewings (1971) have indicated in their empirical studies that the aggregation bias is negligble for single-region input-output models. Miller and Blair (1980, 1981) have arrived at similar results with respect to the aggregation problem in interregional and multiregional input-output systems. However, the latter's analysis concentrated only on total regional outputs and did not report any results for individual industry outputs. To understand how aggregation affects the individual industry output estimates in a multiregional input-output system, a formal definition of aggregation bias is needed. A rather detailed presentation of the aggregation bias will be provided in the following section because the author is not aware of any study where the bias has been determined for a multiregional input-output system.

Aggregation Bias in the MRIO Model

Aggregation bias was defined by Fei (1956) and others in the input-output literature, as the difference between the outputs calculated with a "disaggregate" set of data and those calculated with the same set of data at a more aggregate level. It should be noted that the terms "disaggregate" and "aggregate" are purely relative. Disaggregate economic data generally do not exist in the real world. Most economic data that are collected can be thought of as aggregates of some smaller unit. Nevertheless, an analysis of aggregation has to begin somewhere. The fact that the starting variables are themselves already aggregates of more detailed variables does not preclude the possibility of developing aggregation relationships. Of course, the choice of the base reference point will affect the magnitudes of these relationships for different aggregation schemes. However, the emphasis of this thesis is not on specific magnitudes, but rather, on clarifying the impacts of aggregation upon estimation bias and information loss in the MRIO model.

In the empirical analyses of aggregation bias found in the literature, the outputs calculated with a disaggregate set of data are postaggregated to make them comparable with those from an aggregated set. This relationship can be shown mathematically. Equation (2.7) was used for computing the regional outputs with the disaggregate set of MRIO accounts. An analogous equation can be defined for the output vector, X^*, calculated with aggregated trade, technology, and final demand data as follows:

$$X^* = (I - C^*\hat{A}^*)^{-1} C^*Y^* \tag{2.16}$$

where C^*, $\hat{A}^*$, and Y^* signify that the original C and $\hat{A}$ matrices and the Y vector have been aggregated. After aggregating the output vector, X, calculated with the disaggregate system to be comparable with X^*, the aggregation bias is defined to be:

$$\text{BIAS} = J_1(X) - X^* \tag{2.17}$$

where J_1 is a postaggregation operator.

If the function f_1 is defined to denote the solution procedure given by equation (2.7) and J_2 is defined as a preaggregation operator, the estimation bias can be defined more generally by:

$$\text{BIAS} = J_1[f_1(C,\hat{A},Y)] - f_1[J_2(C,\hat{A},Y)] \tag{2.18}$$

This formulation shows that the bias is a result of the two aggregation processes operating on the same database. Because the postaggregation operator J_1 aggregates only the results of the model and does not affect the trade, technology, or final demand structures, it is generally assumed not to introduce any error when comparing the postaggregated versus preaggregated results. This assumption will be maintained here.

Equation (2.18) does not help very much in understanding how the aggregation process is affecting the results of the model, however. To provide such an understanding, an approach similar to Theil's (1967) is needed. His approach must be generalized to take account of the fact that all components of the model can be aggregated with respect to two components--regions and industries. This generalization is presented below.

Let S be a matrix of the form:

$$S = \begin{bmatrix} 1...1 & 0.... & ....0 \\ 0...0 & 1...1 & 0...0 \\ ..... & ..... & ..... \\ ..... & ..... & ..... \\ 0.... & ....0 & 1...1 \end{bmatrix} \tag{2.19}$$

Matrices of this type have been used in the literature to represent the aggregation process by Moromoto (1969), Ara (1959), Hatanaka (1952), Theil (1957), Miller and Blair (1980, 1981) and others. Four transformation matrices: E_1, E_2, E_3, and E_4, similar to the S matrix , can be specified to aggregate the interindustry and interregional flows into the industrial and regional aggregate classifications. Four transformation matrices are required because the interindustry and interregional flows must each be aggregated by industry and region.

Because the structures of the $\hat{A}$ and C matrices are different, a separate set of transformation matrices must be specified for each. Letting M and N denote the number of aggregate industrial and regional categories; m and n denote the disaggregate sets; and E_1 and E_2 represent the industrial and regional transformation matrices for the interindustry portion of the model, respectively; then postmultiplication of the X and CY vectors by E_1 and E_2 yields an aggregated set of total regional outputs and final demands by industry set:

$$X^* = E_2 E_1 (X) \tag{2.20}$$

and

$$(CY)^* = E_2 E_1 (CY) \tag{2.21}$$

Similarly, premultiplication and postmultiplication of the interindustry transactions matrix for region h by E_1 and E_2 respectively, yields aggregate technical coefficients for the flows from industry group s to industry group k in the aggregate region q:

$$a_{sk}^{oq} = \frac{\sum_{i \in m_s} \sum_{j \in m_k} \sum_{h \in n_q} a_{ij}^{oh} x_j^h}{\sum_{j \in m_k} \sum_{h \in n_q} x_j^h} \tag{2.22}$$

where:

n_q is the set of disaggregate regions in aggregate region q;

m_s, m_k are sets of disaggregate industries in aggregate industries s and k; and

all other terms are as previously defined.

This can be simplified by defining:

$$w_j^h = \frac{\sum_{h \in n_q} x_j^h}{\sum_{j \in m_k} \sum_{h \in n_q} x_j^h} \tag{2.23}$$

to be a set of weights for aggregating the regional technical coefficients. This system of weights can be decomposed into two systems: the first, ${}_1w_{ij}^{oh}$, contains the industry weights holding the regional classification constant; the second, ${}_2w_{ij}^{oh}$, contains the region weights holding the industry classification constant. Because $w_j^h = {}_1w_{ij}^{oh}\ {}_2w_{ij}^{oh}$, substituting ${}_1w_{ij}^{oh}$ and ${}_2w_{ij}^{oh}$ into equation (2.22) yields:

$$a_{sk}^{oq} = \sum_{i \in m_s} \sum_{j \in m_k} \sum_{h \in n_q} a_{ij}^{oh}\ {}_1w_{ij}^{oh}\ {}_2w_{ij}^{oh} \tag{2.24}$$

In a like manner, using the transformation matrices E_3 and E_4, the aggregate trade coefficients for the flows from region group r to region group q for commodity group k are found to be:

$$c_{ok}^{rq} = \frac{\sum_{g \in n_r} \sum_{h \in n_q} \sum_{i \in m_k} c_{oi}^{gh} t_i^h}{\sum_{h \in n_q} \sum_{i \in m_k} t_i^h} \tag{2.25}$$

where:

n_r is a set of disaggregate regions in aggregate region r; and

all other terms are as previously defined.

As in the case of the interindustry flows, a system of weights can be defined for aggregating the interregional trade coefficients:

$$W_i^h = \frac{\sum_{i \in m_s} t_i^h}{\sum_{h \in n_q} \sum_{i \in m_s} t_i^h} \tag{2.26}$$

These weights can be decomposed into two sets, ${}_3w_{ij}^{oh}$ and ${}_4w_{ij}^{oh}$ corresponding, respectively, to industry and region aggregation. Substituting these weights into equation (2.25) yields:

$$e_{ok}^{rq} = \sum_{g \in n_r} \sum_{h \in n_q} \sum_{i \in m_k} c_{oi}^{gh} \; {}_3w_{oi}^{oh} \; {}_4w_{oi}^{oh} \tag{2.27}$$

Each set of weights can be arranged into a transformation matrix W_1 ... W_4 with the same form as the corresponding matrix E_1 ... E_4 where:

$$I = E_i \; W_i^t \tag{2.28}$$

The aggregate technical and trade coefficient matrices, A* and C*, can then be found as follows:

$$\hat{A}* = E_2 E_1 \; \hat{A} \; W_1^t W_2^t \tag{2.29}$$

and

$$C* = E_4 E_3 \; C \; W_3^t W_4^t \tag{2.30}$$

Substituting equations (2.29) and (2.30) into equation (2.16), and noting that $Y* = E_1 \; E_2 \; Y$:

$$X* = (I - E_4 E_3 \; C \; W_3^t W_4^t \; E_2 E_1 \; \hat{A} \; W_1^t W_2^t)^{-1} \; E_4 E_3 \; C \; W_3^t W_4^t \; E_2 E_1 \; Y \tag{2.31}$$

However, the outputs from equation (2.31) are different from the postaggregated outputs of (2.7). From equation (2.20):

$$E_2E_1(X) = E_2E_1[(I - C\hat{A})^{-1} CY] \tag{2.32}$$

The difference between the outputs given by (2.31) and (2.32) is the aggregation bias and is found by:

$$X^* - E_2E_1(X) = [(I - E_4E_3\ C\ W_3^tW_4^t\ E_2E_1\ \hat{A}\ W_1^tW_2^t)^{-1}\ E_4E_3\ C\ W_3^tW_4^t\ E_2E_1\ Y]$$

$$- [E_2E_1(I - C\hat{A})^{-1}\ CY] \tag{2.33}$$

$$= [[(I - E_4E_3\ C\ W_3^tW_4^t\ E_2E_1\ \hat{A}\ W_1^tW_2^t)^{-1}\ E_4E_3\ C\ W_3^tW_4^t\ E_2E_1]$$

$$- [E_2E_1(I - C\hat{A})^{-1}\ C]]\ Y \tag{2.34}$$

$$= BY \tag{2.35}$$

where:

$$B = [[(I - E_4E_3\ C\ W_3^tW_4^t\ E_2E_1\ \hat{A}\ W_1^tW_2^t)^{-1}\ E_4E_3\ C\ W_3^tW_4^t\ E_2E_1]$$

$$- [E_2E_1(I - C\hat{A})^{-1}\ C]] \tag{2.36}$$

Equation (2.36) can be simplified with the following substitutions:

$$\begin{aligned} E_5 &= E_2E_1 \\ E_6 &= E_4E_3 \\ W_5 &= W_1^tW_2^t \\ W_6 &= W_3^tW_4^t \end{aligned} \qquad (2.37)$$

This yields:

$$B = [[(I - E_6\ C\ W_6E_5\ \hat{A}\ W_5)^{-1}\ E_6\ C\ W_6E_5] - [E_5(I - C\hat{A})^{-1}C]] \qquad (2.38)$$

The first-order aggregation bias (Theil, 1967, p. 325) is found by expanding BY into a power series:

$$\begin{aligned} BY = [[E_6\ C\ W_6E_5\ Y &+ (E_6\ C\ W_6E_5\ \hat{A}\ W_5)E_6\ C\ W_6E_5\ Y \\ &+ (E_6\ C\ W_6E_5\ \hat{A}\ W_5)^2\ E_6\ C\ W_6E_5\ Y + \ldots] \\ &- E_5[CY + (C\hat{A})\ CY + (C\hat{A})^2\ CY + \ldots] \end{aligned} \qquad (2.39)$$

and then taking first-order terms:

$$B_1Y = E_6\ C\ W_6E_5\ Y + (E_6\ C\ W_6E_5\ \hat{A}\ W_5)E_6\ C\ W_6E_5Y - E_5\ C\ Y - E_5C\ \hat{A}\ C\ Y \qquad (2.40)$$

$$= [E_6CW_6E_5 + (E_6CW_6E_5\ \hat{A}\ W_5)E_6CW_6E_5 - E_5C - E_5C\ \hat{A}\ C]Y \qquad (2.41)$$

For the first-order aggregation bias to be zero, the following is required:

$$[E_6CW_6E_5 + (E_6CW_6E_5 \hat{A} W_5)E_6CW_6E_5]Y = E_5[C + C \hat{A} C]Y \qquad (2.42)$$

Comparing similar terms, the aggregation bias goes to zero if:

$$E_6 \; C \; W_6E_5 \; Y = E_5(CY) \qquad (2.43)$$

and

$$[(E_6CW_6E_5 \hat{A} W_5)(E_6CW_6E_5Y)] = E_5[(\hat{CA})(CY)] \qquad (2.44)$$

Equations (2.43) and (2.44) imply that the first-order aggregation bias will be zero for all industrial and regional aggregations only if the industries and regions have homogeneous input and trade structures. The total aggregation bias given by equation (2.39) is more complicated because of higher-order terms.

Thus far, only the problem of general aggregation of the economic accounts has been considered. This type of data aggregation is usually carried out if no particular region or industry is of special interest.

In the above discussion, it was shown that the aggregation bias arises both from the interindustry, interregional portion of the model, and from the final demand component. However, Moromoto (1969) showed that no aggregation bias occurs for a particular industry if that industry is not aggregated with others. This second type of aggregation, where all detail not of direct interest to the planner is aggregated, is important to keep in mind. No test of this type of aggregation was carried out for this study because, mathematically, it is a special case of general aggregation. Instead, an analysis of general aggregation is provided in Chapter 3 using the MRIO data for several classification schemes. In addition, a set of tests is discussed that addresses the problem of changes in the structure of the regional final demands. These tests provide an indication of how important the general aggregation problem is in a consistent set of multiregional accounts.

Aggregation and Information Loss

Intuitively, it makes sense that aggregating economic accounts will result in a loss of information. For example, suppose a disaggregate set of accounts provided interindustry transactions and interregional trade data for three types of mining--copper, gold, and coal--for each state. Now suppose this original set of accounts was aggregated so that it contained a composite mining sector that was a combination of the three disaggregate industries. Furthermore, suppose that the states were aggregated into the nine census regions. If a regional analyst now wanted to investigate the impacts of a particular policy on the coal industry in Kentucky having only the aggregated accounts to use, the analyst would find the amount of detail provided by the model to be inadequate. This is because information was lost in the aggregation process.

Of course, aggregation does not necessarily lead to a loss of information. For example, data may be collected at an aggregate level and distributed to a more disaggregate level by questionable means. In this case, the more aggregate dataset may contain more information that is reliable (a quality distinction) than the disaggregate dataset. Another example, often occurring in multiregional input-output analyses, is the representation of production technologies, for different regions by the same matrix of technical coefficients (usually national). In this case, eliminating all but one of the matrices of technical coefficients would not result in a loss of information provided that knowledge of the duplicate nature of the technical coefficients was preserved.

In the MRIO model, however, regional production technologies, interregional trade coefficients, and regional final demands are different for each industry in each region. Because the data for the MRIO 1963 accounts were collected (to the extent possible) at the state level, and because there are state-to-state variations in the data, it would be expected that aggregation of the MRIO accounts would generally lead to a loss of information.

Jiri Skolka (1964) was the first analyst to apply the concepts of information theory in an attempt to quantify the information loss in input-output tables due to aggregation. This work was subsequently extended by Theil (1967) and Theil and Uribe (1967). In these studies, however, only the use of information theory in a single-region input-output framework was considered. A methodology for extending this research to account for the aggregation of interregional trade relationships will be presented in this section.

Equation (2.1) states that total regional outputs are equal to the sum of intermediate requirements and final demands. The trade coefficients represented by the C matrix provide linkages between regions. For example, an increase in the final demand for automobiles in California will result in an increase in the intermediate requirements of the automobile industry in Michigan for steel from Pennsylvania.

In the previous section, it was shown how these interrelationships are affected by aggregation. Yet planners use input-output tables for more than calculating output estimates. Input-output tables are used as a means of presenting visually the interrelationships among industries, as an accounting device, and as a means of generating detailed multipliers. For the purposes of visual inspection, the tables are usually aggregated even though this may result in a significant loss of information. Clearly, it would be useful to regional planners to be able to quantify how much (if any) information is lost in utilizing a particular aggregation scheme. Another use of input-output tables is for the calculation of backward and forward linkages. These measures are an indication of the degree of interdependence present in the model. For many analyses, it may be important to the regional planner to have a means of assessing how the interdependence present in the model is affected by aggregation.

The information theory approach originally proposed by Skolka (1964) and subsequently elaborated upon by Theil (1967) and Theil and Uribe (1967) provides the regional planner with the means for assessing the degree of information and interdependence lost due to aggregation. The latter is important because, if the industries in a table are characterized by complete statistical independence, then only the row and column sums of the table are needed to generate all of the table's elements. In this case, there is no need to gather data on the interindustry transactions because they can be derived directly from the regional production and consumption totals.

As mentioned previously, the information approach for the single-region case has been developed in the literature. This discussion will be generalized for n regions using the MRIO framework. Before doing so, however, an attempt will be made to describe some of the underlying principles of the information technique.

Underlying Principles of Information Theory

If a particular event i occurs with a very high probability p_i, then its occurrence is of little surprise. This is equivalent to saying that the occurrence of the event i provides very little information. Conversely, the occurrence of an event j with a very small probability brings with it a great deal of information. Schwartz (1963, p. 8) has shown that an information generating function, $h(p_i)$, relating the probability of an event's occurrence to its information content must have the following properties:

1. $h(p_i)$ must be continuous for $0 \leq p_i \leq 1$
2. $h(p_i) = \infty$ if $p_i = 0$
3. $h(p_i) = 0$ if $p_i = 1$
4. $h(p_i) \geq h(p_j)$ for $p_j \geq p_i$
5. $h(p_i)+h(p_j)=h(p_i p_j)$ if p_i and p_j are independent

It has been proven (Khinchin, 1957) that the five properties just listed can be satisfied if and only if:

$$h(p_i) = - \log_b p_i = \log_b (1/p_i) \tag{2.45}$$

Equation (2.45) has been applied extensively in the fields of thermodynamics and communications theory as a measure of entropy. Logarithms to the base 2 are usually employed by information theorists so that one unit of information is generated by an event with the probability 0.5 of occurring. The units of logarithms to the base 2 are called bits--shorthand for binary digits. From the definition of expected value for a discrete variable, the average or expected information over a number of events is:

$$I = \sum_i p_i \log_2 (1/p_i) \tag{2.46}$$

The minimum value of this function is zero and occurs when one of the events occurs with probability of 1.0 and all other events have a probability of 0.0. Conversely, the function has a maximum value (equal to $\log_2 n$) when each of the n events has an equal probability of occurring.

Perhaps equally important to understanding how the information concept works is an understanding of the relationship of the probability size of an event and its contribution to the average information content of the input-output table. Figure 2.1 shows this relationship.

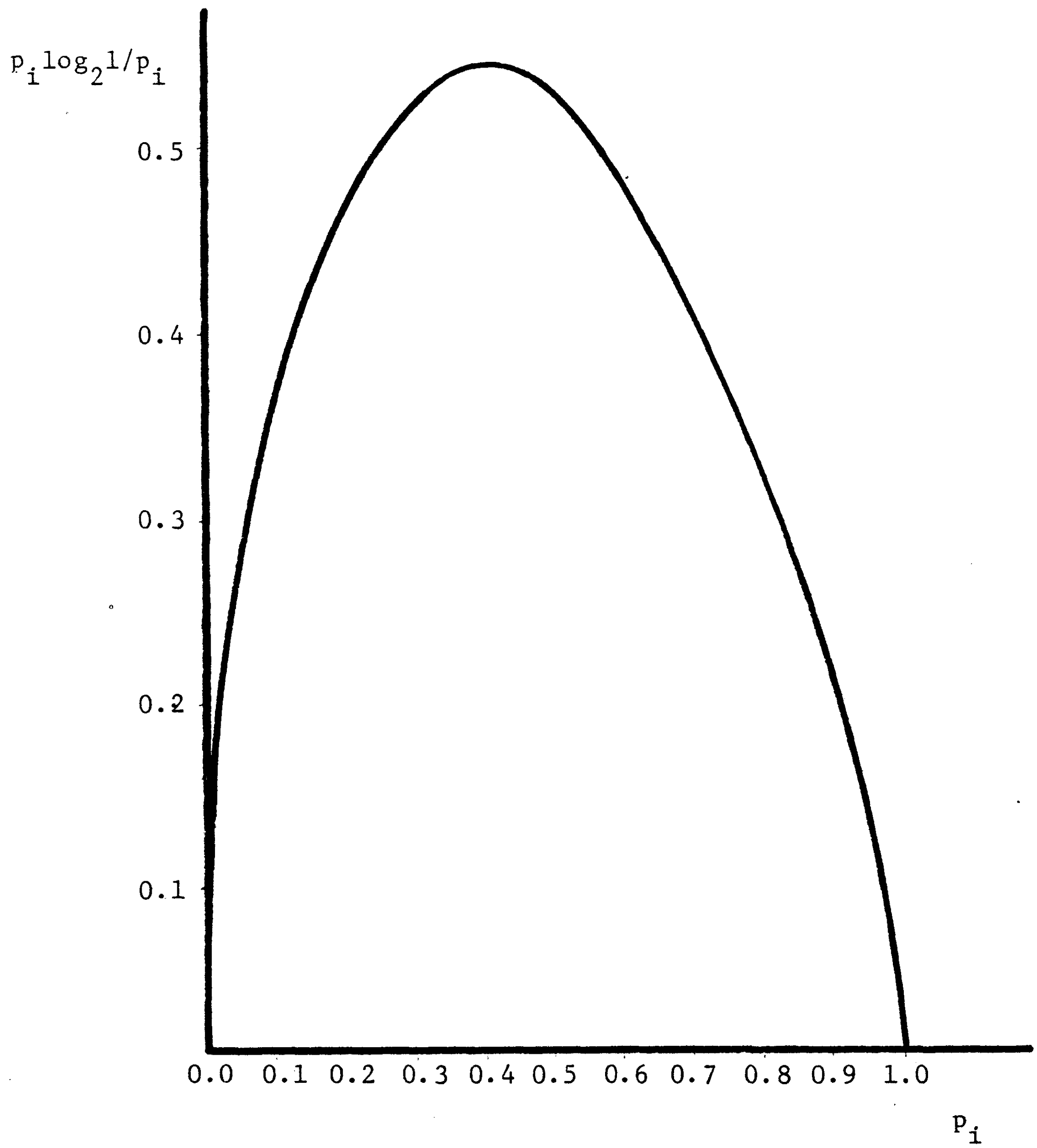

FIGURE 2.1

RELATIONSHIP OF PROBABILITY SIZE
TO INFORMATION CONTRIBUTION

It is interesting to note that the relationship shown in Figure 2.1 is slightly skewed--probabilities in intervals less than 0.5 tend to contribute slightly more to the information content of an input-output table than probabilities in the corresponding intervals greater than 0.5. Figure 2.1 also illustrates that very large and very small probabilities contribute less to the information content of the input-output table than intermediate values. In fact, as the probabilities approach either 0.0 or 1.0, the contribution of the flow to the average information content of the table tends to 0.0. This makes intuitive sense. If almost all interindustry, interregional transactions are subsumed in one flow (corresponding to the case where p_i is close to 1.0), then to study the system, the regional analyst has only to look at one element. As a result, the system as a whole contains almost no information--the detail it contains is unnecessary. At the other extreme, if an extremely small percentage of the total interindustry, interregional transactions are represented in a particular flow (corresponding to the case where p_i is close to 0.0), that flow is unlikely to be of much practical interest to the regional planner. However, if the system is comprised of many transactions between industries in all regions, then a set of multiregional input-output accounts providing a proxy for these interactions would be extremely valuable to a regional planner. In this case, the average information content of the input-output table would be close to a maximum. This is the result that the information approach provides. In the following section, a methodology for applying the information approach to the MRIO model is provided.

Quantifying Information Loss in the MRIO Model

Applying the information approach to the MRIO model entails first subtracting CY from both sides of equation (2.7) in order to isolate the intermediate demands on the right-hand side. If the interindustry transactions matrix, $\hat{G}$, is substituted for AX and the C matrix is used to allocate intermediate production interregionally, a matrix of interregional flows can be specified as before:

$$Z = C\hat{G} \tag{2.47}$$

For notational simplicity, the $\hat{G}$ and C matrices now represent expanded matrices that include the payments to the factors of production and trade of these factors, respectively. In addition, it is assumed that only intraregional trade will take place for the primary factors. This means that the elements of the expanded C matrix corresponding to the trade of the primary factors of production will have coefficients equal to 1.0 for the intraregional flows and zeros elsewhere. The latter assumption is necessary because no data on the interregional shipments of primary factors are available in the 1963 MRIO accounts. Following Theil (1967, p. 332), the $\hat{G}$ matrix is then augmented with sufficient zero columns to make it square.

A probability matrix can be created by dividing each element in Z by the grand total of all the elements of Z:

$$P = \left(\frac{1}{\sum_i \sum_j Z_{ij}} \right) Z \tag{2.48}$$

This matrix forms the basis for the calculations of the information content of the input-output system. The average information content of each cell in P can be found by:

$$I = \sum_i \sum_j P_{ij} \log_2 \frac{P_{ij}}{P_{io} P_{oj}} \qquad (2.49)$$

where o is defined as earlier to represent the relevant summation.

P_{io} and P_{oj} are the marginal probability distributions related to the joint probability distribution P_{ij}. If the table is characterized by independence, then:

$$P_{ij} = P_{io} * P_{oj} \qquad (2.50)$$

and I equals zero. In the case where I is not equal to zero, the total information content of the entire matrix, I_T, can be found by multiplying I by the number of elements in the P matrix.

The summary statistic I_T allows the information content of a set of economic accounts aggregated from equation (2.7) to be compared with the original accounts. It is expected that because aggregation will increase the average coefficient size, the information content of the economic accounts will decrease with aggregation. In the disaggregate accounts, many of the cells will be zero. The fact that the logarithm of zero is infinity presents no problems in information theory because $p_i \log_2 p_i$ is defined to be zero when p_i equals zero. This follows from $\lim_{p \to 0} p_i \log_2 p_i = 0$.

The value for I_T provides a quantitative appraisal of the information content of the model at a particular level of aggregation. By itself, this measure has little meaning. However, if the information content of the model can be shown to change with the level of aggregation, then the degree to which the information content of the model changes with aggregation can be assessed (at least for that specific case). By using equation (2.49), it is possible to investigate the change in the information content arising from an aggregation of the base accounts. Although the degree of change in the information content of the system will vary with the selection of the base accounts and the aggregation scheme, Theil (1967, p. 337-338) proved that the aggregated system will always contain either the same amount or less information than the disaggregate system.

The information measure should be interpreted carefully, however. In particular, the type of aggregation--specific or general, should be kept in mind. For example, suppose data were available for a complete set of multiregional accounts for 50 states and 100 industries. Suppose further that a regional analyst was interested only in the steel industry in Pennsylvania. Then, aggregating all industries other than steel and all regions other than Pennsylvania would lead to a virtual elimination of all the information content of the model from the perspective of information theory, but not from the perspective of the regional analyst.

Because aggregation affects both estimation bias and information content, it would be expected that the concepts are closely linked. Theil (1967) showed that there was a direct correspondence between the "input heterogeneity" component of the average information statistic and aggregation bias. An extension of Theil's proof to the MRIO system is straightforward if the system is first redefined with the net-trade balance adjustment (the proof is identical to Theil's except for the definition of final demand). The results of an empirical implementation of the information approach just outlined is given in Chapter 3.

Thus far in this chapter, only the effects of aggregation on estimation bias and information loss at a particular point in time have been developed. However, if changes in the trade or technical coefficients take place over time, the results given by the model may be affected in different ways. Although technical and trade coefficients for the MRIO model are currently (Spring 1982) available only for 1963, interregional trade flow data are available for several years from the Census of Transportation. Therefore, a methodology for analyzing the stability of trade coefficients is presented in the following section.

INTERTEMPORAL TRADE-COEFFICIENT STABILITY

In addition to aggregation problems, instabilities in the structural parameters of the model may lead to biases in the output estimates over time. These instabilities could occur in either the technical or the trade coefficients. Very little work has been done (especially at the regional level) to investigate stability questions concerning technical and trade coefficients. The work that has been conducted has concentrated largely on questions concerning the stability of technical coefficients rather than trade--primarily because multiregional models are a relatively recent phenomenon (Polenske, 1980, p. 87) and trade data are so scarce.

The studies that have been conducted by Moses (1955), Riefler and Tiebout (1970), Isard (1953), Suzuki (1971), and Crown (1981) are inconclusive with regard to the issue of trade-coefficient stability. Because the trade data necessary to do adequate testing are difficult to obtain, and the number of studies undertaken thus far is small, no definitive conclusions have been reached concerning the stability or instability of trade coefficients. For example, both relative price changes and capacity constraints may lead to trade-coefficient instability. Price changes are expected to induce interregional substitution, but because static input-output models are not designed to handle substitution effects, this will be reflected in trade-coefficient instability. Similarly, capacity constraints can affect the stability of trade coefficients. Where capacity constraints are binding, large shifts in imports may be necessary to meet otherwise infeasible regional demands.

On the other hand, it is also easy to compile a list of factors favoring the stability of trade patterns. These include consumer loyalty, established warehousing and marketing arrangements, geographical barriers, climate (which can also introduce instability), etc. Thus, not only is the empirical literature inconclusive about trade-coefficient stability, the theory offers little in the way of a priori expectations.

Given that interregional trade plays a major role in determining the regional outputs and their distribution in the MRIO model, as well as the interregional multipliers, and given that there is little empirical or theoretical evidence for assuming their stability, it is worthwhile to ascertain how likely trade coefficients are to remain stable over time. Because of the accounting linkage between regional input-output and interregional trade tables in the MRIO accounts, it is clear that changes in interregional trade patterns will be accompanied by changes in regional production technologies and vice versa. However, allowing both of these factors to vary simultaneously clouds the effects of trade-coefficient changes on estimation bias. Furthermore, as noted above, a consistent set of multiregional input-output accounts is not currently available for other than 1963. As a result, the issue of trade-coefficient stability will be studied in isolation of changes in regional technical coefficients. Before proceeding, it is necessary to have a formal definition of trade-coefficient stability.

Definition of Trade-Coefficient Stability

Samuelson (1947) devoted over 50 pages to various definitions of stability concerning difference equations. For the purposes of this study, a definition of trade-coefficient stability is needed that lends itself to empirical testing. For instance, a trade coefficient c_{oi}^{gh} could be defined as stable if the absolute difference between it and some future trade coefficient ${}_{F}c_{oi}^{gh}$ was bounded by some constant epsilon:

$$\left| {}_{F}c_{oi}^{gh} - c_{oi}^{gh} \right| < \varepsilon \tag{2.51}$$

Similarly, a matrix of trade coefficients, C, could be defined to be stable if the absolute difference between each element and that of some future trade-coefficient matrix, ${}_{F}C$, was bounded by some constant epsilon:

$$| {}_{F}C - C | < \varepsilon \qquad (2.52)$$

Equations (2.51) and (2.52) are extremely restrictive, however. Furthermore, the level of instability that is acceptable may vary for different studies. This point will be elaborated upon in the next chapter. For many studies, general measures of differences between the trade coefficients in different years are more useful. These measures can be evaluated in each analysis to determine whether the trade data are sufficiently stable for the purposes of the study at hand.

No definitive measure for comparing the structure of two matrices exists. Thus, for example, studies of technical coefficient matrices by Schaffer and Chu (1969a; 1969b), Czmanski and Malizia (1969), Bozdogan (1969), and Isard and Romanoff (1969) all used different statistical measures. The most straightforward measure of changes in the trade coefficients over time is to calculate the arithmetic difference between the trade-coefficient matrices:

$$D = {}_{F}C - C \qquad (2.53)$$

This approach has obvious drawbacks when many matrices have to be compared, or when the matrices are large. Furthermore, the calculated differences may not be very useful unless they are related to the actual coefficients. Calculating the percentage change of each coefficient provides a more illustrative measure of trade-coefficient changes:

$$\frac{{}_F c_{oi}^{gh} - c_{oi}^{gh}}{c_{oi}^{gh}} * 100 \qquad (2.54)$$

However, large percentage changes may be brought about by very small coefficient values. The percentage change approach also has the same drawbacks as the arithmetic difference with respect to dealing with a large number of matrices or matrix elements. To alleviate this problem of too much detail, a statistic is desired that provides a summary measure of the difference between coefficient matrices over time.

A simple measure would be to calculate the mean of the difference matrix. However, because of the structure of the trade coefficient matrices (all coefficients in a given column sum to one), the mean difference will always be zero. A more useful measure would therefore be to calculate the mean of the absolute value of the errors:

$$\overline{d} = \frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} |d_{ij}| \qquad (2.55)$$

The usefulness of the mean absolute difference is considerably extended when coupled with a measure of variation. A particularly useful and well-known measure is that of the standard deviation (SD).

$$SD = \left[\frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} (d_{ij} - \bar{d})^2 \right]^{1/2} \qquad (2.56)$$

By comparing the mean absolute difference and the standard deviation of the absolute differences for each commodity, it is possible to gain considerable insight into the relative stability of different commodity trade patterns. However, this approach is inadequate when one trade pattern has a smaller absolute mean difference than another but a higher standard deviation.

The coefficient of variation (COV) overcomes this problem by combining the mean absolute difference and standard deviation into one statistic:

$$COV = \frac{SD}{\bar{d}} \qquad (2.57)$$

This allows the comparison of trade-coefficient changes for a broader range of cases.

Effects of Trade-Coefficient Instability

Having determined a method for measuring the stability of trade coefficients over time, it is worthwhile to consider the impacts of trade-coefficient instabilities on the output estimates of a multiregional input-output system. If a matrix of trade coefficients in some future year is given by the matrix ${}_{F}C$, and if the technical coefficients are assumed to remain constant, the new vector of estimated outputs for a given set of final demands can be expressed by:

$$ {}_{F}X = (I - {}_{F}C\hat{A})^{-1} \; {}_{F}CY \qquad (2.58) $$

Subtracting from ${}_{F}X$, the estimates obtained by using base-year trade coefficients gives the bias in the estimates due to trade-coefficient changes over time:

$$ {}_{F}X - X = [(I - {}_{F}C\hat{A})^{-1} {}_{F}CY] - [(I - C\hat{A})^{-1} CY] \qquad (2.59) $$

$$ = [(I - {}_{F}C\hat{A})^{-1} {}_{F}C - (I - C\hat{A})^{-1} C] \; Y \qquad (2.60) $$

It is obvious from equation (2.60) that trade-coefficient changes over time will affect the output estimates through changes in the interregional multipliers. If these impacts are not accounted for by correcting the trade data (either by assembling new data or by adjusting the old), the output estimates will be biased. The size of these impacts is an unanswered empirical question.

Until the 1977 MRIO interregional trade accounts have been assembled, the impacts of trade-coefficient instabilities on the output estimates of the MRIO model cannot be determined. However, it would be expected that aggregation would improve the stability of the trade coefficients because it would smooth much of the variation in the data. For example, it would be expected that the shipment of oranges has shifted increasingly from transport by railroad to transport by truck. Although the interregional shipments of oranges at the modal level of detail may therefore not have remained stable over time, it would be expected that the state-to-state pattern of trade, aggregated for all transportation modes, would have remained quite stable. A test of these types of aggregation impacts on the stability of the trade coefficients will be conducted in the next chapter.

CONCLUSIONS

In this chapter, the relationships between interregional trade effects, trade-coefficient stability, and the effects of aggregation on estimation bias and information loss in the MRIO model have been developed. A methodology for calculating the regional outputs of the MRIO model without detailed trade information by altering regional final demands by the amount of net-trade balances was put forth, as was a means of calculating the information loss and aggregation bias resulting from a consolidation of the MRIO accounts. In Chapter 3, all of these methods will be investigated empirically using several sets of MRIO data.

In addition, a methodology for analyzing the stability of trade coefficients was developed. It was suggested that if significant changes in trade patterns take place over time and the trade data are not updated or adjusted to account for these changes, biases in the output estimates may result. It was also suggested that the stability of interregional trade patterns may be closely related to several of the aggregation issues discussed elsewhere in the chapter. This is because trade-coefficient stability may be affected by the degree to which the trade data are aggregated. Using data from the 1967 and 1972 Census of Transportation, an empirical investigation of trade-coefficient stability will be undertaken in Chapter 3. It is hoped that Chapter 3 will clarify many of the theoretical concepts discussed thus far, and will illustrate the relevance of these issues to the regional analyst.

CHAPTER 3

EMPIRICAL EVIDENCE REGARDING THE ROLE OF TRADE IN THE MRIO MODEL

A theoretical treatment of several issues concerning the role of trade in the MRIO model was given in Chapter 2. The intent of that chapter was to develop an empirically implementable methodology to analyze four of the major issues concerning trade in the MRIO model. The issues discussed included: (a) the importance of trade in determining regional output estimates; (b) the relationship between aggregation and estimation bias; (c) the relationship between aggregation and information loss; and (d) trade-coefficient stability and its implications for the assembly of detailed interregional trade data. Because the most basic question concerns whether detailed interregional trade data are really necessary for implementing multiregional input-output models, the empirical significance of interregional trade effects will be investigated first.(1) An analysis of aggregation bias will be carried out next, by comparing the outputs calculated with the MRIO model at various levels of aggregation. The information content of the 19-industry, 9-region and the 3-industry, 3-region MRIO accounts will also be calculated and compared to determine whether aggregation has a serious effect on the information content of the model. Finally, using data from the 1967 and 1972 Census of Transportation, an analysis of trade-coefficient stability will be carried out.

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(1) The MRIO classification schemes used for the analyses presented in this chapter are given in Appendix C.

INTERREGIONAL TRADE EFFECTS

Because interregional trade data are difficult and expensive to assemble, regional analysts have long debated whether interregional trade flows are necessary for estimating outputs with multiregional and interregional input-output models. In this section, a test of the interregional trade effects is conducted using the 19-industry, 9-region 1963 MRIO accounts. The results of these tests help to clear up much of the ambiguity surrounding the importance of interregional trade effects--at least with respect to multiregional input-output models.

In Chapter 2, it was shown that the interregional trade effects can be calculated by a three-step process: (a) estimating a base set of outputs using detailed interregional trade coefficients, (b) estimating the outputs without the interregional trade data, and (c) computing the difference between the results of (a) and (b). It was also shown in Chapter 2 that by using a net-trade balance adjustment, the accounts could be balanced by altering only the regional final demands. This procedure was adopted because it does not affect the definition of the technical coefficients. It is desired to keep the technical coefficients unchanged between the base case and limited-trade cases (as presented in Chapter 2) so that any differences in output estimates will be due solely to the treatment of interregional trade.

Three tests concerning the interregional trade effects were carried out. In the first test, two sets of outputs were calculated using the 19-industry, 9-region MRIO model. One set included the effects of interregional trade; the other did not. No adjustment was made in calculating the second set of outputs to account for the absence of trade. The difference between the two sets of outputs was then calculated as shown in equation (2.9) of the previous chapter. The results are shown in Table 3.1.

It is evident that the total neglect of trade in the MRIO model leads to serious errors in the estimation of detailed industry outputs in each region. These errors result from the disruption in accounting balances brought about by removing the trade coefficients from the model and making no adjustment for their removal. Of the 171 output estimates, only 29 contained errors of 5 percent or less, while the errors for 22 of the outputs were greater than 100 percent.

Of course, most regional analysts would attempt to make an adjustment for the lack of detailed trade data in the model. Nevertheless, the errors shown in Table 3.1 do provide a "worst case" illustration of the dangers of neglecting trade relationships in multiregional models. (It is a worst case provided the adjustments made by analysts for the lack of trade do not exacerbate the errors.)

To see whether the errors presented in Table 3.1 could be reduced with a net-trade balance adjustment for the omission of trade data, two additional tests were conducted. These tests represent two cases concerning the availability of detailed interregional trade data: (a) no detailed interregional trade data for any of the industries; and (b) no detailed interregional trade data for service industries. A separate test was conducted for the service industries because data are generally more difficult to obtain for these industries. However, because this test was a subset of the case where data were unavailable for all industries, the results for services are presented in Appendix Table D.1.

As discussed in Chapter 2, regional net-trade balances are calculated by subtracting regional consumption of industrial output from

TABLE 3.1

PERCENTAGE DIFFERENCE BETWEEN BASE CASE AND 1963 REGIONAL OUTPUTS
RESULTING FROM OMISSION OF INTERREGIONAL TRADE

	1 NEW ENGLAND	2 MIDDLE ATLANTIC	3 EAST NORTH CENTRAL	4 WEST NORTH CENTRAL	5 SOUTH ATLANTIC	6 EAST SOUTH CENTRAL	7 WEST SOUTH CENTRAL	8 MOUNTAIN	9 PACIFIC
1 LIVESTOCK, PRDTS.	-46.9	-56.1	-11.7	33.4	24.2	33.1	-6.1	-12.6	-56.5
2 OTHER AGRICULTURE PRDTS.	-118.6	-128.0	-17.0	42.0	7.1	23.0	-2.2	18.0	-7.8
3 COAL MINING	-26542.7	13.6	-20.4	-350.4	43.0	72.1	-1884.9	22.8	-2368.3
4 CRUDE PETRO.,NATURAL GAS	46.7	-242.8	-304.6	-68.1	-789.4	-71.6	70.8	51.0	-42.7
5 OTHER MINING	-64.9	-15.7	-4.7	46.8	-15.6	-21.4	-52.7	61.3	-107.7
6 CONSTRUCTION	-0.6	2.9	0.1	0.2	-0.8	-1.4	1.8	-0.7	-0.9
7 FOOD,TOBAC.,FAB.,APPAREL	-18.7	-8.8	-18.2	33.6	37.3	29.4	-35.4	-61.2	-39.5
8 TRANSPORT EQPT.,ORDNANCE	-37.5	-39.4	49.0	-25.3	-80.1	-64.5	-64.8	-105.2	-10.0
9 LUMBER & PAPER	15.9	-6.8	8.8	-38.4	8.2	17.4	-37.6	-59.9	8.7
10 PETROLEUM, RELATED INDS.	-207.6	-20.2	-14.1	-69.6	-250.6	-167.0	63.4	-6.2	-10.1
11 PLASTICS & CHEMICALS	-0.1	12.2	23.1	-27.1	-13.8	9.3	27.8	-168.7	-73.8
12 GLASS, STONE,CLAY PRDTS	-10.8	15.3	26.3	3.0	-13.5	10.7	-18.7	-40.2	-50.0
13 PRIMARY IRON & STEEL MFR	-75.6	34.3	46.4	-300.7	-76.6	19.4	-281.4	-128.4	-204.6
14 PRIMARY NONFERROUS MFR	9.2	17.7	22.1	-125.7	-38.5	1.5	-11.9	50.3	-80.8
15 MACHINERY & EQUIPMENT	28.2	12.4	43.3	-29.1	-117.5	-34.1	-85.0	-221.2	-62.3
16 SERVICES	-0.5	13.8	-1.3	-1.1	-2.7	-13.1	-12.1	-12.4	-3.2
17 TRANSPORT. & WAREHOUSING	-26.1	7.9	-3.2	8.6	-6.9	-4.5	1.1	-1.4	-5.5
18 GAS & WATER SERVICES	-31.4	11.3	5.8	5.6	-23.7	18.1	-4.0	29.9	-17.5
19 ELECTRIC UTILITIES	11.9	0.2	15.0	-5.9	3.4	-21.5	1.9	4.4	-26.6
20 TOTAL	-2.9	5.0	13.7	2.6	-4.5	0.1	-2.4	-17.7	-16.9

regional production of that output. This method ensures that the accounts remain balanced. Using the methodology outlined by equation (2.15), the outputs were calculated with the detailed trade relationships taken out of the model, but with final demands adjusted by the amount of net-trade balances. Differences between these results and those of the base-case outputs are shown in Table 3.2. It is evident that the net-trade balance adjustment to regional final demands allows outputs to be accurately calculated without interregional trade data in the model. The only significant error was found in the coal industry in New England, and this was apparently the result of the small size of the base-case output value (see Appendix Table D.2).

The results presented in Table 3.2 support the conclusion reached in Chapter 2 that the assembly of detailed trade data is unnecessary for making accurate estimates of detailed outputs by region. However, as mentioned in Chapter 2, this is only true if accurate regional production and consumption data are available with which to derive net-trade balances. An inaccurate net-trade balance adjustment could conceivably lead to even larger estimation errors than no adjustment at all. Closely linked to this problem is the role of interregional trade in ensuring consistency in the economic accounts upon which a multiregional input-output model is based. In the MRIO model, consistency between regional production and consumption totals is maintained by requiring that the total value of production in each industry in each region be equal to the total value of the trade of that industry's output to all regions (including itself). In addition, it is required that the sum across all regional production and consumption totals equal the corresponding national values.

TABLE 3.2

PERCENTAGE DIFFERENCE BETWEEN BASE CASE AND 1963 REGIONAL OUTPUTS
RESULTING FROM OMISSION OF INTERREGIONAL TRADE
(WITH NET-TRADE BALANCE ADJUSTMENT)

	1 NEW ENGLAND	2 MIDDLE ATLANTIC	3 EAST NORTH CENTRAL	4 WEST NORTH CENTRAL	5 SOUTH ATLANTIC	6 EAST SOUTH CENTRAL	7 WEST SOUTH CENTRAL	8 MOUNTAIN	9 PACIFIC
1 LIVESTOCK, PRDTS.	-0.7	-0.4	-0.1	0.1	-0.2	-0.1	0.1	[illegible]	0.6
2 OTHER AGRICULTURE PRDTS.	-0.2	0.1	0.1	-0.1	0.2	0.1	-0.0	-0.1	-0.0
3 COAL MINING	-24.6	-0.3	-0.4	-0.9	-0.3	-0.3	-0.9	0.5	-1.3
4 CRUDE PETRO.,NATURAL GAS	-0.1	-0.2	-0.2	-0.2	-0.4	-0.2	-0.1	0.1	0.7
5 OTHER MINING	0.0	-0.2	-0.2	-0.1	-0.2	-0.3	-0.0	0.3	0.4
6 CONSTRUCTION	0.1	0.2	-0.0	0.0	-0.0	-0.2	-0.1	-0.1	-0.0
7 FOOD,TOBAC.,FAB.,APPAREL	-0.1	-0.0	-0.1	-0.1	-0.0	-0.1	-0.1	0.2	0.4
8 TRANSPORT EQPT.,ORDNANCE	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
9 LUMBER & PAPER	0.1	0.1	0.1	0.0	0.1	0.1	0.1	-0.3	-0.4
10 PETROLEUM, RELATED INDS.	-0.2	-0.1	-0.1	-0.2	[illegible]	-0.2	-0.1	0.0	0.5
11 PLASTICS & CHEMICALS	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	0.0	0.0	0.3
12 GLASS, STONE,CLAY PRDTS	-0.1	-0.1	-0.1	-0.1	-0.0	-0.1	0.0	0.3	0.4
13 PRIMARY IRON & STEEL MFR	-0.2	0.0	0.0	-0.4	-0.0	0.0	-0.1	0.2	0.2
14 PRIMARY NONFERROUS MFR	-0.1	0.0	-0.0	-0.2	0.0	-0.0	0.1	0.1	-0.1
15 MACHINERY & EQUIPMENT	0.0	0.0	0.0	-0.1	-0.0	-0.0	-0.0	-0.1	-0.0
16 SERVICES	-0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0
17 TRANSPORT. & WAREHOUSING	-0.1	-0.0	-0.0	-0.1	-0.0	-0.1	-0.0	-0.0	-0.0
18 GAS & WATER SERVICES	0.2	0.1	0.1	-0.1	0.1	0.0	-0.1	-0.4	-0.6
19 ELECTRIC UTILITIES	-1.5	-1.3	-0.9	-0.1	-1.2	-0.6	-0.1	0.2	0.3
20 TOTAL									

Another problem with omitting interregional trade data in a multiregional or interregional input-output model is that the detailed multipliers will be incorrect. These multipliers can be extremely useful for conducting impact analyses. A discussion of the multipliers that can be computed from the MRIO model is given in DiPasquale and Polenske (1977) and Shalizi (1979). Finally, it is obvious that detailed interregional trade data are necessary for conducting transportation studies of state-to-state commodity flows. From these considerations, there appears to be ample justification for the assembly of interregional trade data, provided that the time schedule and funding of a particular project permit it.

The results obtained in this study concerning the importance of trade in multiregional models differ sharply from those of previous analyses. The primary reason for this stems from a difference in the approach used to measure this importance. Previous studies used the interregional feedback approach which measures only the indirect trade effects of a change in final demand in one region on the outputs of that same region. The total trade measure used in this thesis captures the total impacts of trade on the industrial outputs in all regions. This includes the direct and indirect effects of changes in the final demands in all regions. It should be noted that the size of the total trade impacts is sensitive to the regional aggregation level of the data used for the tests. The more aggregate the regions, the less important interregional trade will be for the determination of the regional outputs. This is due to the obvious fact that aggregate regions are likely to be relatively more self-sufficient than their disaggregate counterparts. Nevertheless, it does appear that unless an adjustment is made to correct for the omission of interregional trade, substantial errors in the output estimates produced by multiregional input-output models can be expected.

Aside from impacts on the size of the total trade effects, aggregation may result in information loss and estimation bias. In the next section of this chapter, the results of empirical tests concerning the effects of aggregation on estimation bias and information loss in the MRIO model will be presented. These topics were given considerable weight in Chapter 2 because mathematical expressions for aggregation bias and information loss had not been previously developed for the multiregional input-output case. It will be seen that the actual testing of these concepts is relatively straightforward.

AGGREGATION BIAS AND INFORMATION LOSS

This section attempts to deal with two questions related to the aggregation problem: (a) how much aggregation bias is incurred by using "aggregate" data, and (b) how much information is given up? To address these questions, the same set of 19-industry, 9-region 1963 MRIO accounts used in the analysis of the interregional trade effects was employed. For the purposes of testing for the aggregation bias, these accounts were aggregated to 3 industries and 3 regions. The aggregation bias was calculated as discussed in Chapter 2 by subtracting the outputs estimated with the "aggregate" set of accounts from those of the "disaggregate" accounts (the latter being postaggregated to make them comparable in industrial and regional classification). The results are shown in Table 3.3.

It is immediately apparent from Table 3.3 that the aggregation

Table 3.3

AGGREGATION BIAS: 1963 ESTIMATED OUTPUTS, 19-INDUSTRY, 9-REGION CASE
(TENS OF MILLIONS OF 1963 DOLLARS)

	Post-Aggregated 19-Industry, 9-Region Output Estimates	3-Industry, 3-Region Output Estimates	Aggregation Bias	Aggregation Bias (Percent)
North				
Agriculture & mining	1851	1851	--	--
Construction & manufacturing	28772	28181	591	2.1
Services	21791	21535	256	1.2
South				
Agriculture & mining	2651	2651	--	--
Construction & manufacturing	13267	13047	220	1.7
Services	10521	10376	145	1.4
West				
Agriculture & mining	2967	2962	5	0.2
Construction & manufacturing	11974	11798	176	1.5
Services	11103	10938	165	1.5
Total	104897	103338	1559	1.5

bias incurred from consolidating the 19-industry, 9-region accounts to 3 industries and 3 regions is negligible (the largest error occurring in the Construction and Manufacturing industry in the North, was only about two percent.) Of course, this one test does not conclusively establish that aggregation bias is an empirically insignificant problem. It is possible, for instance, that aggregating the 79-industry, 51-region MRIO accounts to 3 industries and 3 regions would yield higher aggregation errors. The results of such an analysis are presented in Table 3.4. Once again, the aggregation bias was found to be very small--although somewhat larger than that resulting from the aggregation of the 19-industry, 9-region accounts. In this case, the errors ranged from plus or minus one to four percent.

It should be noted that the 79-industry, 51-region MRIO model used for the second test had to be solved by an iterative procedure rather than inversion because of cost and computer memory limitations. Although it would be expected that the errors would be larger in the second test (as they were), the difference between the two solution methodologies may have been a significant factor in the results obtained.

The results for the Agriculture & mining industry in Tables 3.3 and 3.4 are also interesting to note. There is almost no aggregation bias shown for this industry in Table 3.3. The theoretical reason for this is the homogeneity of the production and trade structures of all the disaggregate industries that were combined to form Agriculture & mining. However, because the industry is a composite of the first five industries shown in Tables 3.1 and 3.2, it is difficult to imagine that the homogeneity criteria would hold. Further study is needed that would allow measures of production and trade homegeneity to be calculated as an aid to understanding the aggregation problem in more detail. The reason for the slight underestimation of the outputs for Agriculture & mining produced by the disaggregate model and shown in Table 3.4, is also not immediately apparent. Because a preliminary investigation of the results did not uncover the cause of the underestimation, a more in-depth analysis would be needed. It is possible that these counterintuitive results are a function of the data themselves, rather than the mathematical structure of the model.

The purpose of calculating the errors resulting from these two sets of aggregations was not to arrive at a set of aggregation bias numbers per se. Rather, it was to test whether regional aggregation, in conjunction with industrial aggregation, would lead to significant estimation problems. From the limited testing presented with respect to the base-year accounts, regional and industrial aggregation does not appear to present serious empirical difficulties. This is in line with previous results found by regional analysts concerning the aggregation problem in single-region models.(1)

However, as demonstrated by Moromoto (1969) and others, aggregation bias may also result from structural changes in final demands. To test whether this is likely to be a serious problem in the MRIO model, a set of estimated final demands for 1980 was used to estimate 1980 outputs(2) for various levels of aggregation. This was not an attempt to analyze the impacts of changes in final demands over time.

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(1) See, for example, Hewings (1971). Some research concerning the aggregation problem in interregional and multiregional input-output models was also conducted by Miller and Blair (1980, 1981).

(2) For a description of how the 1980 final demands were estimated, see Scheppach (1972).

Table 3.4

AGGREGATION BIAS: 1963 ESTIMATED OUTPUTS, 79-INDUSTRY, 51-REGION CASE
(TENS OF MILLIONS OF 1963 DOLLARS)

	Post-Aggregated 79-Industry, 51-Region Output Estimates	3-Industry, 3-Region Output Estimates	Aggregation Bias	Aggregation Bias (Percent)
North				
Agriculture & mining	1836	1851	-15	-0.8
Construction & manufacturing	29373	28181	1192	4.1
Services	22146	21535	611	2.8
South				
Agriculture & mining	2617	2651	-34	-1.3
Construction & manufacturing	13473	13047	426	2.4
Services	10698	10376	322	3.0
West				
Agriculture & mining	2909	2962	-53	-1.8
Construction & manufacturing	12149	11798	351	2.9
Services	11280	10938	342	3.0
Total	106481	103339	3142	3.0

The 1980 final demands were used only because they were known to be different in structure from those of 1963. The results are presented in Tables 3.5 and 3.6 respectively, for the two aggregation schemes previously discussed. The aggregation bias resulting from changes in the structure of the final demands, in combination with the changes in the trade and technical coefficients due to consolidation, are considerably larger than those where only changes in the latter took place. The errors shown in Table 3.5 ranged from -10.6 to 5.3 percent, in comparison with values in Table 3.3 which ranged from 0.0 to 2.1 percent. Similarly, the errors in Table 3.6 ranged from -16.1 to 4.1 percent in comparison with values in Table 3.4 which ranged from -1.8 to 4.1 percent. In the particular case tested here, the 1980 final demands were relatively larger than in 1963 for Services and smaller for Agriculture and mining, and Construction and manufacturing in each region. The theoretical reason for the increase in the aggregation bias resulting from the use of the 1980 final demands versus those of 1963 is therefore that the Service industry is comprised of industries with relatively more heterogeneous trade and input structures than the other two composite industries.

It is obvious that aggregation error will occur in the Service industry if this is the case, but why is the aggregation error in the Agriculture and mining, and Construction and manufacturing industries so large? From equation (2.6) of Chapter 2, it can be deduced that the output of the Agriculture and mining industry is partly a function of the output of the Service industry. This, of course, is also the case for the Construction and manufacturing industry. However, the relatively small output level of the Agriculture and mining industry in each region

Table 3.5

AGGREGATION BIAS: 1980 ESTIMATED OUTPUTS, 19-INDUSTRY, 9-REGION CASE
(TENS OF MILLIONS OF 1963 DOLLARS)

	Post-Aggregated 19-Industry, 9-Region Output Estimates	3-Industry, 3-Region Output Estimates	Aggregation Bias	Aggregation Bias (Percent)
North				
Agriculture & mining	3079	3405	-326	-10.6
Construction & manufacturing	59634	56526	3108	5.2
Services	46727	44226	2501	5.3
South				
Agriculture & mining	4647	5078	-431	-9.3
Construction & manufacturing	27638	28455	-817	-3.0
Services	24829	26227	-1398	-5.6
West				
Agriculture & mining	4949	5327	-378	-7.6
Construction & manufacturing	23672	23767	-95	-0.4
Services	25049	24804	245	1.0
Total	220224	217815	2409	1.1

Table 3.6

AGGREGATION BIAS: 1980 ESTIMATED OUTPUTS, 79-INDUSTRY, 51-REGION CASE
(TENS OF MILLIONS OF 1963 DOLLARS)

	Post-Aggregated 79-Industry, 51-Region Output Estimates	3-Industry, 3-Region Output Estimates	Aggregation Bias	Aggregation Bias (Percent)
North				
Agriculture & mining	2931	3405	-474	-16.1
Construction & manufacturing	58954	56526	2428	4.1
Services	45855	44226	1629	3.6
South				
Agriculture & mining	4605	5078	-473	-10.3
Construction & manufacturing	27474	28455	-981	-3.6
Services	24617	26227	-1610	-6.5
West				
Agriculture & mining	4690	5327	-637	-13.6
Construction & manufacturing	23066	23767	-701	-3.0
Services	24438	24804	-366	-1.5
Total	216630	217815	-1185	-0.5

is affected proportionately much more than the Construction and manufacturing industry or the Service industry itself.

Upon closer examination, it is seen that the largest aggregation errors occur in Agriculture and mining which accounts for only 3, 8, and 10 percent of total regional output in the North, South, and West regions, respectively. Taking this into consideration significantly changes the conclusions concerning the size of the errors due to aggregation and the change in final demand structure. For example, the weighted average of the absolute value of the errors in the North region in Table 3.5 is only about 5 percent.

Also, it can be noted from Tables 3.5 and 3.6, that the detailed industry output estimates in each region are much more variable than the estimates for all industries in all regions taken together. This is because the gain by one region creates a loss by another, and the results tend to cancel. Most surprising of all, however, is that the aggregation bias from consolidating the 19 industries and 9 regions to 3 industries and 3 regions was marginally more sensitive overall than that for 79 industries and 51 regions. This may be the result of differences in the solution methodology. As previously mentioned, the 79-industry, 51-region output estimates were obtained by an interative procedure because of the size of the model. Estimates for the outputs of the other two classifications were arrived at by matrix inversion. Because the largest percentage changes occurred in industries with relatively small outputs, these outputs may have been more seriously affected by the solution procedure. Given that the results were very similar for the two aggregation schemes, this may have been the source of the counterintuitive result. Other factors, such as the manner in which secondary products are treated in the MRIO model, may also have had an impact on these results. The treatment of secondary products in national input-output tables has recently been studied by Mizrahi (1981), but a comprehensive analysis has not yet been undertaken at a regional level.

Of course, aggregation may have impacts other than estimation bias with which the regional analyst should be concerned. The information loss in an input-output table due to aggregation is one such impact. In Chapter 2, a means of calculating the average information content of an element in a multiregional input-output system, as well as the total information content of the system was presented. Utilizing this methodology, an analysis was conducted of the information loss that occurred due to aggregating the 19-industry, 9-region MRIO accounts to 3 industries and 3 regions. The results are displayed in Table 3.7. It is apparent that the information content of the 19-industry, 9-region model was virtually exhausted by aggregating to 3 industries and 3 regions. Although the average information content of the elements in the system decreased by about two-thirds due to aggregation, the nearly 100 percent reduction in the number of elements brought about a corresponding decrease of nearly 100 percent in the information content of the model. These results indicate that if a regional analyst intends to use a set of multiregional input-output accounts for other than estimation purposes, the analyst should consider carefully the detail that may be lost due to aggregation.

These results are closely related to the analysis of interregional trade effects presented in the first section of this chapter. One of the virtues of input-output analysis is the tremendous amount of detail that it provides on the interrelationships between different industries in the

Table 3.7

INFORMATION LOSS DUE TO AGGREGATION

MRIO Accounting Framework	Number of Variables in System	Average Information Content (bits)	Total Information Content (bits)
1. 19-Industry, 9-Region	29241	3.498	102290
2. 3-Industry, 3-Region	81	1.252	101
3. Percentage Change (Row 1 to Row 2)	-100	-64	-100

economy. It is the degree of interdependence that the information statistic can be used to measure. The more interrelated are the various industries and regions of the economy, the higher will be the value of the information statistic. Of course, as mentioned in Chapter 2, aggregation may not, in reality, lead to a loss of information. Because of data limitations in constructing multiregional and interregional input-output models, it is common practice to use a matrix of national technical coefficients to approximate regional production technologies. Such tables contain redundant information that should not affect the information content of the model. From the perspective of the regional analyst, the information approach will give erroneous results in such a case.

But from a practical standpoint, what does the information statistic really measure? In Chapter 2, it was pointed out that the regional analyst needs to distinguish between at least two types of aggregation--general and specific. All of the aggregation schemes presented in this thesis have been general. That is, no detail for a specific industry (or group of industries) in a specific region (or set of regions) was preserved. For the case of general aggregation, the information statistic provides a measure of the loss of detail in the accounts. For example, if an analyst was interested in the electric utilities industry in New England (available in the 19-industry, 9-region set of MRIO accounts) but had only the aggregate 3-industry, 3-region accounts to use, very litle in way of useful analysis could be carried out. The 3-industry, 3-region accounts would be of almost no worth relative to the 19-industry, 9-region set of accounts. As desired, the information content of the more aggregate set of accounts would, in this case, be very small relative to the "disaggregate" accounts.

However, the information measure as formulated in this thesis does not provide a useful measure of the information loss associated with specific aggregation. It could be argued that, if an analyst is interested only in a specific industry and region, that aggregation of all other detail in the model will not lead to a loss of information from the analyst's perspective. This is not the case because as the other industries and regions are aggregated, the analyst will lose detail on the inputs into the industry of interest. Similarly, detail will be lost by aggregating "irrelevant" regions in the trade matrix for the industry. It should be possible to develop a measure of the information loss due to specific aggregation through decomposition of the information statistic discussed in this thesis. Such an approach is discussed in Chapter 4.

The issues of total interregional trade effects, aggregation bias, and information loss have been discussed in this thesis in terms of a static model. If the necessary data were available, it would be possible to consider the effects of changes in the economic accounts over time. An issue of particular importance for the assembly of the 1977 accounts (and multiregional input-output accounts in general) is the stability of trade coefficients over time.

TRADE-COEFFICIENT STABILITY

It has been noted at several points in the preceeding chapters that interregional trade data are difficult, time-consuming, and expensive to collect. In each of the studies where the issue of trade-coefficient stability has been investigated, analysts have indicated some evidence supporting the stability of trade coefficients over time, but the literature has been inconclusive overall. It is extremely important to analyze the question of trade stability more closely as funds for data assembly become less and less available, while simultaneously, more multiregional models are being constructed.

MRIO trade data for two or more years are not currently available to use for an analysis of trade-coefficient stability. To circumvent this problem, an analysis of trade-coefficient stability was carried out using data from the 1967 and 1972 Census of Transportation. The Census data were chosen for this study because they are considered to be the most comprehensive source of state-to-state trade-flow data with multimodal detail that is currently available. There are several difficulties with using this data source that should be noted, however. First, the data are available only for manufacturing industries. The exclusion of the interregional trade of services, mining, construction, agriculture, and other industries is obviously a severe drawback to an analysis of trade-coefficient stability, because these industries may have very different stability properties than those of manufacturing industries. Although it would have been preferable to broaden the analysis by including data for nonmanufacturing industries from other sources, it was beyond the scope of this study to do so.

A second major difficulty with the Census material is its lack of complete demand and supply information concerning the interregional shipments of commodities. In particular, the purchasing industry is not identified. Although these data were collected in the 1977 Census of Transportation, they have not been processed. The lack of purchasing industry information hampers the study of trade-coefficient stability, because characteristics of demand are almost certainly different for different industries. Because all of the demanding sectors have been aggregated, it would be expected that the results would show the trade patterns to be more stable than they would be in the case of complete demand sector specification. This point is discussed in Appendix A.

Other difficulties with the Census data are that: (a) modal detail excludes pipelines; (b) Hawaii and Alaska are not included in the Census as origin states; (c) the District of Columbia is combined with the State of Maryland both as an origin and destination area; and (d) for five states (North Dakota, Nevada, New Mexico, Vermont, and Wyoming) only a single line showing all commodities combined is provided. For a discussion of other problems with the Census data, see Crutchfield and Wright (1977).

With these qualifications concerning the use of the Census information established, the results of the trade-coefficient stability tests can be presented. The analysis was undertaken in three steps: (a) checking for consistency of industry definitions in 1967 and 1972; (b) analyzing the degree of intermodal substitution (for all commodities) that took place over the period 1967-1972; and (c) conducting tests of trade variability over the period 1967-1972.

Consistency Between 1967 and 1972 Industry Definitions

The commodity data collected in the Census of Transportation Commodity Transportation Survey are classified by 2-, 3-, 4-, and 5-digit Transportation Commodity Classification (TCC) codes (specifications for the 2- and 3-digit codes are given in Appendix E). Before any analysis was conducted, the 2-digit TCC codes were checked to determine if any redefinitions of industry classifications had been made over the period 1967-1972. No significant redefinitions were found to have taken place, allowing this to be ruled out as a possible source of variation in the data. The first step in the analysis was to investigate the degree to which intermodal substitution took place over the period 1967-1972. The results of this investigation are presented in the next section.

Aggregate Intermodal Substitution

To assess the degree to which intermodal substitution took place over the period 1967 to 1972, the percent distribution of shipments for each 2-digit TCC industry and transportation mode was derived from Table 1 of the Commodity Transportation Survey for each year. This table also included Census estimates of the variability of the data. The results, presented in Table 3.8, are interesting for several reasons. One striking observation that can be made is the loss of market share that the railroad industry has suffered in most industries (the exceptions being Textile mill products; Furniture & fixtures; Petroleum & coal products; and Instruments, photo, & medical goods, watches and clocks.) Furthermore, it is apparent that the trucking industry (including both motor carriers and private trucks) was the main beneficiary of this decline, although the relative impact on motor carriers and private trucks varied widely for commodities. The volume of water transport (as indicated by the totals across all commodities) was, like rail, also in a generally downward direction. The most significant observation in terms of water transport was its approximate 15 percent drop in market share in the Petroleum & coal products industry. In this energy industry, all other modes (even rail) gained at the expense of water. The degree of

TABLE 3.8

PERCENT DISTRIBUTION OF COMMODITIES
SHIPPED IN THE UNITED STATES BY TRANSPORTATION MODE
(1967 and 1972)

Commodity Group	Rail	Motor Carrier	Private Truck	Water	All Others	Sampling Variability*
Food and Kindred Products						
1967	47.0	23.2	27.3	2.0	0.4	0-9
1972	37.4	25.0	33.9	3.5	0.4	5
Tobacco Products						
1967	51.0	45.9	0.9	1.9	0.3	10-19
1972	44.5	53.9	1.1	0.1	0.8	5
Textile Mill Products						
1967	8.4	60.8	29.9	0.4	0.5	10-19
1972	8.5	63.5	27.3	0.6	0.4	8
Apparel and Other Finished Textile Products, incl. Knit.						
1967	10.2	65.7	16.5	0.1	7.5	10-19
1972	10.0	68.5	15.2	0.0	6.6	13
Lumber and Wood Products, except furniture						
1967	52.7	13.7	28.5	5.0	0.1	0-9
1972	44.8	16.1	37.6	1.3	0.4	6
Furniture and Fixtures						
1967	22.2	50.9	25.4	0.8	0.7	10-19
1972	25.1	33.8	40.6	0.1	0.7	12

Commodity Group	Rail	Motor Carrier	Private Truck	Water	All Others	Sampling Variability*
Pulp, Paper, and Allied Products						
1967	56.1	27.2	14.8	1.6	0.3	0-9
1972	52.1	27.7	17.9	2.2	0.3	4
Chemicals and Allied Products						
1967	46.5	29.3	13.0	10.8	0.4	0-9
1972	42.0	33.5	11.3	12.7	0.8	4
Petroleum and Coal Products						
1967	5.9	10.7	4.9	78.4	0.1	0-9
1972	11.5	16.1	8.3	63.8	0.6	6
Rubber and Miscellaneous Plastics Products						
1967	23.7	63.3	11.4	0.1	1.5	0-9
1972	23.4	60.4	15.1	0.1	1.4	4
Leather and Leather Products						
1967	3.8	47.7	44.5	0.1	3.9	20-29
1972	2.4	61.1	31.8	0.0	4.6	10
Stone, Clay, Glass, and Concrete Products						
1967	34.5	45.5	17.8	1.9	0.3	0-9
1972	21.3	48.2	23.1	6.7	1.0	8
Primary Metal Products						
1967	49.0	38.3	6.7	5.8	0.2	0-9
1972	42.1	43.6	9.9	4.1	0.6	6
Fabricated Metal Products, except Ordnance, Mach. and Trans						
1967	26.0	50.2	21.2	1.7	0.9	0-9
1972	25.1	49.3	24.0	1.0	1.0	6

Commodity Group	Rail	Motor Carrier	Private Truck	Water	All Others	Sampling Variability*
Machinery, except Electrical						
1967	27.7	55.4	13.8	0.3	2.8	0-9
1972	20.6	61.6	15.5	0.2	2.4	4
Electrical Machinery, Equipment, and Supplies						
1967	31.7	54.2	11.0	0.2	2.9	0-9
1972	30.3	53.1	13.8	0.2	3.0	4
Transportation Equipment						
1967	54.4	38.5	6.3	0.1	0.7	0-9
1972	54.2	37.3	8.0	0.2	0.7	2
Instruments, Photo, and Medical Goods, Watches and Clocks						
1967	16.1	69.4	7.2	0.2	7.1	0-9
1972	22.6	60.0	12.5	0.2	5.0	8
Miscellaneous Products of Manufacturing						
1967	14.4	62.0	15.9	0.5	7.2	10-19
1972	20.3	51.8	19.2	4.2	4.9	10
All Commodities						
1967	32.9	26.7	13.8	26.3	0.3	-
1972	31.7	31.2	18.3	18.4	0.8	2

Source: U.S. Department of Commerce, Bureau of the Census. _1967 Census of Transportation_, Vol. 3, _Commodity Transportation Survey_, Part 3, _Commodity Groups_, Table 1.

U.S. Department of Commerce, Bureau of the Census. _1972 Census of Transportation_, Vol. 3, _Commodity Transportation Survey_, Part 3, _Area Statistics, South and West Regions and U.S. Summary_, Table 1.

*Note that only the range of sampling variability was given by the Census for 1967.

intermodal substitution in all industries, particularly the energy industry, over the period 1967-1972 is an important point to be noted for the study of trade stability, as will be seen in the more detailed results presented in the following section.

Analysis of Trade-Coefficient Stability

The major focus of the trade-stability research presented in this thesis was the calculation of several measures of variation in state-to-state trade-coefficients. These calculations were difficult and time-consuming to carry out because of the large amount of data that had to be processed. The Census tapes processed for this study contained nearly 1.5 million records of information. In order to facilitate the research, the data were therefore aggregated as they were processed. The 5-digit TCC information on the tapes was collapsed to the 2-digit level, and the six transportation modes (rail, private truck, motor carrier, water, air, and unknown) were aggregated to three (rail, truck, and other). Even after this aggregation process, it was still necessary to process 60 matrices (each with dimension 51x51) for each calculation. As a result, the calculations were kept relatively simple to stay within budget limitations.

In the first set of tests, state-to-state flows were aggregated for all commodities and modes to derive a total state-to-state commodity shipments table for each year. The elements in each column of both tables were then divided by their respective column sums to arrive at a set of trade relationships that were independent of the tonnage levels shipped. This method assumed fixed supply relationships as in the MRIO model. A matrix of aggregate trade-coefficient changes between the two years was then calculated. These results are shown in Appendix Table F.1. It is clear that even at this aggregate level, too much detail is provided for easy assessment. In addition, the magnitudes of the numbers are not related in any meaningful way to the 1967 or 1972 coefficients. To address this problem, the figures in Table F.1 were converted into percentage changes. The result is shown in Appendix Table F.2.

From the results presented in Table F.2, there appears to be an extraordinary amount of variation in the aggregate trade pattern over the time period 1967-1972. These results are misleading, however. The percentages were calculated by subtracting each 1967 trade coefficient from the corresponding 1972 value and dividing the result by the 1967 value. In those cases where the 1967 coefficient was very small, the resulting percentage calculation was apt to be very large. Nearly all of the large percentage changes in Table F.2 can be shown to be caused by small 1967 coefficients. To verify this point, the 1967 coefficients are provided in Appendix Table F.3.

These results, even though aggregated for all commodities and transportation modes, are too voluminous to be of much value in assessing the stability of trade coefficients over the 1967-1972 period. Furthermore, nothing has been learned about the stability of intermodal commodity flows by transportation mode. By calculating the mean, standard deviation, and coefficient of variation of the values in Table F.1, it was possible to obtain a summary measure of the stability of the aggregate data. For the reasons discussed in Chapter 2, these calculations were carried out based upon absolute values. The mean was found to be 0.017; the standard deviation to be 0.070, and the coefficient of variation to be 4.12. These measures provide some indication of the variability in the total state-to-state trade pattern aggregated for all commodities and transportation modes over the 1967-1972 period, as well as a base reference point with which to compare the more disaggregate testing presented below.

As has been stressed previously, it would be expected that the aggregate trade data just discussed would be more stable than data disaggregated by commodity and transportation mode. In Table 3.9, the means and standard deviations, and coefficients of variation for 20 commodities and 3 transportation modes are provided. As before, these calculations were based upon absolute values of the changes over the 1967-1972 period. Interestingly, the majority of the entries have a smaller coefficient of variation than the aggregate case. However, most also have larger mean changes and standard deviations. The latter statistics are the most relevant for comparing the stability of different trade patterns. The coefficient of variation is useful mainly as an aid when the mean and standard deviation of different trade patterns cannot be easily compared. Thus, it would appear that the trade data are somewhat more variable at this level of disaggregation. Of particular note are the relatively larger values for the mean, standard deviation, and the coefficient of variation in such industries as tobacco, textile, and leather products. The production of textile and leather products is known to have shifted substantially from the northeast to the southern part of the United States. Thus, the variability in the trade patterns of these industries seems to be associated with long-term structural change in the economy. On the otherhand, changes in the trade pattern of Tobacco products seem to be related to short-term fluctuations. For example, a partial listing of the Tobacco products trade-coefficients

Table 3.9

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION
FOR TRADE-COEFFICIENT CHANGES, 1967-1972
(Based upon absolute values)

Commodity	Rail			Truck			Other		
	Mean	Standard Deviation	Coef. of Variation	Mean	Standard Deviation	Coef. of Variation	Mean	Standard Deviation	Coef. of Variation
Food & kindred products	0.018	0.055	3.056	0.028	0.095	3.393	0.026	0.089	3.423
Tobacco products	0.016	0.100	6.250	0.028	0.138	4.929	0.026	0.141	5.423
Textile mill products	0.020	0.100	5.000	0.028	0.110	3.929	0.024	0.095	3.958
Apparel & other textile products	0.027	0.123	4.556	0.024	0.071	2.958	0.022	0.063	2.864
Lumber & wood products, except furniture	0.014	0.055	3.928	0.029	0.123	4.241	0.030	0.122	4.067
Furniture & fixtures	0.028	0.095	3.393	0.030	0.105	3.500	0.026	0.089	3.423
Pulp, paper & allied products	0.016	0.055	3.438	0.030	0.100	3.333	0.027	0.100	3.704
Printing, publishing, & allied industries	0.000	0.000	--	0.000	0.000	--	0.000	0.000	--
Chemicals & allied products	0.016	0.063	3.398	0.027	0.095	3.519	0.029	0.100	3.448
Petroleum & coal products	0.021	0.095	4.524	0.028	0.127	4.536	0.030	0.127	4.233
Rubber & miscellaneous products	0.026	0.110	4.231	0.024	0.078	3.250	0.027	0.105	3.889
Leather & leather products	0.023	0.127	5.522	0.023	0.090	3.913	0.021	0.089	4.238
Stone, clay, glass, & concrete products	0.018	0.078	4.333	0.028	0.105	3.750	0.024	0.110	4.583
Primary metal products	0.019	0.078	4.105	0.028	0.110	3.929	0.030	0.114	3.800
Fabricated metal products	0.022	0.090	4.091	0.024	0.084	3.500	0.027	0.089	3.296
Machinery, except electrical	0.019	0.071	3.737	0.023	0.071	3.087	0.028	0.084	3.000
Electrical machinery & equipment	0.020	0.071	3.550	0.022	0.063	2.864	0.024	0.078	3.250
Transportation equipment	0.017	0.063	3.706	0.025	0.089	3.560	0.027	0.110	4.074
Instruments	0.029	0.148	5.103	0.026	0.084	3.231	0.025	0.095	3.800
Miscellaneous manufactured products	0.031	0.134	4.323	0.025	0.084	3.360	0.029	0.114	3.931

Note: No data were provided for Printing, publishing, & allied industries on the 1967 or 1972 Census tapes.

changes showed that Wisconsin purchased all of its Tobacco products from North Carolina in one year and from Kentucky in the other. Thus, the instabilities reflected in Table 3.9 seem to be caused by very different types of factors. This is an area that requires considerably more research. Some possible ways of proceeding are discussed in Chapter 4.

There is often no trade between certain states for a commodity. The large number of zero entries in each trade matrix may make the trade data appear to be much more stable than they really are. To test for this possibility, the computations presented in Table 3.9 were repeated for those cases where a positive entry occurred in either 1967 or 1972. The results are shown in Table 3.10. Over half of the 2601 possible entries are zero for each commodity. From Table 3.10, it is apparent that the omission of zero values from the calculations results in generally larger mean coefficient changes and standard deviations, but smaller coefficients of variation. The reason for the smaller coefficients of variation stems from the sparcity of the trade patterns for those commodities that tend to be unstable. The relative variability of the industries in Table 3.10 are found to be very close to those of Table 3.9 if the mean and standard deviation are used as measures. However, the coefficients of variation were affected by the fact that when only the non zero elements were considered, the mean changes tended to grow more rapidly than the standard deviation. This was because deviations were no longer being taken from zero and the divisor used in calculating the mean and standard deviation was generally much smaller.

To provide more detail on the variability of the trade-coefficient changes, a frequency distribution of the changes for each commodity and transportation mode was constructed. The results are shown in Tables

Table 3.10

MEANS, STANDARD DEVIATIONS, ZERO ENTRIES, AND COEFFICIENTS OF VARIATION
FOR TRADE-COEFFICIENT CHANGES: NON-ZERO ENTRIES, 1967-1972
(Based upon absolute values)

Commodity	Rail				Truck				Other			
	Mean	Standard Deviation	Zero Entries	Coef. of Variation	Mean	Standard Deviation	Zero Entries	Coef. of Variation	Mean	Standard Deviation	Zero Entries	Coef. of Variation
Food & kindred products	0.035	0.066	1296	1.886	0.048	0.119	1113	2.479	0.049	0.114	1308	2.327
Tobacco products	0.404	0.303	2515	0.750	0.352	0.344	2433	0.977	0.444	0.377	2457	0.849
Textile mill products	0.166	0.224	2340	1.349	0.126	0.202	2033	1.603	0.104	0.163	2025	1.567
Apparel & other textile products	0.171	0.257	2228	1.503	0.068	0.106	1687	1.559	0.060	0.095	1674	1.583
Lumber & wood products, except furniture	0.042	0.079	1819	1.881	0.092	0.204	1880	2.217	0.123	0.227	1984	1.846
Furniture & fixtures	0.109	0.155	1961	1.422	0.084	0.160	1693	1.905	0.078	0.133	1775	1.705
Pulp, paper & allied products	0.035	0.062	1483	1.771	0.065	0.141	1413	2.169	0.063	0.145	1517	2.302
Printing, publishing, & allied industries	--	--	--	--	--	--	--	--	--	--	--	--
Chemicals & allied products	0.057	0.083	1501	1.456	0.051	0.128	1247	2.510	0.060	0.138	1386	2.300
Petroleum & coal products	0.125	0.190	2167	1.520	0.149	0.263	2158	1.765	0.122	0.235	2021	1.926
Rubber & miscellaneous products	0.106	0.194	2006	1.830	0.056	0.113	1503	2.018	0.080	0.164	1725	2.050
Leather & leather products	0.341	0.344	2502	1.009	0.129	0.170	2143	1.318	0.153	0.192	2256	1.255
Stone, clay, glass, & concrete products	0.067	0.128	1916	1.910	0.084	0.171	1755	2.036	0.098	0.202	1978	2.061
Primary metal products	0.058	0.120	1764	2.069	0.071	0.167	1590	2.352	0.096	0.189	1826	1.969
Fabricated metal products	0.070	0.143	1806	2.043	0.047	0.115	1298	2.447	0.063	0.128	1518	2.032
Machinery, except electrical	0.053	0.097	1723	1.830	0.038	0.089	1064	2.342	0.056	0.109	1310	1.946
Electrical machinery & equipment	0.060	0.116	1760	1.933	0.040	0.080	1236	2.000	0.052	0.103	1448	1.981
Transportation equipment	0.080	0.113	2063	1.413	0.080	0.149	1797	1.863	0.100	0.188	1927	1.880
Instruments	0.343	0.386	2410	1.125	0.113	0.145	2009	1.283	0.135	0.186	2140	1.378
Miscellaneous manufactured products	0.246	0.291	2292	1.183	0.111	0.149	2033	1.342	0.153	0.224	2127	1.464

Note: No data were provided for Printing, publishing, & allied industries on the 1967 or 1972 Census tapes.

Total number of entries in each trade matrix is 2601.

3.11 to 3.13. It is clear that the bulk of the trade-coefficient differences are distributed in the 0.0 to 0.1 interval, although a significant number of observations are spread throughout the upper intervals.

There is a difficulty with accepting these distributions as an indication of trade-coefficient stability, however. This is because the size of the differences between the coefficients in the two years for a particular trade pattern have not been related to the size of the coefficients in either 1967 or 1972. For example, suppose the size of the trade coefficient associated with shipments of Tobacco by rail from Kentucky to Maine was 0.001 in 1967 and 0.011 in 1972. Then the absolue difference between the coefficients in the two years would be 0.010 and this value would be listed in Interval 2 of Table 3.11. However, the percentage change that occurred relative to 1967 was 1000 percent! To address this problem, Tables 3.14 to 3.16 were constructed to present the distribution of the percentage changes that occurred in the trade coefficients relative to 1967. These percentages were calculated only for those cases where a non zero coefficient existed in one year or the other. The most interesting point to note about Tables 3.14 to 3.16 is the tendency of the trade changes to be either zero or greater than 75 percent. It is not within the scope of this study to investigate the determinants of the distributions shown in Tables 3.11 to 3.16. Such an analysis would require a massive amount of regional demographic, political, and economic data.

Although by no means exhaustive, the research concerning trade-coefficient stability just described is the most comprehensive analysis of the subject undertaken to date. Previous studies by Moses

Table 3.11

DISTRIBUTION OF RAIL TRADE COEFFICIENT CHANGES
(Based Upon Absolute Values, Non-Zero Entries, 1967-1972)

Commodity	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10
Food & kindred products	1172	76	42	11	3	0	0	0	1	0
Tobacco products	18	5	13	7	7	11	5	9	3	6
Textile mill products	153	29	19	21	9	11	6	7	1	4
Apparel & other textile products	239	33	24	14	20	6	9	7	7	14
Lumber & wood products, except furniture	687	59	17	12	2	3	2	0	0	0
Furniture & fixtures	433	88	47	35	15	9	8	1	0	4
Pulp, paper & allied products	1016	75	16	6	3	0	1	1	0	0
Printing, publishing, & allied industries	--	--	--	--	--	--	--	--	--	--
Chemicals & allied products	1002	60	17	10	1	4	0	4	2	0
Petroleum & coal products	286	66	27	18	10	6	10	3	2	6
Rubber & miscellaneous products	444	66	24	21	5	7	9	4	3	12
Leather & leather products	41	8	8	8	4	2	5	6	7	10
Stone, clay, glass, & concrete products	564	52	30	12	10	9	2	5	0	1
Primary metal products	693	64	45	16	6	6	1	1	1	4
Fabricated metal products	652	60	28	24	12	3	6	3	2	5
Machinery, except electrical	745	80	30	9	5	3	1	4	0	1
Electrical machinery & equipment	707	76	27	5	7	11	3	1	1	3
Transportation equipment	398	77	30	16	8	7	2	0	0	0
Instruments	92	13	5	10	11	5	5	3	11	35
Miscellaneous manufactured products	145	40	24	20	18	16	8	14	8	15

Interval 1 = $0.0 <$ changes ≤ 0.1
Interval 2 = $0.1 <$ changes ≤ 0.2
Interval 3 = $0.2 <$ changes ≤ 0.3
Interval 4 = $0.3 <$ changes ≤ 0.4
Interval 5 = $0.4 <$ changes ≤ 0.5
Interval 6 = $0.5 <$ changes ≤ 0.6
Interval 7 = $0.6 <$ changes ≤ 0.7
Interval 8 = $0.7 <$ changes ≤ 0.8
Interval 9 = $0.8 <$ changes ≤ 0.9
Interval 10 = $0.9 <$ changes ≤ 1.0

Note: No data were provided for Printing, publishing, & allied industries on the 1967 and 1972 Census tapes.

Table 3.12

DISTRIBUTION OF TRUCK TRADE COEFFICIENT CHANGES
(Based Upon Absolute Values, Non-Zero Entries, 1967-1972)

Commodity	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10
Food & kindred products	1321	66	33	22	20	7	8	2	5	4
Tobacco products	59	23	11	9	12	13	3	10	7	21
Textile mill products	389	65	37	24	11	10	7	12	9	4
Apparel & other textile products	716	114	47	20	6	5	5	0	0	1
Lumber & wood products, except furniture	573	51	30	14	7	8	8	5	9	16
Furniture & fixtures	709	97	40	18	9	5	7	9	8	6
Pulp, paper & allied products	991	88	39	19	14	10	13	7	3	4
Printing, publishing, & allied industries	--	--	--	--	--	--	--	--	--	--
Chemicals & allied products	1187	75	35	13	14	7	3	10	6	4
Petroleum & coal products	307	37	18	17	12	11	7	7	9	18
Rubber & miscellaneous products	935	85	28	18	15	6	3	4	3	1
Leather & leather products	286	79	29	28	12	11	4	5	2	2
Stone, clay, glass, & concrete products	677	56	31	20	21	14	9	7	8	3
Primary metal products	848	60	30	16	12	10	10	9	9	7
Fabricated metal products	1139	79	33	14	17	4	6	6	5	0
Machinery, except electrical	1392	79	28	14	12	4	3	3	2	0
Electrical machinery & equipment	1202	103	32	15	6	3	1	2	1	0
Transportation equipment	629	71	41	18	16	11	10	5	2	1
Instruments	393	80	50	38	15	7	5	1	3	0
Miscellaneous manufactured products	374	82	47	33	16	5	4	7	0	0

Interval 1 = 0.0 < changes ≤ 0.1
Interval 2 = 0.1 < changes ≤ 0.2
Interval 3 = 0.2 < changes ≤ 0.3
Interval 4 = 0.3 < changes ≤ 0.4
Interval 5 = 0.4 < changes ≤ 0.5
Interval 6 = 0.5 < changes ≤ 0.6
Interval 7 = 0.6 < changes ≤ 0.7
Interval 8 = 0.7 < changes ≤ 0.8
Interval 9 = 0.8 < changes ≤ 0.9
Interval 10 = 0.9 < changes ≤ 1.0

Note: No data were provided for Printing, publishing, & allied industries on the 1967 and 1972 Census tapes.

Table 3.13

DISTRIBUTION OF OTHER TRADE COEFFICIENT CHANGES
(Based Upon Absolute Values, Non-Zero Entries, 1967-1972)

Commodity	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10
Food & kindred products	1125	82	30	23	12	10	4	2	1	4
Tobacco products	38	17	16	10	3	6	7	7	8	32
Textile mill products	405	75	38	18	17	8	6	4	1	4
Apparel & other textile products	760	93	39	15	16	2	2	0	0	0
Lumber & wood products, except furniture	450	61	22	12	13	14	12	8	12	13
Furniture & fixtures	644	93	35	22	10	8	8	1	3	2
Pulp, paper & allied products	924	69	27	18	9	10	11	5	6	5
Printing, publishing, & allied industries	--	--	--	--	--	--	--	--	--	--
Chemicals & allied products	1035	67	42	28	9	11	6	5	8	4
Petroleum & coal products	424	48	23	17	12	15	7	11	3	19
Rubber & miscellaneous products	700	75	36	18	15	5	10	4	4	9
Leather & leather products	203	48	30	20	23	7	7	3	0	4
Stone, clay, glass, & concrete products	488	40	28	11	14	11	9	5	6	11
Primary metal products	597	57	30	31	13	16	11	3	7	10
Fabricated metal products	895	83	30	26	20	18	6	4	1	0
Machinery, except electrical	1077	110	44	23	17	12	6	2	0	0
Electrical machinery & equipment	964	105	35	24	13	8	0	2	2	0
Transportation equipment	509	53	29	18	18	22	6	6	12	1
Instruments	285	72	34	24	16	14	5	6	0	5
Miscellaneous manufactured products	309	42	34	23	17	14	13	5	13	4

Interval 1 = 0.0 < changes ≤ 0.1
Interval 2 = 0.1 < changes ≤ 0.2
Interval 3 = 0.2 < changes ≤ 0.3
Interval 4 = 0.3 < changes ≤ 0.4
Interval 5 = 0.4 < changes ≤ 0.5
Interval 6 = 0.5 < changes ≤ 0.6
Interval 7 = 0.6 < changes ≤ 0.7
Interval 8 = 0.7 < changes ≤ 0.8
Interval 9 = 0.8 < changes ≤ 0.9
Interval 10 = 0.9 < changes ≤ 1.0

Note: No data were provided for Printing, publishing, & allied industries on the 1967 and 1972 Census tapes.

Table 3.14

DISTRIBUTION OF PERCENTAGE TRADE COEFFICIENT CHANGES FOR RAIL
(Based upon absolute values, 1967-1972)

Commodity	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7
Food & kindred products	202	51	88	152	171	362	279
Tobacco products	43	2	4	12	8	15	2
Textile mill products	44	5	7	12	16	144	33
Apparel & other textile products	85	5	7	8	13	223	32
Lumber & wood products, except furniture	283	23	32	68	54	226	96
Furniture & fixtures	200	11	19	23	37	258	92
Pulp, paper, & allied products	181	57	98	151	135	248	248
Printing, publishing, & allied industries	--	--	--	--	--	--	--
Chemicals & allied products	177	42	56	121	104	400	200
Petroleum & coal products	74	10	24	33	40	191	62
Rubber & miscellaneous products	208	11	24	31	41	201	79
Leather & leather products	6	2	0	1	1	75	14
Stone, clay, glass, & concrete products	108	38	23	53	75	271	117
Primary metal products	101	34	42	52	77	390	141
Fabricated metal products	196	26	31	60	56	279	147
Machinery, except electrical	181	25	31	71	79	347	144
Electrical machinery & equipment	195	25	38	78	77	291	137
Transportation equipment	97	15	33	60	56	192	85
Instruments	34	3	0	1	4	118	31
Miscellaneous manufactured products	110	1	2	7	16	120	53

Interval 1 = percentage change equal to 0.0
Interval 2 = 0.0 < percentage change $\leq$ 10.0
Interval 3 = 10.0 < percentage change $\leq$ 25.0
Interval 4 = 25.0 < percentage change $\leq$ 50.0
Interval 5 = 50.0 < percentage change $\leq$ 75.0
Interval 6 = 75.0 < percentage change $\leq$ 100.0
Interval 7 = percentage change greater than 100.0

Note: No data were provided for Printing, publishing, & allied industries on the 1967 and 1972 Census tapes.

Table 3.15

DISTRIBUTION OF PERCENTAGE TRADE COEFFICIENT CHANGES FOR TRUCK
(Based upon absolute values, 1967-1972)

Commodity	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7
Food & kindred products	1005	10	20	37	45	141	230
Tobacco products	115	0	1	7	5	34	6
Textile mill products	201	17	9	37	41	155	108
Apparel & other textile products	237	22	23	42	104	277	209
Lumber & wood products, except furniture	581	4	5	5	8	79	39
Furniture & fixtures	591	10	11	23	31	144	98
Pulp, paper, & allied products	592	9	20	44	53	219	251
Printing, publishing, & allied industries	--	--	--	--	--	--	--
Chemicals & allied products	500	22	28	39	61	237	467
Petroleum & coal products	283	3	2	6	12	57	80
Rubber & miscellaneous products	505	27	38	51	73	227	179
Leather & leather products	153	10	19	36	22	138	80
Stone, clay, glass, & concrete products	423	10	14	36	50	189	124
Primary metal products	460	9	13	37	41	176	275
Fabricated metal products	518	33	44	70	92	196	350
Machinery, except electrical	450	44	61	97	119	285	481
Electrical machinery & equipment	447	28	74	111	108	296	301
Transportation equipment	338	10	23	29	47	230	127
Instruments	148	13	21	32	29	224	125
Miscellaneous manufactured products	202	12	22	30	52	118	132

Interval 1 = percentage change equal to 0.0
Interval 2 = 0.0 < percentage change ≤ 10.0
Interval 3 = 10.0 < percentage change ≤ 25.0
Interval 4 = 25.0 < percentage change ≤ 50.0
Interval 5 = 50.0 < percentage change ≤ 75.0
Interval 6 = 75.0 < percentage change ≤ 100.0
Interval 7 = percentage change greater than 100.0

Note: No data were provided for Printing, publishing, & allied industries on the 1967 and 1972 Census tapes.

Table 3.16

DISTRIBUTION OF PERCENTAGE TRADE COEFFICIENT CHANGES FOR OTHER
(Based upon absolute values, 1967-1972)

Commodity	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7
Food & kindred products	28	11	17	41	28	1043	125
Tobacco products	76	2	1	4	6	43	12
Textile mill products	2	10	13	26	36	390	99
Apparel & other textile products	238	23	56	80	77	266	187
Lumber & wood products, except furniture	95	3	5	13	11	441	49
Furniture & fixtures	114	13	24	32	49	492	102
Pulp, paper, & allied products	42	16	18	39	55	753	161
Printing, publishing, & allied industries	--	--	--	--	--	--	--
Chemicals & allied products	158	12	23	35	68	747	172
Petroleum & coal products	35	3	2	7	9	477	47
Rubber & miscellaneous products	333	15	13	33	45	297	67
Leather & leather products	143	6	15	19	19	122	21
Stone, clay, glass, & concrete products	254	8	11	16	30	226	78
Primary metal products	229	3	10	18	28	429	58
Fabricated metal products	616	13	20	50	53	233	98
Machinery, except electrical	695	15	22	45	79	357	78
Electrical machinery & equipment	757	10	18	74	68	144	82
Transportation equipment	336	9	11	15	40	219	44
Instruments	173	15	20	24	42	124	63
Miscellaneous manufactured products	162	8	20	26	42	165	51

Interval 1 = percentage change equal to 0.0
Interval 2 = 0.0 < percentage change ≤ 10.0
Interval 3 = 10.0 < percentage change ≤ 25.0
Interval 4 = 25.0 < percentage change ≤ 50.0
Interval 5 = 50.0 < percentage change ≤ 75.0
Interval 6 = 75.0 < percentage change ≤ 100.0
Interval 7 = percentage change greater than 100.0

Note: No data were provided for Printing, publishing, & allied industries on the 1967 and 1972 Census tapes.

(1955), Riefler and Tiebout (1970), Isard (1953), and Suzuki (1971) all used extremely aggregate data that virtually ensured some evidence of stability in the trade coefficients. It was clear from a review of this literature (Crown, 1981b) that a much more rigorous study was needed if any useful results were to be obtained concerning trade-coefficient stability. The analysis presented in this section extends the earlier work by Crown (1981a) and was an attempt at a more rigorous study than those that have been presented in the literature. In particular, it included considerably more commodity, regional, and modal detail than previous analyses. However, the study was limited by the fact that data were available only for 1967 and 1972. In addition, all of the industries tested were manufacturing industries. The mineral, agricultural, and service industry flows remain to be studied.

CONCLUSIONS

In this chapter, an empirical analysis of four major issues concerning interregional trade was presented: (a) the size of interregional trade effects, (b) the relationship between aggregation and estimation bias, (c) the relationship between aggregation and information loss, and (d) the stability of interregional trade coefficients.

The interregional trade effects were measured using the 19-industry, 9-region MRIO accounts. As anticipated from Chapter 2, the degree to which trade effects could be captured by the MRIO model without detailed trade data was found to be a function of the accuracy of the adjustment made to the regional final demands as a correction for the omission of trade. When the final demands were adjusted by the amount of regional net-trade balances, the trade effects were generally found to be under 1.0 percent. To be able to make precisely the right net-trade balance adjustment requires a set of internally consistent economic accounts. It must also be stressed that although not directly necessary in terms of accurately estimating detailed regional outputs, interregional trade data are necessary for ensuring that a set of multiregional input-output accounts is consistent. In addition, these trade data are necessary if detailed multipliers are desired, and are required for all studies of state-to-state commodity flows.

An investigation of the error introduced into the output estimates by aggregating the MRIO accounts was also carried out. This analysis was conducted for two sets of aggregation schemes: (a) collapsing the 19-industry, 9-region MRIO data to 3 industries and 3 regions; and (b) aggregating the 79-industry, 51-region results for comparison with the 3-region, 3-indusry model. The largest error found was only about 4 percent (in aggregating the 79-industry, 51-region results for comparison with the 3-industry, 3-region results). This testing of aggregation errors in the MRIO model was supplemented by an analysis of the effects of changes in the structure of regional final demands. It was found that these errors could be quite substantial, particularly for industries with relatively small regional outputs.

Because aggregation can also affect the information content of a model, the implications of aggregation for the average and total information content of the MRIO model were analyzed for the case where the 19-industry, 9-region accounts were consolidated to 3 regions and 3 industries. It was found that the average information content of each cell in the multiregional probability matrix declined by about one third. However, because the number of elements in the matrix declined by nearly one hundred percent, so did the information content of the model. Regional analysts should therefore be wary of aggregating data even though the results may not be serious in terms of aggregation bias.

The final set of empirical tests conducted were with respect to trade-coefficient stability. For this part of the analysis, data from the 1967 and 1972 Census of Transportation were used because trade data are currently available in the MRIO model for 1963 only. The results showed considerable differences between the stability of trade-coefficients for different commodities by different transportation modes. However, definite conclusions of whether particular commodity trade patterns were "stable" or not, were not possible. It seems likely that interregional trade data, such as those analyzed in this thesis, may be stable enough for some applications, but not for others. This situation is complicated by the fact that aggregation appears to play a significant role in affecting the stability of the coefficients.

Research concerning the determinants of interregional trade-coefficient changes is potentially an extremely fertile field. Existing theories of interregional trade, such as the Heckscher-Ohlin and product life-cycle theories, have proven to be inadequate for explaining trade between regions. In a review of the trade components of eight major U.S. multiregional models, Moses (1980, p. 3) claimed that none of the models incorporated explicitly a means of handling "questions of trade equilibrium and the mechanisms that assure a tendency towards such an equilibrium." The results presented in this chapter provide a foundation for further research concerning the role of trade in multiregional models. The importance of a consistent framework of analysis was stressed, as was the importance of sufficient detail in the data with which the testing was carried out. Without considering these factors, it is extremely difficult to ascertain the causes of counterintuitive empirical results. This, in turn, inhibits the development of sound economic theory. The manner in which these results may be used for further analysis is discussed in Chapter 4.

CHAPTER 4

CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

The objective of this study was to clarify some of the issues concerning the representation of trade in multiregional models. These issues have been debated by regional analysts for many years and include: the size of interregional trade effects, the importance of aggregation bias and information loss, and the stability of interregional trade coefficients.

Because the MRIO model is based upon the only consistent multiregional system of economic accounts constructed from actual regional data that is currently available for the United States, it was chosen as the tool with which to reconsider the issues of interregional trade effects, and the impacts of aggregation on estimaton bias and information loss. The analysis of trade-coefficient stability was conducted using data from the 1967 and 1972 Census of Transportation because trade data are currently available only for one year in the MRIO model.

In the next four sections of this chapter, the results of each of the three research areas outlined above will be briefly summarized and areas for future research will be outlined.

INTERREGIONAL TRADE EFFECTS

Studies of interregional trade effects that have been undertaken in the past have used the measure provided by the interregional feedback effects to judge the importance of interregional trade. As mentioned in

Chapter 3, interregional feedback effects are defined to be the change in the output of a region brought about by changes in demands in other regions which themselves were due to a change in production in the origin region. Empirical studies of interregional feedbacks have been conducted by Miller (1966, 1969), Riefler and Tiebout (1970), and Greytak (1970). A brief discussion of the approach taken in these studies is given in Appendix B.

The interregional feedback approach was not used in the present study as a measure of the importance of trade. This is because the interregional feedbacks measure only the indirect impacts of a change in final demand in a particular region on that region's output. The approach used here to measure the importance of interregional trade takes into account the total impacts of trade in the MRIO model. These total impacts were arrived at by calculating the industrial outputs in each region with and without trade in the model. It was found that the total trade impacts were substantial for individual industrial output estimates in each region using the 19-industry, 9-region set of MRIO accounts. The size of the impacts, however, is a function of the level of regional aggregation. As the number of regions approaches one, the trade effects will approach zero.

A methodology was also developed in Chapter 2 which indicated that interregional trade effects in the MRIO model could be accounted for by a proper net-trade adjustment to regional final demands. This is an important development because it enables the solution for regional outputs in the MRIO model without detailed interregional trade data. To test this empirically, an aggregation of the MRIO accounts (19 industries and 9 regions) was used to keep down computation requirements, yet, still allow enough regional and industrial detail for the measurement of the interregional trade effects. The net-trade adjustment was found to be justified empirically. Despite this finding, it should be stressed that interregional trade data are still useful as a means of balancing regional consumption and demand in each industry in the MRIO accounts. Interregional trade data are also necessary for detailed multiplier studies, and are needed for comprehensive state-to-state analyses of commodity flows. In fact, given that there are less data-intensive methods for estimating regional outputs and much of the value of using a multiregional or interregional input-output model stems from the detailed multipliers and transportation information provided, it would appear that the concern over the need for trade in these types of models has been misdirected. Very likely, the primary usefulness of the net-trade adjustment developed in the thesis is in balancing the accounts for those industries where interregional trade data are not available.

The fact that detailed trade data are needed to conduct multiplier studies illustrates an important point--although the interregional trade effects can be captured with the net-trade adjustment, interdependence between regions is a very real economic occurrence. As mentioned above, the extent of this interdependence is a function of the aggregation level of the data. A more comprehensive study which investigated how the total trade effects varied with the level of regional aggregation would be useful to conduct. Such a study could be carried out by holding the industrial classification constant and incrementally aggregating the regional classification. This brings out an important point concerning the inverse relationship between interregional trade effects and aggregation bias. Although aggregating the regional classification will lead to a reduction in the interregional trade effects, it will usually result in an increase in aggregation bias. Of course, aggregating the accounts may also lead to a loss of information in the model. The results concerning the impacts of aggregation on estimation bias and information loss are presented in the next section.

AGGREGATION BIAS AND INFORMATION LOSS

Although the effects of aggregation on detailed output estimates have been extensively debated, there has been almost no work concerning the effects of aggregation in multiregional models. Two studies by Miller and Blair (1980, 1981) have dealt with this issue but they have neglected the impacts of aggregation on detailed output estimates. Because detailed impacts are often of more interest to regional analysts than impacts on total regional output, an analysis of aggregation in a multiregional input-output model was carried out in this thesis.

To investigate the effect of aggregation on detailed industry outputs in the MRIO model, a mathematical formulation of the estimation bias was developed in Chapter 2. In Chapter 3, an empirical evaluation of the aggregation problem was conducted for two aggregation schemes. First, the 19-industry, 9-region MRIO outputs were aggregated and compared to the outputs produced with the aggregate 3-industry, 3-region MRIO accounts. The largest aggregation error found was only about 2 percent. A similar analysis was then conducted to compare the outputs from the 79-industry, 51-region MRIO model with those produced by the 3-industry, 3-region MRIO model. In this instance, the largest error found was about 4 percent. Therefore, in this first set of tests, no strong evidence was found to indicate that aggregation creates serious estimation bias. There was some evidence, however, that the more severe the aggregation was, the larger would be the estimation bias. Conceivably, aggregating a very disaggregate dataset could create substantial estimation problems. This is a question that requires further research.

Moromoto (1969) and others showed that changes in the structure of the final demands may also contribute to aggregation error. Because input-output models are often utilized to conduct impact analyses, it is important to consider the aggregation error that might be introduced from such changes. As a test of these impacts in the MRIO model, a set of estimated final demands for 1980 was used to calculate the detailed regional outputs for three sets of MRIO accounts. The errors were found to be much more substantial than those of the initial tests (the largest error exceeded 10 percent). However, the most substantial errors were found to occur in industries with relatively small output levels. Nevertheless, the error introduced from different final demand structures is a matter that deserves further attention from regional analysts.

Intertwined with the topic of aggregation bias in input-output analysis is that of information loss. Intuitively, it would be expected that as a set of input-output accounts is aggregated, its information content will be reduced. This is an issue of utmost importance to regional analysts, yet, there has been very little work done on the subject. In fact, no analyses have been conducted concerning the impacts of aggregation on the information content of multiregional input-output systems.

Jiri Skolka (1964) was the first analyst to utilize concepts from information theory to analyze the aggregation problem in input-output analysis; his analysis was subsequently extended by Theil (1967) and Theil and Uribe (1967). Building upon the work by these authors, the theoretical relationship between aggregation in a multiregional input-output system and information loss was developed in Chapter 2. This relationship was investigated empirically in Chapter 3. As a test of the information loss resulting from aggregation, the average information content of the elements in the 19-industry, 9-region MRIO accounts was calculated, as were the corresponding values for the 3-industry, 3-region accounts. In addition, the total information content of each set of accounts was calculated. It was found that the average information content of each element in the 3-industry, 3-region accounts was about two-thirds of the corresponding value for the 19-industry, 9-region accounts. However, because the number of elements in the 3-industry, 3-region case was less than one percent of those in the 19-industry, 9-region accounts, the total information content of the "aggregate" accounts was found to be less than one percent of the "disaggregate" dataset. These results indicate that if a regional analyst intends to use a multiregional input-output model for other than estimation purposes, the analyst should carefully consider the value of the detail that may be lost due to aggregation.

It was pointed out that the information approach formulated in the thesis measures the information loss resulting from general aggregation. No information measure was presented for the case of specific aggregation--the case where detail is preserved only for those industries and regions of particular interest to the analyst, and all other detail is aggregated. Some thoughts on deriving such a measure are given in the final section of this chapter.

The issues of interregional trade effects, aggregation bias, and information loss were considered in some detail in this thesis using a static model and data for only one time period. If the necessary data were readily available, it would be possible to conduct a comparative static analysis of the effects of changes in the parameters of the model over time. With data on capital flows a dynamic model could also be developed. Although an analysis of changes in regional technical coefficients was not possible because the data do not currently exist, data sources were available that allowed the analysis of changes in interregional trade coefficients over time. Because of its importance for the use of the MRIO and MRPIS models, transportation studies, and multiregional modeling in general, an empirical investigation of trade-coefficient stability was carried out in this thesis. A summary of the results is presented in the next section.

TRADE-COEFFICIENT STABILITY

Several studies of trade-coefficient stability have been conducted, each of which has indicated some evidence of constancy in trade patterns. As with the literature concerning interregional feedback effects, however, the conclusions of these analyses are suspect because of data and methodological problems. A difficulty common to nearly every analysis has been a lack of sufficient industrial and regional detail with which to conduct a proper analysis. The research concerning trade-coefficient stability that was conducted for this thesis, was an extension of the earlier work by Crown (1981). Several summary statistics and distributions were constructed that indicate some commodities to be more stable than others. However, it was not possible, using this information, to judge whether a particular commodity flow by a particular transportation mode was "stable" in any absolute sense. Such a judgement depends upon the purpose for which the trade data are to be used. It is quite likely that a set of interregional trade data will be stable enough for some purposes, but not for others.

It was not within the scope of the thesis to probe deeper into the causes of trade-coefficient instability. From the discussion in Chapter 2, it is clear that this could be the subject of several studies. The purpose of this study was not to resolve all of these questions, but rather, to provide a firmer foundation upon which to carry out further research. In the following section, some suggestions on how the results of this study might be extended are presented.

DIRECTIONS FOR FUTURE RESEARCH

There are many ways in which the research could be extended. In fact, extensions are possible in each of the individual areas, as well as in other areas that build upon the collective results of the thesis. With respect to interregional trade effects, a useful extension would be to conduct a incremental aggregation of the regional detail in the MRIO model. This would enable an assessment of how the interregional trade effects are impacted by aggregation. Of course, as the regional detail is aggregated, this will produce aggregation bias (assuming the regional production and trade technologies are somewhat heterogeneous). Thus, such a study should be coupled with a more detailed study of aggregation bias in the MRIO model.

It was indicated throughout the thesis that aggregation will also lead to information loss in the model. Theil (1967) showed that this information loss was directly related to the first-order aggregation bias. However, the aggregation bias that was considered resulted from general aggregation. What if only specific industrial and regional details were desired and all other data were aggregated? Moromoto (1969) showed that no aggregation error would occur in those industries where the detail was preserved, but there would be errors associated with the aggregated industries. A formal analysis of Moromoto's results with respect to the MRIO model is needed, as well as a study to develop a measure of the infromation loss resulting from specific aggregation. The key to the latter would seem to lie in Theil's (1967) decomposition of the information statistic presented in this thesis.

All of the possibilities for future research identified thus far are concerned with static issues in the MRIO model. Analyses of changes in the regional production and interregional trade technologies over time are also very important. In particular, further testing of trade-coefficient stability is critical to the continued use of multiregional and interregional input-output models. Research in this field would also seem to hold the greatest promise in terms of improving the theory of interregional trade. As Richardson (1972, pp. 78-85) points out, there is little a priori theoretical expectation for either the stability or instability of trade coefficients. The research presented in this thesis suggests evidence of stability, but the aggregation level of the data has a clear impact on the strength of this assertion. Summary statistics for entire trade patterns exhibited much more stability than changes in individual cells. The analysis of trade-coefficient stability should be extended to include data for more years, more transportation modes, and more commodity detail. This could be achieved by using additional data from the Census of Transportation. The assembly of the 1977 MRIO data will supplement the Census data and allow the analysis of trade-coefficient stability in non-manufacturing industries, such as agriculture, mining, and services. Perhaps even more importantly, the 1977 MRIO data will allow an analysis of trade-coefficient stability to be carried out in conjunction with a study of the stability of regional technical coefficients within a consistent accounting system. As stressed early in the dissertation, the theoretical and empirical link between production and trade requires that they be analyzed together if at all possible.

The possibility of additional statistical measures of variation should also be considered, such as the information approach of Tilanus and Theil (1965) and that of Greytak (1974). When a better understanding of the variability in trade patterns has been developed, it should be possible to begin developing a more adequate understanding of what makes them change over time. Perhaps then it will be possible to begin modeling trade in a less mechanical fashion--more as a integral part of the economy than as a mechanistic means of accounting for interregional trade effects.

APPENDIX A

MATRIX STRUCTURE OF THE MRIO MODEL

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MATRIX STRUCTURE OF THE MRIO MODEL

The MRIO accounts can be derived from the more general system of interregional input-output (IRIO) accounts. The relationships of the two accounting systems and some issues concerning the structural parameters of the two systems are discussed in this appendix. In addition, the structure of the matrices that comprise the MRIO system are given, and the MRIO balance equations for m industries and n regions are presented. A brief description of the IRIO accounting framework is given first.

The IRIO Accounting Framework

Walter Isard first presented the "ideal" system of IRIO accounts in his book Methods of Regional Analysis (1960, pp.309-373). This IRIO accounting framework, presented in Figure A.1, is said to be ideal because it identifies a complete set of interregional transactions in terms of the origin region and industry of a shipment and the destination region and industry of a shipment. Each row in Figure A.1 indicates the region and industry in which a good or service is consumed.

The interrregional balance equation for the IRIO model can be expressed as follows:

$$x_i^g = \sum_h \sum_j g_{ij}^{gh} + \sum_h y_i^{gh} \qquad \text{(A.1)}$$

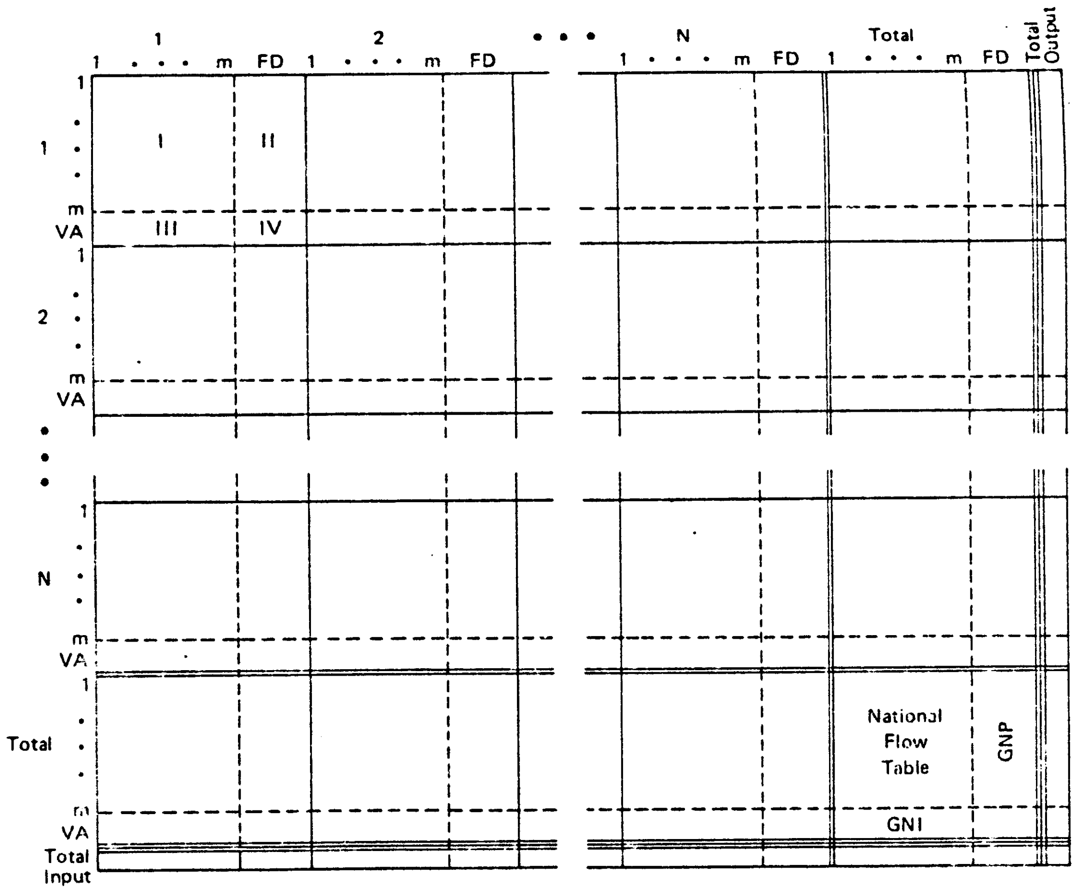

FIGURE A.1. INTERREGIONAL INPUT-OUTPUT ACCOUNTING FRAMEWORK

Source: Polenske (1980, p. 45).

where:

x_i^g = output of industry i in region g;

g_{ij}^{gh} = intermediate demands for the output of industry or value added sector i in region g by industry j in region h; and

y_i^{gh} = final demand in region h for the output of industry i produced in region g.

Thus, the output of industry i in region h is equal to the sum of intermediate and final demands for its production in all regions. To formulate the model, the individual interregional, interindustry coefficients must be derived from the flows, g_{ij}^{gh}, as follows:

$$a_{ij}^{gh} = \frac{g_{ij}^{gh}}{\sum_g \sum_i g_{ij}^{gh}} \qquad (A.2)$$

Substituting (A.2) into (A.1) yields:

$$x_i^g = \sum_j \sum_h a_{ij}^{gh} x_j^h + \sum_h y_i^{gh} \qquad (A.3)$$

The a_{ij}^{gh} coefficients are the key to implementing the IRIO model. One issue of relevance to the present study is the IRIO assumption that these coefficients remain stable. In the IRIO model, both the spatial structure of the interregional economy and the technical structure of each regional economy are assumed to remain constant. This means that the a_{ij}^{gh}'s (which measure the proportion of each input i imported from region g for use by industry j in region h) remain constant. The manner in which trade is represented in the IRIO framework, as an integral part of each interregional interindustry coefficient, rather than as a separate structural parameter, creates serious difficulties if the a_{ij}^{gh} coefficients are unstable. In this case, it is impossible to determine whether the instability is caused by changes in interregional trade patterns, or by changes in regional production technologies, or by changes in both.

The issue of the stability of the IRIO coefficients deserves further comment. As is discussed in Chapters 2 and 3, the estimation error stemming from instabilities in the coefficients of any type of input-output model is partly a function of the data aggregation level. To use Polenske's example:

> ...it is obvious that even coal machinery is not homogeneous, that strip mining and pit mining require different machinery, that variations do occur from region to region in the cost of manufacturing the machinery, and that, therefore, some means of disaggregating the inputs into the coal-mining industry is desirable. If both production processes

> are combined in one coal-mining industry and a shift occurs in the mix of the processes used, the input coefficients will vary...the trade coefficients will also vary because of the different states of origin of the two types of equipment (1974, p.10).

Polenske goes on to point out that there are at least two ways to handle the problem. One is to specify more detailed production processes. For instance, the coal-mining industry could be separated into two parts--one for strip mining and one for pit mining. The second alternative is to separate coal machinery inputs by the location of the producer. With regard to the second possibility, Polenske makes the following remarks:

> If the separation is by production process, the assumption of constant input and trade coefficients can be maintained as long as changes occur only in the amount of coal produced by the two processes. If the separation is according to the location of the producer, the input and trade coefficients cannot be assumed to remain constant, because they will vary whenever changes occur in the mix of the two basic techniques used to produce the coal. A separation by location of producers will therefore be less desirable than one by type of production process (1974, p.11).

It follows from Polenske's comments that, even if combined with disaggregation by more detailed production processes, disaggregation of production technologies by location of producer may introduce instability into the coefficients of the model.

Thus, although conceptually the IRIO system of accounts is complete, it is empirically less than ideal for at least two reasons: (a) the data necessary to implement it are not readily available (at least for the United States), and (b) the manner in which interregional trade and technology impacts are blurred by the composite a_{ij}^{gh} coefficients inhibits the analysis of instabilities in the coefficients.

An alternative to the IRIO system that requires fewer data and that keeps the structural trade and production parameters separate, is the multiregional input-output (MRIO) system developed by Polenske (1980). This is briefly described in the following section.

The MRIO Accounts and Model

The MRIO accounts, while still requiring large amounts of data, need only a small subset of the data required by the IRIO accounts. Considering Figure A.1 once again, only the n blocks at the bottom of the figure are required to form the input-output tables for the MRIO accounts. The elements in these blocks can be represented mathematically as follows:

MRIO interindustry elements

$$g_{ij}^{oh} = \sum_{g} g_{ij}^{gh} \qquad \text{(A.4)}$$

MRIO final demand elements

$$y_{ik}^{oh} = \sum_{g} y_{ik}^{gh} \tag{A.5}$$

MRIO value added elements

$$v_{sj}^{oh} = \sum_{g} v_{sj}^{gh} \tag{A.6}$$

MRIO value added, final demand elements

$$v_{sk}^{oh} = \sum_{g} v_{sk}^{gh} \tag{A.7}$$

where:

g_{ij}^{oh} = output purchased by industry j in region h from industry i regardless of where industry i is located;

y_{ik}^{gh} = output purchased by final user k in region h from industry i in region g;

v_{sj}^{gh} = payment made by industry j in region h to factor of production s in region g;

v_{sk}^{gh} = payment made to final user k in region h to factor of production s in region g; and

o as a superscript, is the notation for summation over all supplying regions.

In addition to the regional input-output tables, the MRIO accounts include the shipments of each commodity between regions. These data are obtained from the IRIO set of accounts shown in Figure A.1 by summing all elements in each row of each regional block. The entries in trade-flow matrix i represent the amount of commodity i shipped from region g to all intermediate and final users in region h. Stated mathematically:

MRIO interregional commodity shipments

$$t_{io}^{gh} = \sum_{j} g_{ij}^{gh} + \sum_{k} y_{ik}^{gh} \tag{A.8}$$

where:

o as a subscript, is the notation for summation over all demanding sectors of commodity i in region h shipped from region g.

Similarly, interregional flows of factors of production (value added shipments) can be obtained as follows:

Interregional value added shipments

$$v_{so}^{gh} = \sum_j v_{sj}^{gh} + \sum_k v_{sk}^{gh} \qquad (A.9)$$

where all notations are as previously defined.

This section has very briefly outlined the MRIO accounts. For more detail, the reader is referred to Polenske (1980). In the following section, the structure of the matrices used in solving the MRIO model is given.

Matrix Structure of the MRIO Model

The matrix structure of the MRIO model for n regions and m industries is presented in Polenske (1980, pp. 112-114), but is repeated in Figures A.2 through A.4 for the convenience of the reader. All terms are as defined in Chapter 2 of the thesis.

The detailed equation system for n regions and m industries, corresponding to matrix equation (2.1) in the text, is provided in Figure A.5 as an aid to the reader. The notation:

$$b_{ij}^{gh} = a_{ij}^{oh} \; c_{io}^{gh} \qquad (A.10)$$

is adapted from Moses to simplify the presentation.

$$X = \begin{bmatrix} x_1^1 \\ x_2^1 \\ \vdots \\ x_m^1 \\ x_1^2 \\ x_2^2 \\ \vdots \\ x_m^2 \\ \vdots \\ x_1^n \\ x_2^n \\ \vdots \\ x_m^n \end{bmatrix} \qquad Y = \begin{bmatrix} y_1^1 \\ y_2^1 \\ \vdots \\ y_m^1 \\ y_1^2 \\ y_2^2 \\ \vdots \\ y_m^2 \\ \vdots \\ y_1^n \\ y_2^n \\ \vdots \\ y_m^n \end{bmatrix}$$

FIGURE A.2. MRIO OUTPUT AND FINAL DEMAND VECTORS

Source: Polenske (1980, p. 112).

$$
\hat{A} = \begin{bmatrix}
a_{11}^{o1} & a_{12}^{o1} & \cdots & a_{1m}^{o1} & 0 & 0 & \cdots & 0 & \cdots & 0 & 0 & \cdots & 0 \\
a_{21}^{o1} & a_{22}^{o1} & \cdots & a_{2m}^{o1} & 0 & 0 & \cdots & 0 & \cdots & 0 & 0 & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\
a_{m1}^{o1} & a_{m2}^{o1} & \cdots & a_{mm}^{o1} & 0 & 0 & \cdots & 0 & \cdots & 0 & 0 & \cdots & 0 \\
0 & 0 & \cdots & 0 & a_{11}^{o2} & a_{12}^{o2} & \cdots & a_{1m}^{o2} & \cdots & 0 & 0 & \cdots & 0 \\
0 & 0 & \cdots & 0 & a_{21}^{o2} & a_{22}^{o2} & \cdots & a_{2m}^{o2} & \cdots & 0 & 0 & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & 0 & a_{m1}^{o2} & a_{m2}^{o2} & \cdots & a_{mm}^{o2} & \cdots & 0 & 0 & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 & \cdots & a_{11}^{on} & a_{12}^{on} & \cdots & a_{1m}^{on} \\
0 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 & \cdots & a_{21}^{on} & a_{22}^{on} & \cdots & a_{2m}^{on} \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 & \cdots & a_{m1}^{on} & a_{m2}^{on} & \cdots & a_{mm}^{on}
\end{bmatrix}
$$

FIGURE A.3. EXPANDED TECHNICAL COEFFICIENT MATRIX

Source: Polenske (1980, p. 113).

$$
C = \begin{bmatrix}
c^{11}_{o1} & 0 & \cdots & 0 & c^{12}_{o1} & 0 & \cdots & 0 & \cdots & c^{1n}_{o1} & 0 & \cdots & 0 \\
0 & c^{11}_{o2} & \cdots & 0 & 0 & c^{12}_{o2} & \cdots & 0 & \cdots & 0 & c^{1n}_{o2} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & c^{11}_{om} & 0 & 0 & \cdots & c^{12}_{om} & \cdots & 0 & 0 & \cdots & c^{1n}_{om} \\
c^{21}_{o1} & 0 & \cdots & 0 & c^{22}_{o1} & 0 & \cdots & 0 & \cdots & c^{2n}_{o1} & 0 & \cdots & 0 \\
0 & c^{21}_{o2} & \cdots & 0 & 0 & c^{22}_{o2} & \cdots & 0 & \cdots & 0 & c^{2n}_{o2} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & c^{21}_{om} & 0 & 0 & \cdots & c^{22}_{om} & \cdots & 0 & 0 & \cdots & c^{2n}_{om} \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\
c^{n1}_{o1} & 0 & \cdots & 0 & c^{n2}_{o1} & 0 & \cdots & 0 & \cdots & c^{nn}_{o1} & 0 & \cdots & 0 \\
0 & c^{n1}_{o2} & \cdots & 0 & 0 & c^{n2}_{o2} & \cdots & 0 & \cdots & 0 & c^{nn}_{o2} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & c^{n1}_{om} & 0 & 0 & \cdots & c^{n2}_{om} & \cdots & 0 & 0 & \cdots & c^{nn}_{om}
\end{bmatrix}
$$

FIGURE A.4. EXPANDED TRADE COEFFICIENT MATRIX

Source: Polenske (1980, p. 114).

$$
\begin{array}{lllllllllllllllll}
x^{1o}_{o1} & -b^{11}_{11}x^{1o}_{o1} & -b^{11}_{12}x^{1o}_{o2} & -\cdots & -b^{11}_{1m}x^{1o}_{om} & -\cdots & -b^{1n}_{11}x^{no}_{o1} & -b^{1n}_{12}x^{no}_{o2} & -\cdots & -b^{1n}_{1m}x^{no}_{om} & = & c^{11}_{1o}y^{o1}_{1o} & +c^{12}_{1o}y^{o2}_{1o} & +\cdots & +c^{1n}_{1o}y^{on}_{1o} \\
x^{1o}_{o2} & -b^{11}_{21}x^{1o}_{o1} & -b^{11}_{22}x^{1o}_{o2} & -\cdots & -b^{11}_{2m}x^{1o}_{om} & -\cdots & -b^{1n}_{21}x^{no}_{o1} & -b^{1n}_{22}x^{no}_{o2} & -\cdots & -b^{1n}_{2m}x^{no}_{om} & = & c^{11}_{2o}y^{o1}_{2o} & +c^{12}_{2o}y^{o2}_{2o} & +\cdots & +c^{1n}_{2o}y^{on}_{2o} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
x^{1o}_{om} & -b^{11}_{m1}x^{1o}_{o1} & -b^{11}_{m2}x^{1o}_{o2} & -\cdots & -b^{11}_{mm}x^{1o}_{om} & -\cdots & -b^{1n}_{m1}x^{no}_{o1} & -b^{1n}_{m2}x^{no}_{o2} & -\cdots & -b^{1n}_{mm}x^{no}_{om} & = & c^{11}_{mo}y^{o1}_{mo} & +c^{12}_{mo}y^{o2}_{mo} & +\cdots & +c^{1n}_{mo}y^{on}_{mo} \\
x^{2o}_{o1} & -b^{21}_{11}x^{1o}_{o1} & -b^{21}_{12}x^{1o}_{o2} & -\cdots & -b^{21}_{1m}x^{1o}_{om} & -\cdots & -b^{2n}_{11}x^{no}_{o1} & -b^{2n}_{12}x^{no}_{o2} & -\cdots & -b^{2n}_{1m}x^{no}_{om} & = & c^{21}_{1o}y^{o1}_{1o} & +c^{22}_{1o}y^{o2}_{1o} & +\cdots & +c^{2n}_{1o}y^{on}_{1o} \\
x^{2o}_{o2} & -b^{21}_{21}x^{1o}_{o1} & -b^{21}_{22}x^{1o}_{o2} & -\cdots & -b^{21}_{2m}x^{1o}_{om} & -\cdots & -b^{2n}_{21}x^{no}_{o1} & -b^{2n}_{22}x^{no}_{o2} & -\cdots & -b^{2n}_{2m}x^{no}_{om} & = & c^{21}_{2o}y^{o1}_{2o} & +c^{22}_{2o}y^{o2}_{2o} & +\cdots & +c^{2n}_{2o}y^{on}_{2o} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
x^{2o}_{om} & -b^{21}_{m1}x^{1o}_{o1} & -b^{21}_{m2}x^{1o}_{o2} & -\cdots & -b^{21}_{mm}x^{1o}_{om} & -\cdots & -b^{2n}_{m1}x^{no}_{o1} & -b^{2n}_{m2}x^{no}_{o2} & -\cdots & -b^{2n}_{mm}x^{no}_{om} & = & c^{21}_{mo}y^{o1}_{mo} & +c^{22}_{mo}y^{o2}_{mo} & +\cdots & +c^{2n}_{mo}y^{on}_{mo} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
x^{no}_{o1} & -b^{n1}_{11}x^{1o}_{o1} & -b^{n1}_{12}x^{1o}_{o2} & -\cdots & -b^{n1}_{1m}x^{1o}_{om} & -\cdots & -b^{nn}_{11}x^{no}_{o1} & -b^{nn}_{12}x^{no}_{o2} & -\cdots & -b^{nn}_{1m}x^{no}_{om} & = & c^{n1}_{1o}y^{o1}_{1o} & +c^{n2}_{1o}y^{o2}_{1o} & +\cdots & +c^{nn}_{1o}y^{on}_{1o} \\
x^{no}_{o2} & -b^{n1}_{21}x^{1o}_{o1} & -b^{n1}_{22}x^{1o}_{o2} & -\cdots & -b^{n1}_{2m}x^{1o}_{om} & -\cdots & -b^{nn}_{21}x^{no}_{o1} & -b^{nn}_{22}x^{no}_{o2} & -\cdots & -b^{nn}_{2m}x^{no}_{om} & = & c^{n1}_{2o}y^{o1}_{2o} & +c^{n2}_{2o}y^{o2}_{2o} & +\cdots & +c^{nn}_{2o}y^{on}_{2o} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \cdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
x^{no}_{om} & -b^{n1}_{m1}x^{1o}_{o1} & -b^{n1}_{m2}x^{1o}_{o2} & -\cdots & -b^{n1}_{mm}x^{1o}_{om} & -\cdots & -b^{nn}_{m1}x^{no}_{o1} & -b^{nn}_{m2}x^{no}_{o2} & -\cdots & -b^{nn}_{mm}x^{no}_{om} & = & c^{n1}_{mo}y^{o1}_{mo} & +c^{n2}_{mo}y^{o2}_{mo} & +\cdots & +c^{nn}_{mo}y^{on}_{mo}
\end{array}
$$

FIGURE A.5. DETAILED MATRIX BALANCE EQUATIONS (REARRANGED)

Source: Polenske (1980, p. 118).

APPENDIX B

MATHEMATICAL FORMULATION OF INTERREGIONAL FEEDBACK EFFECTS

APPENDIX B

MATHEMATICAL FORMULATION OF INTERREGIONAL FEEDBACK EFFECTS

In the literature, the importance of interregional trade data for estimating outputs accurately with interregional input-output models has been measured by the size of the "interregional feedbacks". Because the approach used in this thesis was different than that traditionally used in the literature, a brief summary of the traditional approach is provided in this appendix. In addition, a formulation of the feedback effects for the MRIO model is presented.

Feedback Effects in an Interregional Input-Output Model

In the interregional system of input-output accounts, each interindustry transaction is identified in terms of both industry and region of origin and destination. Thus, the interregional interindustry coefficients are defined as:

$$a_{ij}^{gh} = z_{ij}^{gh} \; / \; x_j^h \qquad \text{(B.1)}$$

where:

z_{ij}^{gh} is the demand of industry j in region h for the output of industry i in region g; and

x_j^h is the total output of industry j in region h.

In matrix notation, the entire system can be written as:

$$(I - A)X = Y \qquad (B.2)$$

Assuming that there are two regions (g and h) in this system, equation (B.2) can be partitioned into intraregional and interregional components, as follows:

$$(I - A^{gg})X^g \qquad - A^{gh}X^h = Y^g \qquad (B.3)$$

$$- A^{hg}X^g \qquad + (I - A^{hh})X^h = Y^h \qquad (B.4)$$

where:

A^{gg} are the coefficients for the intraregional flows in region g;

A^{hh} are the coefficients for the intraregional flows in region h;

A^{gh} are the coefficients for the flows from region g to region h; and

A^{hg} are the coefficients for the flows from region h to region g.

Solving equations (B.3) and (B.4) simultaneously for X^g:

$$X^g = [(I - A^{gg}) - A^{gh} (I - A^{hh})^{-1} A^{hg}]^{-1} Y^g$$

$$+ [(I - A^{hg}) - A^{gh} (I - A^{hh})^{-1} A^{hg}]^{-1} A^{gh}(I - A^{hh})^{-1} Y^h \qquad (B.5)$$

A similar expression can be found for X^h.

To examine the impact of interregional feedbacks on the outputs in region g, only changes in the final demands of region g are of interest. Thus, Y^h is considered to be zero and equation (B.5) becomes:

$$\Delta X^g = [(I - A^{gg}) - A^{gh} (I - A^{hh})^{-1} A^{hg}]^{-1} \Delta Y^g \qquad \text{(B.6)}$$

where: Δ signifies the change in X^g and Y^g.

To isolate the interregional feedback effects, equation (B.6) is rewritten:

$$[(I - A^{gg}) - A^{gh}(I - A^{hh})^{-1} A^{hg}] \Delta X^g = \Delta Y^g \qquad \text{(B.7)}$$

The impact of the interregional feedbacks on the outputs of region g can be calculated by comparing the outputs of (B.7) with those of the simple single-region case:

$$\Delta X^g = (I - A^{gg}) \Delta Y^g \qquad \text{(B.8)}$$

Subtracting equation (B.8) from equation (B.6), the impact of the interregional feedback effects in the two-region case can be shown as:

$$[[(I-A^{gg}) - A^{gh}(I-A^{hh})^{-1} A^{hg}]^{-1} - (I-A^{gg})^{-1}] \Delta Y^g \qquad \text{(B.9)}$$

Similar results for a three-region interregional input-output system have been derived by Miller (1966). In the following section, the interregional feedback effects are derived for a multiregional input-output system.

Feedback Effects in the Multiregional Input-Output Model

The multiregional input-output (MRIO) framework attempts to capture intraregional and interregional linkages with fewer data than those required by an IRIO system. A discussion of how the MRIO accounts are related to the IRIO accounts is given in Appendix A. For the MRIO system, Miller and Blair (1981, p. 6) showed that the technical and trade coefficient matrices could be partitioned, for a two-region case (regions g and h) as follows:

$$\hat{A} = \left[\begin{array}{c|c} A^g & 0 \\ \hline 0 & A^h \end{array}\right] \qquad \text{(B.10)}$$

$$C = \left[\begin{array}{c|c} C^{gg} & C^{gh} \\ \hline C^{hg} & C^{hh} \end{array}\right] \qquad \text{(B.11)}$$

Rearranging the MRIO balance equation (2.1):

$$(I - CA)X = CY \tag{B.12}$$

Writing this in partitioned form:

$$(I - C^{gg}A^{g})X^{g} - C^{gh}A^{h}X^{h} = C^{gg}Y^{g} + C^{gh}Y^{h} \tag{B.13}$$

$$- C^{hg}A^{g}X^{g} + (I - C^{hh}A^{h})X^{h} = C^{hg}Y^{g} + C^{hh}Y^{h} \tag{B.14}$$

Comparing these equations with (B.3) and (B.4), it is readily seen that $C^{gg}A^{g}$ is the MRIO proxy for A^{gg} in the IRIO system. Similarly, $C^{gh}A^{h}$, $C^{hg}A^{g}$, and $C^{hh}A^{h}$ correspond to A^{gh}, A^{hg}, and A^{hh} in the IRIO system, respectively. From this, it is possible to derive the feedback effect with respect to X^{g} in the MRIO system by substituting into equation (B.9):

$$[[(I - C^{gg}A^{g}) - C^{gh}A^{h}(I - C^{hh}A^{h})^{-1} C^{hg}A^{g}]^{-1}$$

$$- (I - C^{gg}A^{g})^{-1}] \Delta C^{gg}Y^{g} \tag{B.15}$$

The expressions for the interregional feedback effects derived for the IRIO and MRIO frameworks in this appendix do not capture the full impacts of interregional trade on regional outputs, however. All of the feedbacks due to changes in the final demands in other are neglected. The methodology presented in Chapter 2 and tested in Chapter 3 provides a measure of the total effect of interregional trade on the output estimates produced by the MRIO model.

APPENDIX C

MRIO CLASSIFICATION SCHEMES

TABLE C.1

MULTIREGIONAL INPUT-OUTPUT CLASSIFICATION
FOR NINETEEN INDUSTRIES

Industry No. MRIO	Industry No. BEA	Industry Title
1	1	Livestock & livestock prdts.
2	2	Other agricultural prdts.
3	7	Coal mining
4	8	Crude petro., natural gas
5		Other mining
	5	Iron & ferro. ores mining
	6	Nonferrous metal ores mining
	9	Stone & clay mining
	10	Chem. & fert. mineral mining
6		Construction
	11	New construction
	12	Maint. & repair construction
7		Food, tobacco, fabrics, & apparel
	14	Food & kindred prdts.
	15	Tobacco manufactures
	16	Fabrics
	17	Textile prdts.
	18	Apparel
	19	Misc. textile prdts.
	33	Leather tanning & prdts.
	34	Footwear, leather prdts.
8		Transport. equip. & ordnance
	13	Ordnance & accessories
	59	Motor vehicles, equip.
	60	Aircraft & parts
	61	Other transport. equip.
9		Lumber & paper
	20	Lumber & wood prdts.
	21	Wooden containers
	22	Household furniture
	23	Other furniture
	24	Paper & allied prdts.
	25	Paperboard containers
	26	Printing & publishing
10	31	Petroleum, related inds.
11		Plastics & chemicals
	27	Chemicals, selected prdts.
	28	Plastics & synthetics
	29	Drugs & cosmetics
	30	Paint & allied prdts.
	32	Rubber, misc. plastics
12		Glass, stone, clay prdts.
	35	Glass & glass prdts.
	36	Stone & clay prdts.
13	37	Primary iron, steel, mfr.
14	38	Primary nonferrous mfr.
15		Machinery & equipment
	39	Metal containers
	40	Fabricated metal prdts.
	41	Screw mach. prdts., etc.
	42	Other fab. metal prdts.
	43	Engines & turbines
	44	Farm mach. & equip.
	45	Construction mach. & equip.
	46	Materials hand. mach & equip.
	47	Metalworking mach. & equip.
	48	Special mach. & equip.
	49	General mach. & equip.
	50	Machine shop prdts.
	51	Office, computing machines
	52	Service industry machines
	53	Elect. transmission equip.
	54	Household appliances
	55	Electric lighting equip.
	56	Radio, TV, etc., equip.
	57	Electronic components
	58	Misc. electrical mach.
	62	Professional, scien. instru.
	63	Medical, photo. equip.
	64	Misc. manufacturing
16		Services
	3	Forestry & fishery prdts.
	4	Ag., for., & fish. services
	66	Communications, exc. brdcast.
	67	Radio & TV broadcasting
	69	Wholesale & retail trade
	70	Finance & insurance
	71	Real estate & rental
	72	Hotels; repair serv., exc. auto
	73	Business services
	74	Research & development
	75	Automobile repair & services
	76	Amusements
	77	Med., ed. serv., nonprof. org.
	78	Federal gov't enterprises
	79	State & local gov't enterp.
17	65	Transportation & warehousing
18		Gas, water, & sanitary services
	68.02	Gas utilities
	68.03	Water & sanitary services
19	68.01	Electric utilities

TABLE C.2

INDUSTRIAL CLASSIFICATION SCHEME
(79 to 3 Industries)

	C-1 Agriculture & Mining
IO- 1	Livestock & livestock prdts.
IO- 2	Other agricultural prdts.
IO- 5	Iron & ferro. ores mining
IO- 6	Nonferrous metal ores mining
IO- 7	Coal mining
IO- 8	Crude petro., natural gas
IO- 9	Stone & clay mining
IO-10	Chem. & fert. mineral mining
	C-2 Construction & manufacturing
IO-11	New construction
IO-12	Maint. & repair construction
IO-13	Ordnance & accessories
IO-14	Food & kindred prdts.
IO-15	Tobacco manufactures
IO-16	Fabrics
IO-17	Textile prdts.
IO-18	Apparel
IO-19	Misc. textile prdts.
IO-20	Lumber & wood prdts.
IO-21	Wooden containers
IO-22	Household furniture
IO-23	Other furniture
IO-24	Paper & allied prdts.
IO-25	Paperboard containers
IO-26	Printing & publishing
IO-27	Chemicals, selected prdts.
IO-28	Plastics & synthetics
IO-29	Drugs & cosmetics
IO-30	Paint & allied prdts.
IO-31	Petroleum, related inds.
IO-32	Rubber, misc. plastics
IO-33	Leather tanning & prdts.
IO-34	Footwear, leather prdts.
IO-35	Glass & glass prdts.
IO-36	Stone & clay prdts.
IO-37	Primary iron, steel mfr.
IO-38	Primary nonferrous mfr.
IO-39	Metal containers
IO-40	Fabricated metal prdts.
IO-41	Screw mach. prdts., etc.
IO-42	Other fab. metal prdts.
IO-43	Engines & turbines
IO-44	Farm mach. & equip.
IO-45	Construction mach. & equip.
IO-46	Material hand. mach. & equip.
IO-47	Metalworking mach. & equip.
IO-48	Special mach. & equip.
IO-49	General mach. & equip.
IO-50	Machine shop prdts.
IO-51	Office, computing machines
IO-52	Service industry machines
IO-53	Elec. transmission equip.
IO-54	Household appliances
IO-55	Electric lighting equip.
IO-56	Radio, TV, etc., equip.
IO-57	Electronic components
IO-58	Misc. electrical mach.
IO-59	Motor vehicles, equip.
IO-60	Aircraft & parts
IO-61	Other transport. equip.
IO-62	Professional, scien. instru.
IO-63	Medical, photo. equip.
IO-64	Misc. manufacturing
	C-3 Services*
IO- 3	Forestry & fishery prdts.
IO- 4	Ag., for., & fish. services
IO-65	Transportation & warehousing
IO-66	Communications, exc. brdcast.
IO-67	Radio & TV brdcasting
IO-68	Elec., gas, water, & san. serv.
IO-69	Wholesale & retail trade
IO-70	Finance & insurance
IO-71	Real estate & rental
IO-72	Hotels; repair serv., exc. auto
IO-73	Business services
IO-74	Research & development
IO-75	Automobile repair & services
IO-76	Amusements
IO-77	Med., ed. serv., nonprofit org.
IO-78	Federal gov't. enterprises
IO-79	State & local gov't. enterp.

*Nontraded commodities.

TABLE C.3

REGIONAL CLASSIFICATION SCHEME
(51, 9, and 3 Regions)

R-1 NORTH		R-2 SOUTH		R-3 WEST	
Regional Classification		Regional Classification		Regional Classification	
9-Region	51-Region	9-Region	51-Region	9-Region	51-Region
1 New England	6 Connecticut	5 South Atlantic	7 Delaware	4 West North Central	14 Iowa
	18 Maine		8 District of Columbia		15 Kansas
	20 Massachusetts		9 Florida		22 Minnesota
	28 New Hampshire		10 Georgia		24 Missouri
	38 Rhode Island		19 Maryland		26 Nebraska
	44 Vermont		32 North Carolina		33 North Dakota
2 Middle Atlantic	29 New Jersey		39 South Carolina		40 South Dakota
	31 New York		45 Virginia	8 Mountain	2 Arizona
	37 Pennsylvania		47 West Virginia		5 Colorado
3 East North Central	12 Illinois	6 East South Central	1 Alabama		11 Idaho
	13 Indiana		16 Kentucky		25 Montana
	21 Michigan		23 Mississippi		27 Nevada
	34 Ohio		41 Tennessee		30 New Mexico
	48 Wisconsin	7 West South Central	3 Arkansas		43 Utah
			17 Louisiana		49 Wyoming
			35 Oklahoma	9 Pacific	4 California
			42 Texas		36 Oregon
					46 Washington
					50 Alaska
					51 Hawaii

APPENDIX D

ADDITIONAL RESULTS RELATED TO INTERREGIONAL TRADE EFFECTS

TABLE D.1

PERCENTAGE DIFFERENCE BETWEEN BASE CASE AND 1963 REGIONAL OUTPUTS
RESULTING FROM OMISSION OF INTERREGIONAL TRADE FOR SERVICES INDUSTRIES
(WITH NET-TRADE BALANCE ADJUSTMENT)

	1 NEW ENGLAND	2 MIDDLE ATLANTIC	3 EAST NORTH CENTRAL	4 WEST NORTH CENTRAL	5 SOUTH ATLANTIC	6 EAST SOUTH CENTRAL	7 WEST SOUTH CENTRAL	8 MOUNTAIN	9 PACIFIC
1 LIVESTOCK, PRDTS.	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 OTHER AGRICULTURE PRDTS.	-0.0	-0.0	-0.0	0.0	-0.0	0.0	0.0	0.0	0.0
3 COAL MINING	-0.7	-0.3	-0.2	-0.0	-0.3	-0.2	-0.0	0.1	0.1
4 CRUDE PETRO.,NATURAL GAS	0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.1	-0.1
5 OTHER MINING	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
6 CONSTRUCTION	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0
7 FOOD,TOBAC.,FAB.,APPAREL	-0.0	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TRANSPORT EQPT.,ORDNANCE	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	0.0	-0.0	-0.0
9 LUMBER & PAPER	-0.0	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 PETROLEUM, RELATED INDS.	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
11 PLASTICS & CHEMICALS	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0
12 GLASS, STONE,CLAY PRDTS	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0
13 PRIMARY IRON & STEEL MFR	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	-0.0	-0.0
14 PRIMARY NONFERROUS MFR	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
15 MACHINERY & EQUIPMENT	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0
16 SERVICES	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 TRANSPORT. & WAREHOUSING	-0.1	-0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.1	-0.1
18 GAS & WATER SERVICES	0.2	0.1	0.1	-0.1	0.1	0.0	-0.1	-0.4	-0.6
19 ELECTRIC UTILITIES	-1.5	-1.3	-0.9	-0.1	-1.2	-0.6	-0.1	0.2	0.3

TABLE D.2

1963 CALCULATED BASE CASE OUTPUTS: 19 INDUSTRIES, 9 REGIONS
(THOUSANDS OF 1963 DOLLARS)

	1 NEW ENGLAND	2 MIDDLE ATLANTIC	3 EAST NORTH CENTRAL	4 WEST NORTH CENTRAL	5 SOUTH ATLANTIC	6 EAST SOUTH CENTRAL	7 WEST SOUTH CENTRAL	8 MOUNTAIN	9 PACIFIC
1 LIVESTOCK, PRDTS.	644671	1862644	5019302	7945307	2423536	1759842	2654500	2043834	2360069
2 OTHER AGRICULTURE PRDTS.	381285	1361240	4968982	6154060	3605158	2197499	3323221	1760744	3628328
3 COAL MINING	378	680740	436570	35199	901388	477103	9259	82317	7886
4 CRUDE PETRO.,NATURAL GAS	365106	559639	575967	607415	113584	307866	7346678	1183284	1207911
5 OTHER MINING	104940	698998	854707	779004	659713	276225	455843	1451325	422191
6 CONSTRUCTION	4523869	12356312	14588084	6370863	11504908	3925810	8930435	4805958	18310976
7 FOOD,TOBAC.,FAB.,APPAREL	7230647	26809824	19273792	13238464	26162272	8613146	7326300	2648111	11735413
8 TRANSPORT EQPT.,ORDNANCE	2836102	7518132	29874816	4823813	3974407	1427797	2558239	907390	9936810
9 LUMBER & PAPER	3737051	11242236	11356227	2694072	6640129	2664607	2788801	1103190	8377723
10 PETROLEUM, RELATED INDS.	342829	3300641	3617290	1061120	718350	371372	8655764	867636	2898348
11 PLASTICS & CHEMICALS	2699779	10036110	10514189	2234297	5942666	2771957	5147485	474894	2940646
12 GLASS, STONE,CLAY PRDTS	559045	2681500	3269053	931821	1552401	659882	985193	397867	1440903
13 PRIMARY IRON & STEEL MFR	568382	7138407	11407083	472344	1653399	1343479	554758	356455	1022465
14 PRIMARY NONFERROUS MFR	1212933	3593144	3778209	408513	1161418	681779	991554	1105015	1264902
15 MACHINERY & EQUIPMENT	9075359	25838560	36738128	5868081	5585162	3104895	3970516	1110925	9935010
16 SERVICES	22872272	90944816	71305344	28249088	44530640	15240652	26975168	13021610	52195424
17 TRANSPORT. & WAREHOUSING	1734088	9127472	7683406	3259128	4917580	1634361	3784708	1452686	5549429
18 GAS & WATER SERVICES	533895	2746923	3446699	1276478	1508640	912938	1315306	863046	1644223
19 ELECTRIC UTILITIES	1052893	2948476	3511151	1130071	2234331	695424	1463832	654580	1736153
20 TOTAL	60475536	221445840	242219040	87539136	125789696	49066624	89237568	36290864	136614816

APPENDIX E

TRANSPORTATION COMMODITY CLASSIFICATION CODES

TWO- AND THREE-DIGIT TRANSPORTATION COMMODITY CLASSIFICATION (TCC) CODES FOR MANUFACTURED GOODS*

19 Ordnance and Accessories
(Excluded from Census of Transportation Survey (CTS))

20 Food and Kindred Products

- 201 Meat Products
- 202 Dairy Products (2026, Fluid Milk, is excluded as involving local commerce only.)
- 203 Canned and Preserved Fruits, Vegetables, and Sea Foods
- 204 Grain Mill Products
- 205 Bakery Products (Totally excluded in 1963 and 1967 on grounds of involving local commerce only. In 1972, 2052, Packaged Cookies and Crackers, is included in survey.)
- 206 Sugar
- 207 Confectionary and Related Products
- 208 Beverages
- 209 Miscellaneous Food Preparations and Kindred Products (2097, Manufactured Ice, is excluded.)

21 Tobacco Products

- 211 Cigarettes
- 212 Cigars
- 213 Tobacco (Chewing and Smoking) and Snuff
- 214 Tobacco, Stemmed and Redried

22 Textile Mill Products

- 221 Broad Woven Fabric, Cotton
- 222 Broad Woven Fabric, Man-Made Fiber and Silk
- 223 Broad Woven Fabric, Wool
- 224 Narrow Fabric and Other Smallwares, Cotton, Wool, Silk, and Man-Made Fiber

*Note: Complete descriptions of the 2,3,4, and 5-digit commodity codes may be found in publications by the U.S. Bureau of the Census from the 1972 Census of Transportation, e.g., _Commodity Transportation Survey-Area Series: Area Reports 1 thru 8, TC72C2_, in _The Commodity Classification for Transportation Statistics_ published by the Office of Management and Budget, or in _Standard Transportation Commodity Code_ published by the Association of American Railroads.

225 Knitware
226 Dyed and Finished Textiles, except Wood Fabrics and Knit Goods
227 Floor Coverings --Carpets and Rugs
228 Yarn and Thread
229 Miscellaneous Textile Goods

23 Apparel and Other Finished Products Made from Fabrics and Similar Materials

231 Mens', Youths', and Boys' Suits, Coats, and Overcoats
232 Mens', Youths', and Boys' Furnishings, Work Clothing and Allied Garments
233 Womens', Misses', and Juniors' Outerwear
234 Womens', Misses', Children's, and Infants' Under Garments
235 Hats, Caps, and Millinery
236 Girls', Children's, and Infants' Outerwear
237 Fur Goods
238 Miscellaneous Apparel and Accessories
239 Miscellaneous Fabricated Textile Products

24 Lumber and Wood Products, except Furniture

241 Logs
242 Sawmill Products
243 Millwork, Veneer, Plywood, and Pre-Fabricated Structural Wood Products
244 Wooden Containers
249 Miscellaneous Wood Products

25 Furniture and Fixtures

251 Household Furniture
252 Office Furniture
253 Public Building and Related Furniture
254 Partitions, Shelving, Lockers, and Office and Store Fixtures
255 Miscellaneous Furniture and Fixtures

26 Paper and Allied Products

261 Wood Pulp
262 Paper Mill Products, except Building Paper
263 Paperboard
264 Converted Paper and Paperboard Products, except Containers
265 Containers and Boxes
266 Building Paper and Building Board

27 Printing, Publishing and Allied Industries
(Not included in CTS Shipper Surveys)

28 Chemicals and Allied Products

281 Industrial Chemicals
282 Plastic Materials and Synthetics
283 Drugs
284 Soap, Cleaners, and Toilet Goods
285 Paints and Allied Products
286 Gum and Wood Products
287 Agricultural Chemicals
289 Miscellaneous Chemical Products

29 Petroleum and Coal Products

291 Petroleum Refining
295 Paving and Roofing Materials
299 Miscellaneous Petroleum and Coal Products

30 Rubber and Plastics Products, n.e.c.

301 Tires and Inner Tubes
302 Rubber Footwear
303 Reclaimed Rubber
306 Fabricated Rubber Products, n.e.c.
307 Miscellaneous Plastics Products

31 Leather and Leather Products

311 Leather Tanning and Finishing
312 Industrial Leather Belting
313 Footwear Cut Stock
314 Footwear, except Rubber
315 Leather Gloves and Mittens
316 Luggage
317 Handbags and Personal Leather Goods
319 Leather Goods, n.e.c.

32 Stone, Clay, and Glass Products

321 Flat Glass
322 Glass and Glassware, Pressed or Blown
323 Products of Purchased Glass
324 Cement, Hydraulic
325 Structural Clay Products
326 Pottery and Related Products
327 Concrete, Gypsum, and Plaster Products
328 Cut Stone and Stone Products
329 Miscellaneous Nonmetallic Mineral Products

33 Primary Metal Industries

331 Blast Furnace and Basic Steel Products
332 Iron and Steel Foundries
333 Primary Nonferrous Metals
334 Secondary Nonferrous Metals
335 Nonferrous Rolling and Drawing
336 Nonferrous Foundries
339 Miscellaneous Primary Metal Products

34 Fabricated Metal Products

341 Metal Cans
342 Cutlery, Hand Tools, and Hardware
343 Plumbing and Heating, except Electric
344 Fabricated Structural Metal Products
345 Screw Machine Products, Bolts, etc.
346 Metal Stampings
347 Metal Services, n.e.c.
348 Miscellaneous Fabricated Wire Products
349 Miscellaneous Fabricated Metal Products

35 Machinery, except Electrical

351 Engines and Turbines
352 Farm Machinery
353 Construction and Related Machinery
354 Metal Working Machinery
355 Special Industry Machinery
356 General Industrial Machinery
357 Office and Computing Machines
358 Service Industry Machines
359 Miscellaneous Machinery, except Electrical

36 Electrical Equipment and Supplies

361 Electric Test and Distributing Equipment
362 Electrical Industrial Apparatus
363 Household Appliances
364 Electric Lighting and Wiring Equipment
365 Radio and TV Receiving Equipment
366 Communication Equipment
367 Electronic Components and Accessories
369 Miscellaneous Electrical Equipment and Supplies

37 Transportation Equipment

- 371 Motor Vehicles and Equipment
- 372 Aircraft and Parts
- 373 Ship and Boat Building and Repairing
- 374 Railroad Equipment
- 375 Motorcycles, Bicycles, and Parts
- 379 Miscellaneous Transportation Equipment

38 Instruments and Related Products

- 381 Engineering and Scientific Instruments
- 382 Mechanical Measuring and Control Devices
- 383 Optical Instruments and Lenses
- 384 Medical Instruments and Supplies
- 385 Ophthalmic Goods
- 386 Photographic Equipment and Supplies
- 387 Watches, Clocks, and Watchcases

39 Miscellaneous Manufacturing Industries

- 391 Jewelry, Silverware, and Plated Ware
- 393 Musical Instruments and Parts
- 394 Toys and Sporting Goods
- 395 Pens, Pencils, Office and Art Supplies
- 396 Costume Jewelry and Notions
- 399 Miscellaneous Manufactures

APPENDIX F

ADDITIONAL RESULTS RELATED TO TRADE-COEFFICIENT STABILITY

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	1 ALABAMA	2 ARIZONA	3 ARKANSAS	4 CALIFORNIA	5 COLORADO	6 CONNECTICUT	7 DELAWARE	8 DISTRICT OF COLUMBIA	9 FLORIDA
1 ALABAMA	-0.073	0.001	0.035	0.001	0.005	-0.003	0.001	-0.027	-0.015
2 ARIZONA	-0.000	-0.011	-0.002	-0.000	-0.001	-0.000	0.000	-0.000	-0.000
3 ARKANSAS	-0.005	0.005	0.032	-0.000	0.010	-0.000	0.000	-0.001	-0.001
4 CALIFORNIA	0.003	0.192	0.002	0.085	0.053	-0.005	0.003	-0.017	-0.001
5 COLORADO	0.000	0.001	0.000	0.001	-0.008	-0.000	-0.000	-0.005	0.000
6 CONNECTICUT	0.000	-0.000	0.001	-0.001	-0.002	-0.009	0.001	-0.003	-0.000
7 DELAWARE	-0.000	-0.000	0.001	-0.000	-0.001	-0.003	0.003	-0.015	-0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	-0.028	0.006	0.003	-0.001	-0.004	-0.001	0.002	-0.025	-0.154
10 GEORGIA	-0.018	-0.001	-0.001	-0.003	-0.033	-0.009	0.002	-0.010	-0.035
11 IDAHO	-0.000	-0.000	-0.000	-0.000	0.007	-0.001	0.001	-0.003	-0.000
12 ILLINOIS	-0.050	-0.003	-0.038	-0.020	-0.031	-0.018	0.007	-0.037	-0.011
13 INDIANA	-0.016	-0.000	-0.033	-0.006	-0.014	-0.009	0.008	-0.009	-0.004
14 IOWA	-0.003	-0.001	-0.005	-0.008	-0.007	-0.006	-0.001	-0.009	-0.003
15 KANSAS	-0.001	-0.003	-0.007	-0.001	0.002	-0.001	0.000	-0.007	-0.000
16 KENTUCKY	-0.008	-0.004	-0.001	-0.002	-0.005	-0.002	0.001	-0.012	-0.001
17 LOUISIANA	0.192	-0.001	-0.090	-0.000	-0.017	0.001	0.006	-0.011	0.298
18 MAINE	0.000	0.004	0.002	-0.000	0.005	-0.007	0.002	-0.015	-0.001
19 MARYLAND	0.001	-0.000	-0.000	-0.000	0.000	-0.002	0.011	-0.043	-0.000
20 MASSACHUSETTS	0.001	0.000	0.001	0.001	0.003	-0.031	0.007	-0.012	-0.000
21 MICHIGAN	-0.003	0.002	-0.006	-0.012	-0.001	-0.003	0.035	-0.024	-0.002
22 MINNESOTA	0.000	0.001	0.001	-0.003	0.000	-0.001	0.000	-0.003	-0.001
23 MISSISSIPPI	-0.025	-0.001	-0.016	-0.003	-0.006	-0.001	0.000	-0.002	-0.007
24 MISSOURI	0.001	0.000	-0.012	-0.006	-0.035	-0.002	-0.000	0.464	-0.001
25 MONTANA	-0.000	-0.001	-0.000	-0.000	-0.014	-0.000	0.0	0.0	-0.000
26 NEBRASKA	-0.002	-0.003	0.001	-0.002	-0.004	-0.001	-0.000	-0.012	-0.002
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.000	0.000	0.000	-0.000	0.000	-0.001	0.000	0.029	0.001
29 NEW JERSEY	0.001	0.008	-0.002	-0.002	-0.005	-0.159	0.351	-0.107	-0.005
30 NEW MEXICO	0.000	0.000	0.008	0.000	0.003	0.000	0.0	0.255	0.001
31 NEW YORK	0.004	0.007	0.008	-0.001	0.009	-0.061	0.067	0.187	-0.003
32 NORTH CAROLINA	-0.009	-0.001	-0.022	-0.002	0.002	-0.007	0.000	-0.053	-0.005
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	1 ALABAMA	2 ARIZONA	3 ARKANSAS	4 CALIFORNIA	5 COLORADO	6 CONNECTICUT	7 DELAWARE	8 DISTRICT OF COLUMBIA	9 FLORIDA
34 OHIO	0.025	0.006	0.015	-0.014	-0.013	-0.013	0.078	-0.064	-0.006
35 OKLAHOMA	0.004	0.002	0.041	-0.000	0.006	0.000	0.000	-0.000	-0.001
36 OREGON	0.013	-0.025	0.019	-0.019	-0.056	-0.004	0.008	-0.008	0.001
37 PENNSYLVANIA	0.001	0.005	0.004	0.001	-0.003	-0.027	-0.036	-0.136	-0.004
38 RHODE ISLAND	0.000	-0.000	0.001	-0.000	0.000	-0.000	0.000	-0.001	-0.000
39 SOUTH CAROLINA	-0.003	0.001	-0.002	-0.002	-0.006	-0.005	0.002	-0.017	-0.002
40 SOUTH DAKOTA	0.000	-0.000	0.0	0.000	-0.000	0.000	0.000	-0.001	0.000
41 TENNESSEE	-0.010	-0.001	0.008	-0.002	-0.000	-0.002	-0.001	-0.003	-0.003
42 TEXAS	0.011	-0.175	0.063	0.060	0.084	0.408	-0.577	-0.012	-0.022
43 UTAH	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
44 VERMONT	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
45 VIRGINIA	-0.003	-0.001	-0.002	-0.003	0.004	-0.008	0.009	-0.031	-0.002
46 WASHINGTON	0.001	-0.008	-0.003	-0.030	-0.010	-0.002	0.001	-0.013	-0.003
47 WEST VIRGINIA	-0.003	-0.001	-0.001	-0.002	-0.001	-0.002	0.003	-0.159	-0.001
48 WISCONSIN	0.002	-0.000	-0.000	-0.003	0.002	-0.003	0.004	-0.027	-0.003
49 WYOMING	0.0	0.0	0.0	0.000	0.082	0.000	0.0	0.0	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	10 GEORGIA	11 IDAHO	12 ILLINOIS	13 INDIANA	14 IOWA	15 KANSAS	16 KENTUCKY	17 LOUISIANA	18 MAINE
1 ALABAMA	-0.002	0.000	0.016	0.016	0.017	0.015	0.025	-0.005	-0.000
2 ARIZONA	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.0
3 ARKANSAS	0.001	0.003	0.004	0.002	0.031	0.001	0.002	-0.022	-0.001
4 CALIFORNIA	0.016	0.050	0.026	0.023	0.012	0.040	0.010	0.009	-0.004
5 COLORADO	-0.000	0.003	0.004	0.000	0.001	0.002	-0.000	-0.001	0.000
6 CONNECTICUT	0.004	-0.002	0.004	0.004	0.001	-0.000	0.002	0.001	-0.003
7 DELAWARE	-0.001	-0.001	0.000	0.000	-0.000	0.000	-0.001	-0.000	-0.003
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	-0.014	-0.004	-0.005	-0.005	-0.003	0.004	0.002	-0.001	-0.003
10 GEORGIA	-0.226	-0.038	-0.004	-0.006	-0.001	-0.006	-0.008	-0.002	-0.002
11 IDAHO	-0.000	-0.021	0.001	0.001	0.004	0.009	-0.001	0.000	-0.000
12 ILLINOIS	-0.029	0.006	-0.216	-0.164	-0.105	-0.017	-0.074	-0.038	-0.045
13 INDIANA	-0.023	0.002	-0.125	-0.176	-0.051	-0.010	-0.075	-0.004	-0.008
14 IOWA	-0.005	-0.009	-0.032	-0.001	-0.155	-0.003	0.000	-0.001	-0.016
15 KANSAS	0.000	0.000	-0.001	0.001	0.002	-0.205	-0.000	-0.001	-0.007
16 KENTUCKY	-0.006	-0.002	-0.006	-0.010	0.001	0.000	-0.037	-0.001	-0.001
17 LOUISIANA	-0.032	0.000	0.073	0.088	0.026	-0.001	-0.101	0.029	0.303
18 MAINE	0.001	-0.000	0.005	0.002	0.001	-0.001	-0.003	0.000	-0.071
19 MARYLAND	0.002	-0.000	0.001	0.001	0.000	0.001	0.001	-0.000	-0.000
20 MASSACHUSETTS	0.002	0.000	0.008	0.002	0.004	0.001	0.005	0.001	-0.036
21 MICHIGAN	-0.009	0.009	-0.024	-0.033	-0.001	-0.005	-0.015	-0.002	-0.011
22 MINNESOTA	0.001	-0.001	-0.005	-0.005	0.004	0.004	-0.002	0.000	-0.004
23 MISSISSIPPI	-0.005	-0.001	-0.002	0.004	-0.003	-0.004	-0.003	-0.058	-0.003
24 MISSOURI	-0.002	0.019	-0.016	-0.004	-0.007	-0.077	-0.017	-0.001	-0.000
25 MONTANA	-0.001	-0.012	-0.000	-0.001	-0.004	-0.002	-0.001	-0.000	-0.000
26 NEBRASKA	-0.001	-0.008	-0.007	-0.001	-0.008	-0.003	-0.001	-0.003	-0.003
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	-0.000	0.006	0.000	-0.000	-0.000	0.000	0.000	0.000	-0.009
29 NEW JERSEY	0.007	-0.001	0.015	0.013	0.007	0.018	-0.005	0.000	-0.065
30 NEW MEXICO	0.0	0.039	0.001	0.000	0.001	0.004	0.001	0.000	0.002
31 NEW YORK	0.013	0.018	0.037	0.021	0.012	0.013	0.022	0.004	-0.002
32 NORTH CAROLINA	-0.010	-0.001	0.000	-0.001	0.003	0.002	0.004	0.001	-0.006
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	10 GEORGIA	11 IDAHO	12 ILLINOIS	13 INDIANA	14 IOWA	15 KANSAS	16 KENTUCKY	17 LOUISIANA	18 MAINE
34 OHIO	0.019	-0.010	0.080	0.108	0.053	0.027	0.076	0.014	-0.064
35 OKLAHOMA	0.001	-0.005	0.019	0.002	0.019	0.044	0.004	0.008	-0.000
36 OREGON	0.011	0.136	0.021	0.021	0.015	0.033	0.006	0.003	-0.002
37 PENNSYLVANIA	0.036	-0.003	0.068	0.136	0.080	0.075	0.045	0.020	-0.066
38 RHODE ISLAND	0.001	0.000	0.001	0.001	0.000	0.000	0.000	-0.000	-0.000
39 SOUTH CAROLINA	-0.014	0.000	-0.001	-0.001	-0.001	0.001	0.000	0.000	-0.007
40 SOUTH DAKOTA	-0.000	-0.000	0.000	0.000	0.003	0.001	0.0	0.000	-0.000
41 TENNESSEE	-0.005	-0.005	-0.004	-0.006	-0.001	-0.002	-0.016	-0.004	-0.002
42 TEXAS	0.269	-0.138	0.062	-0.034	0.044	0.016	0.166	0.058	0.144
43 UTAH	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
44 VERMONT	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000
45 VIRGINIA	-0.001	-0.001	0.000	0.001	-0.003	-0.002	-0.001	-0.002	-0.001
46 WASHINGTON	0.003	-0.044	0.012	0.005	0.008	0.009	0.000	-0.002	0.001
47 WEST VIRGINIA	-0.003	-0.004	-0.002	-0.002	-0.000	0.002	-0.008	-0.000	-0.000
48 WISCONSIN	-0.001	-0.007	-0.011	-0.003	-0.004	0.015	-0.000	0.001	-0.003
49 WYOMING	0.0	0.025	0.000	0.001	0.002	0.0	0.0	0.000	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	19 MARYLAND	20 MASSA-CHUSETTS	21 MICHIGAN	22 MINNESOTA	23 MISSISSIPPI	24 MISSOURI	25 MONTANA	26 NEBRASKA	27 NEVADA
1 ALABAMA	0.007	0.003	0.007	0.021	-0.016	0.015	0.000	0.012	0.000
2 ARIZONA	-0.016	-0.000	-0.000	-0.000	-0.000	-0.000	-0.001	-0.001	0.000
3 ARKANSAS	-0.000	0.002	0.001	-0.001	0.001	-0.000	0.005	0.013	-0.005
4 CALIFORNIA	0.010	0.005	0.012	0.037	0.029	0.027	0.092	0.043	0.028
5 COLORADO	0.000	-0.000	0.000	-0.000	0.000	0.000	-0.001	0.009	0.006
6 CONNECTICUT	0.000	0.005	0.001	0.003	0.001	0.010	-0.000	-0.001	-0.000
7 DELAWARE	-0.007	-0.002	-0.000	-0.000	0.001	-0.001	0.000	-0.002	0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	-0.005	0.000	-0.002	-0.001	-0.005	-0.003	-0.010	-0.003	0.002
10 GEORGIA	-0.005	-0.009	-0.005	-0.001	-0.005	-0.006	-0.001	-0.006	0.011
11 IDAHO	0.000	-0.000	0.001	0.007	0.000	-0.003	-0.054	0.001	-0.001
12 ILLINOIS	-0.019	-0.009	-0.058	-0.005	-0.004	-0.096	-0.002	-0.033	-0.011
13 INDIANA	-0.023	-0.001	-0.135	-0.079	-0.000	-0.045	-0.047	-0.016	0.008
14 IOWA	-0.001	-0.008	-0.003	-0.045	-0.003	0.001	0.020	-0.056	-0.001
15 KANSAS	-0.001	-0.001	-0.000	-0.005	-0.000	-0.054	-0.000	-0.024	-0.000
16 KENTUCKY	-0.008	0.000	-0.005	-0.004	0.001	-0.004	-0.001	-0.007	-0.002
17 LOUISIANA	-0.005	-0.028	0.000	-0.008	-0.056	-0.014	0.251	-0.032	0.001
18 MAINE	0.001	0.000	0.002	-0.001	-0.000	0.001	0.000	-0.005	-0.000
19 MARYLAND	-0.036	-0.002	0.001	0.000	-0.002	0.001	-0.000	0.001	0.001
20 MASSACHUSETTS	-0.000	0.020	0.004	0.005	0.004	0.003	-0.000	0.002	-0.000
21 MICHIGAN	-0.006	-0.002	-0.225	0.003	0.008	-0.042	-0.001	0.001	0.003
22 MINNESOTA	-0.002	0.000	-0.004	-0.129	0.002	-0.003	-0.028	-0.012	-0.002
23 MISSISSIPPI	-0.001	-0.001	-0.003	-0.003	-0.057	-0.010	-0.001	-0.009	-0.001
24 MISSOURI	0.001	0.002	0.002	0.006	0.006	-0.094	-0.014	-0.064	0.007
25 MONTANA	-0.000	-0.000	-0.000	-0.006	-0.000	-0.002	-0.126	-0.003	-0.001
26 NEBRASKA	-0.003	-0.002	-0.001	-0.009	-0.004	-0.005	-0.000	-0.075	-0.017
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.001	-0.002	-0.000	-0.000	0.000	0.000	0.000	-0.004	0.001
29 NEW JERSEY	0.049	-0.049	0.007	0.006	0.003	0.005	0.001	0.009	0.065
30 NEW MEXICO	0.003	0.002	0.000	0.002	0.004	0.000	0.000	0.0	0.007
31 NEW YORK	0.017	0.016	0.048	0.033	0.013	0.018	0.005	0.006	0.001
32 NORTH CAROLINA	-0.005	0.000	0.001	0.004	0.005	0.004	0.001	-0.002	-0.003
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	19 MARYLAND	20 MASSA-CHUSETTS	21 MICHIGAN	22 MINNESOTA	23 MISSISSIPPI	24 MISSOURI	25 MONTANA	26 NEBRASKA	27 NEVADA
34 OHIO	0.002	0.013	0.271	0.045	0.018	0.044	-0.029	0.019	-0.009
35 OKLAHOMA	-0.001	0.000	0.000	0.018	0.008	0.036	0.012	0.018	0.000
36 OREGON	0.108	0.006	0.010	0.040	0.012	0.026	-0.025	0.059	-0.078
37 PENNSYLVANIA	0.043	0.035	0.078	0.039	0.027	0.023	0.035	0.045	0.005
38 RHODE ISLAND	0.001	-0.001	0.000	0.001	0.000	0.000	-0.000	-0.000	0.002
39 SOUTH CAROLINA	-0.006	-0.002	-0.002	-0.000	-0.002	-0.000	0.001	-0.000	0.000
40 SOUTH DAKOTA	0.000	-0.000	-0.000	0.005	-0.000	0.000	-0.000	0.001	0.001
41 TENNESSEE	-0.002	-0.001	-0.003	0.000	-0.004	-0.001	-0.003	-0.001	-0.003
42 TEXAS	-0.066	0.013	0.008	-0.004	0.009	0.170	-0.017	0.067	-0.009
43 UTAH	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.001	-0.000	-0.000
44 VERMONT	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.000	0.0
45 VIRGINIA	-0.008	-0.004	-0.001	0.001	0.002	0.001	-0.000	-0.001	0.000
46 WASHINGTON	0.001	0.002	0.011	0.014	0.002	0.002	-0.064	0.005	0.002
47 WEST VIRGINIA	-0.022	-0.002	-0.003	-0.004	0.001	-0.001	-0.000	0.003	-0.005
48 WISCONSIN	0.005	0.001	-0.010	0.009	0.002	-0.001	-0.020	0.008	-0.005
49 WYOMING	0.0	0.000	0.0	0.007	0.0	0.000	0.024	0.037	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	28 NEW HAMPSHIRE	29 NEW JERSEY	30 NEW MEXICO	31 NEW YORK	32 NORTH CAROLINA	33 NORTH DAKOTA	34 OHIO	35 OKLAHOMA	36 OREGON
1 ALABAMA	-0.026	0.004	0.015	0.001	-0.026	-0.014	0.003	0.008	-0.000
2 ARIZONA	-0.000	-0.002	-0.002	0.000	-0.000	0.0	-0.000	-0.000	-0.001
3 ARKANSAS	-0.001	-0.000	-0.000	0.000	-0.001	-0.006	-0.000	-0.006	0.001
4 CALIFORNIA	-0.022	0.005	0.016	0.004	-0.001	0.027	0.013	-0.001	0.240
5 COLORADO	-0.000	0.000	-0.013	0.001	0.001	-0.006	-0.000	0.001	-0.001
6 CONNECTICUT	-0.010	-0.002	-0.000	-0.002	-0.000	0.001	-0.000	0.000	0.000
7 DELAWARE	-0.002	-0.007	0.000	-0.004	-0.006	0.000	-0.000	-0.000	-0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	-0.007	-0.002	0.000	-0.004	-0.014	-0.000	-0.007	-0.004	-0.001
10 GEORGIA	-0.013	-0.008	-0.005	-0.006	-0.058	-0.001	-0.006	-0.008	-0.002
11 IDAHO	0.0	-0.001	-0.001	0.000	-0.000	0.004	0.000	-0.000	-0.000
12 ILLINOIS	-0.038	-0.022	-0.018	-0.028	-0.027	-0.055	-0.062	-0.039	-0.001
13 INDIANA	-0.011	-0.007	-0.008	-0.013	-0.013	-0.101	-0.052	-0.022	-0.011
14 IOWA	-0.016	-0.004	-0.001	-0.010	-0.001	-0.002	-0.007	-0.001	-0.003
15 KANSAS	-0.004	-0.001	-0.006	-0.004	-0.006	0.005	-0.000	-0.059	0.002
16 KENTUCKY	-0.011	-0.003	-0.000	-0.002	-0.005	0.003	-0.015	-0.004	-0.003
17 LOUISIANA	-0.006	-0.006	-0.000	-0.003	0.044	-0.009	-0.031	-0.010	0.002
18 MAINE	-0.093	-0.001	-0.000	-0.001	-0.000	-0.000	0.002	-0.000	-0.000
19 MARYLAND	-0.001	-0.006	-0.000	-0.006	-0.002	-0.001	-0.001	-0.000	-0.000
20 MASSACHUSETTS	-0.201	-0.002	-0.001	0.001	0.002	-0.001	0.001	0.000	0.001
21 MICHIGAN	-0.010	-0.018	-0.001	-0.043	-0.002	0.001	-0.076	-0.009	-0.000
22 MINNESOTA	-0.003	-0.002	-0.000	-0.004	-0.004	-0.059	-0.004	-0.001	-0.001
23 MISSISSIPPI	-0.001	-0.001	-0.001	-0.001	0.001	-0.002	-0.002	-0.006	-0.002
24 MISSOURI	-0.001	-0.001	-0.002	0.000	-0.001	0.034	-0.005	-0.017	0.001
25 MONTANA	-0.002	-0.000	-0.001	-0.000	-0.000	-0.024	-0.000	-0.001	-0.001
26 NEBRASKA	-0.003	-0.003	-0.002	-0.004	-0.003	-0.011	-0.001	-0.003	-0.002
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	-0.001	-0.000	0.002	0.001	-0.000	0.005	-0.000	0.000	0.002
29 NEW JERSEY	-0.044	-0.130	-0.001	-0.037	0.002	-0.002	0.003	0.001	-0.000
30 NEW MEXICO	0.006	0.0	0.018	0.001	0.000	0.111	0.000	0.000	0.007
31 NEW YORK	-0.084	-0.017	0.002	-0.046	0.005	0.007	0.021	0.001	0.005
32 NORTH CAROLINA	-0.007	-0.010	-0.001	-0.002	-0.136	0.003	-0.004	-0.001	0.000
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	28 NEW HAMPSHIRE	29 NEW JERSEY	30 NEW MEXICO	31 NEW YORK	32 NORTH CAROLINA	33 NORTH DAKOTA	34 OHIO	35 OKLAHOMA	36 OREGON
34 OHIO	-0.092	-0.012	-0.013	0.007	0.005	-0.010	0.178	0.005	-0.011
35 OKLAHOMA	-0.000	0.000	0.008	-0.000	-0.000	0.007	0.001	0.273	-0.000
36 OREGON	-0.019	0.002	-0.011	0.005	0.012	0.017	0.005	0.001	-0.152
37 PENNSYLVANIA	-0.058	-0.019	-0.005	0.001	0.047	0.037	0.118	0.008	-0.010
38 RHODE ISLAND	-0.001	0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	0.000
39 SOUTH CAROLINA	-0.015	-0.007	-0.000	-0.003	-0.037	0.001	-0.005	-0.003	0.000
40 SOUTH DAKOTA	0.0	-0.000	0.000	-0.000	0.001	0.005	-0.000	0.0	0.000
41 TENNESSEE	-0.002	-0.003	-0.000	-0.004	-0.026	0.000	-0.005	-0.007	-0.001
42 TEXAS	0.856	0.304	0.035	0.222	0.300	-0.050	-0.040	-0.126	-0.009
43 UTAH	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
44 VERMONT	0.000	0.000	0.0	0.000	0.000	0.000	0.000	0.0	0.000
45 VIRGINIA	-0.032	-0.007	0.000	-0.005	-0.032	-0.001	-0.003	-0.002	0.000
46 WASHINGTON	-0.007	-0.002	0.002	-0.003	-0.002	0.013	-0.001	-0.006	-0.050
47 WEST VIRGINIA	-0.003	-0.005	-0.000	-0.003	-0.016	-0.000	-0.007	-0.004	-0.001
48 WISCONSIN	-0.014	-0.004	-0.003	-0.006	0.002	0.011	-0.007	0.042	-0.003
49 WYOMING	0.0	0.0	0.0	0.0	0.0	0.063	0.000	0.0	0.003
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	37 PENNSYL-VANIA	38 RHODE ISLAND	39 SOUTH CAROLINA	40 SOUTH DAKOTA	41 TENNESSEE	42 TEXAS	43 UTAH	44 VERMONT	45 VIRGINIA
1 ALABAMA	0.005	0.001	0.010	-0.013	-0.016	-0.000	-0.001	-0.002	-0.003
2 ARIZONA	-0.000	-0.000	0.0	0.0	-0.000	-0.002	-0.001	0.000	-0.000
3 ARKANSAS	-0.000	-0.000	0.000	-0.008	-0.016	-0.004	0.012	-0.001	-0.001
4 CALIFORNIA	0.003	-0.001	0.012	0.006	0.008	0.009	0.219	0.003	0.008
5 COLORADO	0.000	-0.000	0.000	-0.002	-0.000	-0.003	0.000	-0.000	-0.000
6 CONNECTICUT	-0.002	0.001	-0.002	0.000	-0.000	0.000	0.001	-0.007	0.001
7 DELAWARE	-0.005	-0.002	-0.001	0.000	-0.002	-0.000	0.000	-0.001	-0.001
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	-0.005	0.000	-0.005	0.005	-0.011	-0.004	-0.004	0.001	-0.006
10 GEORGIA	-0.007	-0.001	-0.034	-0.009	-0.017	-0.009	-0.000	0.004	-0.018
11 IDAHO	0.000	0.0	-0.001	0.002	-0.001	-0.001	0.006	-0.002	0.000
12 ILLINOIS	-0.044	-0.002	-0.013	-0.076	-0.068	-0.019	-0.032	-0.089	-0.012
13 INDIANA	-0.013	-0.002	-0.009	0.002	-0.034	-0.010	-0.073	-0.012	-0.011
14 IOWA	-0.006	-0.001	-0.002	-0.012	-0.008	-0.003	-0.002	-0.028	-0.000
15 KANSAS	-0.001	-0.000	-0.000	-0.044	-0.006	-0.004	-0.002	0.001	0.000
16 KENTUCKY	-0.010	-0.001	-0.001	-0.000	-0.009	-0.003	-0.024	-0.004	-0.002
17 LOUISIANA	0.227	-0.041	0.219	0.001	0.333	0.016	0.005	-0.035	0.081
18 MAINE	-0.003	-0.001	-0.001	-0.000	-0.002	-0.000	0.000	0.009	-0.007
19 MARYLAND	-0.010	-0.001	0.002	-0.000	0.001	0.000	0.001	0.007	-0.014
20 MASSACHUSETTS	-0.001	-0.016	0.005	0.002	-0.001	0.000	-0.001	0.002	-0.001
21 MICHIGAN	-0.012	-0.000	-0.002	-0.022	-0.008	-0.003	0.008	0.001	-0.010
22 MINNESOTA	-0.002	-0.001	0.001	-0.021	0.000	-0.000	0.006	-0.000	0.002
23 MISSISSIPPI	-0.002	-0.000	-0.000	-0.003	-0.007	-0.006	-0.003	-0.000	0.002
24 MISSOURI	-0.002	0.002	0.000	0.016	-0.014	-0.009	0.003	0.023	0.001
25 MONTANA	-0.000	-0.000	-0.001	-0.019	-0.000	-0.000	-0.018	-0.001	-0.001
26 NEBRASKA	-0.003	-0.000	-0.004	-0.006	-0.004	-0.003	-0.004	-0.005	-0.002
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	-0.001	0.003	-0.001	0.020	0.000	-0.000	-0.000	0.052	-0.002
29 NEW JERSEY	0.000	-0.004	0.028	0.014	0.001	0.003	0.004	0.074	0.016
30 NEW MEXICO	0.000	0.002	0.0	0.006	0.001	0.000	0.000	0.030	0.0
31 NEW YORK	-0.005	-0.009	0.008	0.016	0.007	0.003	-0.003	0.096	0.008
32 NORTH CAROLINA	-0.007	-0.000	-0.056	-0.001	-0.004	-0.001	-0.001	0.001	-0.034
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	37 PENNSYL-VANIA	38 RHODE ISLAND	39 SOUTH CAROLINA	40 SOUTH DAKOTA	41 TENNESSEE	42 TEXAS	43 UTAH	44 VERMONT	45 VIRGINIA
34 OHIO	-0.042	-0.005	0.020	-0.013	-0.010	0.013	-0.044	-0.062	-0.015
35 OKLAHOMA	-0.000	-0.000	0.000	0.008	0.007	0.016	0.011	-0.000	-0.000
36 OREGON	0.003	-0.003	0.015	-0.027	0.006	0.005	-0.125	0.007	0.023
37 PENNSYLVANIA	-0.046	-0.006	0.044	-0.013	0.014	0.002	0.014	-0.022	0.013
38 RHODE ISLAND	-0.000	0.000	0.001	0.000	-0.000	-0.000	0.000	-0.000	-0.000
39 SOUTH CAROLINA	-0.004	-0.001	-0.049	0.000	-0.006	-0.001	-0.001	-0.002	-0.011
40 SOUTH DAKOTA	-0.000	0.000	0.000	0.014	0.000	-0.000	0.001	0.0	0.0
41 TENNESSEE	-0.004	-0.001	-0.033	-0.004	-0.035	-0.004	-0.001	-0.001	-0.013
42 TEXAS	0.015	0.095	-0.144	-0.008	-0.089	0.028	-0.009	-0.012	0.087
43 UTAH	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
44 VERMONT	0.000	0.000	0.000	0.0	0.000	0.000	0.0	0.001	0.000
45 VIRGINIA	-0.008	-0.002	-0.001	-0.019	-0.001	-0.001	-0.003	-0.011	-0.062
46 WASHINGTON	0.004	-0.001	0.001	-0.015	0.004	-0.000	0.050	-0.004	0.005
47 WEST VIRGINIA	-0.007	-0.001	-0.006	-0.002	-0.006	-0.001	-0.009	-0.000	-0.019
48 WISCONSIN	-0.005	-0.001	0.001	-0.034	-0.004	-0.005	0.000	-0.013	-0.001
49 WYOMING	0.0	0.0	0.0	0.260	0.0	0.0	0.018	0.0	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	46 WASHINGTON	47 WEST VIRGINIA	48 WISCONSIN	49 WYOMING	50 ALASKA	51 HAWAII
1 ALABAMA	-0.000	-0.008	0.031	-0.017	-0.003	0.008
2 ARIZONA	-0.001	0.000	0.000	-0.001	0.0	0.0
3 ARKANSAS	0.008	-0.000	0.001	-0.009	-0.075	0.000
4 CALIFORNIA	0.359	0.000	0.021	-0.100	0.465	-0.055
5 COLORADO	-0.001	0.000	0.000	0.003	-0.000	0.001
6 CONNECTICUT	0.001	-0.000	0.003	-0.007	0.000	0.000
7 DELAWARE	-0.000	-0.001	0.000	0.0	0.0	0.0
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	-0.003	-0.005	0.002	0.004	-0.000	-0.002
10 GEORGIA	-0.001	-0.008	-0.003	-0.022	-0.028	-0.011
11 IDAHO	0.017	-0.000	0.004	-0.102	-0.016	0.000
12 ILLINOIS	-0.021	-0.071	-0.056	-0.010	-0.030	0.002
13 INDIANA	0.001	-0.015	-0.188	-0.021	-0.037	0.003
14 IOWA	-0.003	-0.003	-0.033	-0.010	-0.000	0.001
15 KANSAS	-0.000	-0.001	0.002	-0.003	-0.012	-0.000
16 KENTUCKY	-0.002	-0.017	-0.001	-0.006	-0.015	-0.003
17 LOUISIANA	0.016	0.642	0.012	-0.006	-0.001	0.000
18 MAINE	-0.000	-0.001	0.005	-0.007	0.000	-0.001
19 MARYLAND	-0.000	-0.009	0.000	-0.000	-0.002	-0.000
20 MASSACHUSETTS	0.002	0.000	0.009	-0.001	-0.001	-0.002
21 MICHIGAN	-0.005	-0.011	-0.007	0.001	-0.007	0.001
22 MINNESOTA	-0.001	-0.007	-0.008	-0.002	-0.004	0.000
23 MISSISSIPPI	-0.001	-0.003	-0.004	-0.000	-0.001	-0.000
24 MISSOURI	-0.006	0.000	0.005	-0.015	-0.026	-0.006
25 MONTANA	-0.003	-0.000	-0.002	-0.010	-0.023	0.0
26 NEBRASKA	-0.004	-0.003	-0.005	-0.000	-0.000	-0.015
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.003
28 NEW HAMPSHIRE	0.000	-0.000	0.000	0.000	-0.003	0.0
29 NEW JERSEY	0.002	-0.026	0.006	-0.016	-0.006	0.015
30 NEW MEXICO	0.003	0.000	0.000	0.0	0.0	0.001
31 NEW YORK	0.002	-0.000	0.019	-0.021	0.002	-0.003
32 NORTH CAROLINA	0.000	-0.010	0.005	-0.029	-0.004	-0.000
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.1

AGGREGATE TRADE-COEFFICIENT DIFFERENCES
1967 TO 1972

	46 WASHINGTON	47 WEST VIRGINIA	48 WISCONSIN	49 WYOMING	50 ALASKA	51 HAWAII
34 OHIO	-0.011	-0.112	0.101	-0.085	-0.022	-0.007
35 OKLAHOMA	0.000	-0.000	0.008	-0.005	0.002	0.000
36 OREGON	-0.030	0.001	0.008	0.064	-0.018	-0.121
37 PENNSYLVANIA	0.000	-0.102	0.052	-0.058	0.125	-0.002
38 RHODE ISLAND	-0.000	-0.000	0.000	0.000	0.000	-0.000
39 SOUTH CAROLINA	-0.000	-0.008	0.000	0.001	-0.000	-0.000
40 SOUTH DAKOTA	-0.000	0.0	-0.001	0.001	0.003	0.0
41 TENNESSEE	-0.012	-0.008	-0.003	-0.004	-0.004	0.001
42 TEXAS	-0.008	-0.101	0.014	-0.043	-0.225	0.212
43 UTAH	-0.000	-0.000	-0.000	-0.000	0.0	0.0
44 VERMONT	0.000	0.000	0.000	0.0	0.0	0.0
45 VIRGINIA	-0.000	-0.009	0.002	-0.001	-0.000	0.002
46 WASHINGTON	-0.302	-0.000	0.055	-0.037	-0.035	-0.014
47 WEST VIRGINIA	-0.000	-0.093	0.001	-0.000	0.001	0.000
48 WISCONSIN	-0.002	-0.010	-0.063	-0.009	0.004	-0.006
49 WYOMING	0.007	0.0	0.006	0.586	0.0	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	1 ALABAMA	2 ARIZONA	3 ARKANSAS	4 CALIFORNIA	5 COLORADO	6 CONNECTICUT	7 DELAWARE	8 DISTRICT OF COLUMBIA	9 FLORIDA
1 ALABAMA	-44	70	54	24	51	-157	55	0	-104
2 ARIZONA	-271	-442	-574	-79	-147218	-4866.	100	0	-9496
3 ARKANSAS	-334	63	22	-9	74	-120	49	0	-98
4 CALIFORNIA	27	25	9	11	39	-115	91	0	-18
5 COLORADO	24	15	46	38	-17	-91	0	0	65
6 CONNECTICUT	22	-60	46	-73	-118	-151	87	0	-26
7 DELAWARE	-355	-22711	82	-98	-4034	-649	43	-249436	-67
8 DISTRICT OF COLUMBIA	0	0	0	0	0	0	0	0	0
9 FLORIDA	-243	78	27	-41	-98	-61	66	0	-1701
10 GEORGIA	-73	-55	-11	-236	-722	-566	56	0	-447
11 IDAHO	-73	-15	0	-5	72	-268	100	0	-140
12 ILLINOIS	-294	-22	-83	-306	-56	-469	45	0	-195
13 INDIANA	-219	-1	-332	-229	-86	-1459	65	0	-189
14 IOWA	-91	-66	-71	-462	-84	-338	-64	0	-213
15 KANSAS	-129	-160	-66	-410	14	-231	100	0	-13
16 KENTUCKY	-441	-783	-32	-394	-482	-610	49	0	-190
17 LOUISIANA	51	-24	-92	-2	-136	1	61	0	64
18 MAINE	2	100	98	-268	98	-127	74	0	-3103
19 MARYLAND	68	-104	-184	-21.	40	-179	79	0	-27
20 MASSACHUSETTS	38	40	48	23	66	-181	93	0	-6
21 MICHIGAN	-91	32	-76	-361	-7	-87	72	0	-143
22 MINNESOTA	7	32	13	-471	2	-218	34	0	-58
23 MISSISSIPPI	-230	-1037	-293	-3017	-501	-308	39	0	-422
24 MISSOURI	7	1	-34	-380	-170	-251	-102	100	-57
25 MONTANA	0	0	0	0	0	0	0	0	0
26 NEBRASKA	-1333	-145	22	-832	-56	-720	0	0	-772
27 NEVADA	0	0	0	0	0	0	0	0	0
28 NEW HAMPSHIRE	77	100	70	-192	100	-130	55	91	92
29 NEW JERSEY	9	79	-24	-33	-87	-165	83	0	-74
30 NEW MEXICO	100	100	100	100	100	100	0	100	100
31 NEW YORK	40	69	65	-9	47	-146	91	76	-40
32 NORTH CAROLINA	-196	-93	-612	-122	34	-357	14	0	-252
33 NORTH DAKOTA	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	1 ALABAMA	2 ARIZONA	3 ARKANSAS	4 CALIFORNIA	5 COLORADO	6 CONNECTICUT	7 DELAWARE	8 DISTRICT OF COLUMBIA	9 FLORIDA
34 OHIO	48	33	40	-260	-38	-88	84	0	-57
35 OKLAHOMA	82	65	57	-1	17	57	100	0	-283
36 OREGON	71	-61	60	-44	-130	-142	83	0	20
37 PENNSYLVANIA	2	39	9	8	-12	-47	-19	0	-36
38 RHODE ISLAND	49	-190	94	-50	38	-17	99	0	-95
39 SOUTH CAROLINA	-73	92	-141	-326	-466	-370	53	0	-207
40 SOUTH DAKOTA	64	-163	0	46	-11	77	100	0	61
41 TENNESSEE	-98	-247	37	-308	-8	-581	-30	0	-252
42 TEXAS	7	-673	26	68	30	62	-1522	0	-5
43 UTAH	0	0	0	0	0	0	0	0	0
44 VERMONT	100	100	100	100	100	100	0	0	0
45 VIRGINIA	-90	-170	-55	-371	78	-380	81	0	-225
46 WASHINGTON	22	-31	-87	-107	-26	-64	71	0	-288
47 WEST VIRGINIA	-1301	0	-59	-427	-857	-369	55	0	-1388
48 WISCONSIN	28	-2	-3	-107	9	-124	87	0	-122
49 WYOMING	0	0	0	100	100	100	0	0	0
50 ALASKA	0	0	0	0	0	0	0	0	0
51 HAWAII	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	10 GEORGIA	11 IDAHO	12 ILLINOIS	13 INDIANA	14 IOWA	15 KANSAS	16 KENTUCKY	17 LOUISIANA	18 MAINE
1 ALABAMA	-2	14	64	65	72	56	42	-28	-4
2 ARIZONA	-78	0	-187	-268	100	-196	-145	-1488	0
3 ARKANSAS	46	82	54	49	82	7	49	-186	-1305
4 CALIFORNIA	68	25	63	74	48	51	73	67	-123
5 COLORADO	-15	68	74	14	50	32	-444	-133	93
6 CONNECTICUT	60	-516	69	70	60	-19	54	75	-947
7 DELAWARE	-43	-3003	23	70	-180	85	-357	-170	-1185
8 DISTRICT OF COLUMBIA	0	0	0	0	0	0	0	0	0
9 FLORIDA	-95	-1653820	-81	-61	-18	32	22	-27	-76
10 GEORGIA	-493	-9567	-53	-124	-31	-147	-60	-65	-604
11 IDAHO	-25	-24	65	67	52	59	-138	55	-103
12 ILLINOIS	-120	14	-287	-226	-83	-24	-125	-234	-1912
13 INDIANA	-304	42	-496	-530	-224	-54	-291	-111	-2325
14 IOWA	-115	-2188	-400	-25	-217	-28	5	-33	-797
15 KANSAS	4	57	-42	56	18	-520	-12	-54	-2214
16 KENTUCKY	-219	-263	-160	-204	27	9	-204	-41	-230
17 LOUISIANA	-93	0	51	65	52	-4	-419	7	82
18 MAINE	26	-251	44	36	24	-329	-51	56	-1986
19 MARYLAND	42	0	58	46	3	85	52	-103	-30
20 MASSACHUSETTS	37	78	66	40	73	54	70	61	-188
21 MICHIGAN	-52	60	-97	-116	-4	-19	-76	-82	-600
22 MINNESOTA	22	-31	-52	-133	11	40	-115	15	-299
23 MISSISSIPPI	-138	-70	-65	47	-74	-371	-94	-1444	-272358
24 MISSOURI	-27	78	-148	-39	-29	-224	-124	-21	-19
25 MONTANA	0	0	0	0	0	0	0	0	0
26 NEBRASKA	-204	-1156	-834	-286	-119	-45	-666	-1701	-2516
27 NEVADA	0	0	0	0	0	0	0	0	0
28 NEW HAMPSHIRE	-8	100	20	-467	-1153	100	98	70	-1120
29 NEW JERSEY	31	-21	60	63	61	82	-41	9	-380
30 NEW MEXICO	0	100	100	100	100	100	100	100	100
31 NEW YORK	52	70	76	64	61	79	71	64	-7
32 NORTH CAROLINA	-60	-50	4	-12	29	67	51	46	-982
33 NORTH DAKOTA	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	10 GEORGIA	11 IDAHO	12 ILLINOIS	13 INDIANA	14 IOWA	15 KANSAS	16 KENTUCKY	17 LOUISIANA	18 MAINE
34 OHIO	27	-54	55	42	59	42	39	54	-1665
35 OKLAHOMA	80	-1528	90	58	72	43	99	83	0
36 OREGON	64	42	68	71	29	43	36	47	-66
37 PENNSYLVANIA	59	-69	64	70	80	88	30	51	-335
38 RHODE ISLAND	70	74	61	91	75	78	58	-128	-242
39 SOUTH CAROLINA	-145	77	-76	-137	-208	19	17	26	-1294
40 SOUTH DAKOTA	0	0	23	66	71	82	0	41	-94
41 TENNESSEE	-54	-903	-201	-300	-62	-60	-227	-174	-828
42 TEXAS	59	-598	50	-128	43	11	67	15	29
43 UTAH	0	0	0	0	0	0	0	0	0
44 VERMONT	100	0	100	100	100	0	100	100	100
45 VIRGINIA	-9	-121	9	15	-215	-295	-26	-522	-63
46 WASHINGTON	47	-38	69	52	33	38	2	-72	17
47 WEST VIRGINIA	-238	0	-156	-102	-56	60	-185	-64	-3
48 WISCONSIN	-10	-41	-40	-20	-8	47	-2	31	-311
49 WYOMING	0	100	100	100	100	0	0	100	0
50 ALASKA	0	0	0	0	0	0	0	0	0
51 HAWAII	0	0	0	0	0	0	0	0	C

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	19 MARYLAND	20 MASSA-CHUSETTS	21 MICHIGAN	22 MINNESOTA	23 MISSISSIPPI	24 MISSOURI	25 MONTANA	26 NEBRASKA	27 NEVADA
1 ALABAMA	54	40	46	75	-37	48	90	74	13
2 ARIZONA	-1641	-272	-168	-773	-300552	-33321	0	0	15
3 ARKANSAS	-74	72	43	-31	6	-1	85	55	0
4 CALIFORNIA	66	36	63	70	86	60	40	76	4
5 COLORADO	27	-1	78	-42	57	24	-60	74	74
6 CONNECTICUT	14	43	38	76	42	92	-47	-139	-84
7 DELAWARE	-473	-173	-88	-41	83	-186	100	-253	100
8 DISTRICT OF COLUMBIA	0	0	0	0	0	0	0	0	0
9 FLORIDA	-57	5	-37	-4	-95	-25	-411	-48	73
10 GEORGIA	-63	-169	-93	-23	-31	-82	-149	-142	85
11 IDAHO	84	-88	35	90	100	-545	-3172	22	-92
12 ILLINOIS	-93	-81	-154	-4	-10	-116	-3	-29	-44
13 INDIANA	-219	-27	-770	-268	-5	-178	-814	-60	71
14 IOWA	-29	-226	-105	-184	-61	6	91	-151	-940
15 KANSAS	-171	-101	-35	-51	-8	-514	-3	-71	-1843
16 KENTUCKY	-284	12	-177	-117	23	-115	-111	-309	-176
17 LOUISIANA	-149	-331	6	-91	-14	-24	99	-145	35
18 MAINE	14	1	53	-44	-207	35	52	-582	0
19 MARYLAND	-232	-70	36	30	-690	62	-1202	31	54
20 MASSACHUSETTS	0	22	64	58	84	45	-16	73	-61
21 MICHIGAN	-49	-34	-513	7	62	-161	-10	3	50
22 MINNESOTA	-56	2	-64	-139	84	-51	-124	-74	-633
23 MISSISSIPPI	-86	-2373	-222	-245	-125	-533	-9015	-15614	0
24 MISSOURI	21	52	28	31	51	-373	-133	-186	52
25 MONTANA	0	0	0	0	0	0	0	0	0
26 NEBRASKA	-419	-275	-142	-241	-980	-264	-2	-519	-464
27 NEVADA	0	0	0	0	0	0	0	0	0
28 NEW HAMPSHIRE	59	-102	-94	-387	52	99	100	-19316	100
29 NEW JERSEY	37	-61	35	49	47	35	11	72	98
30 NEW MEXICO	100	100	100	100	100	100	100	0	100
31 NEW YORK	33	18	78	81	85	68	57	47	16
32 NORTH CAROLINA	-47	2	35	65	54	59	77	-57	-638
33 NORTH DAKOTA	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	19 MARYLAND	20 MASSA-CHUSETTS	21 MICHIGAN	22 MINNESOTA	23 MISSISSIPPI	24 MISSOURI	25 MONTANA	26 NEBRASKA	27 NEVADA
34 OHIO	2	29	54	43	44	45	-158	36	-119
35 OKLAHOMA	-9199	73	39	79	82	71	88	74	85
36 OREGON	91	51	56	48	73	63	-43	60	-139
37 PENNSYLVANIA	14	33	54	61	61	45	51	58	33
38 RHODE ISLAND	82	-50	36	55	73	49	-8	-119	94
39 SOUTH CAROLINA	-148	-40	-151	-7	-47	-20	80	-27	70
40 SOUTH DAKOTA	49	-133	-1	76	0	59	-5	55	100
41 TENNESSEE	-119	-54	-236	6	-39	-31	-3418	-21	-540
42 TEXAS	-86	3	28	-10	5	63	-81	44	-197
43 UTAH	0	0	0	0	0	0	0	0	0
44 VERMONT	100	100	100	100	100	100	0	100	0
45 VIRGINIA	-48	-82	-65	33	53	39	-6	-40	34
46 WASHINGTON	9	23	69	43	46	14	-49	25	13
47 WEST VIRGINIA	-595	-151	-339	-586	33	-60	0	73	-9047
48 WISCONSIN	36	12	-70	12	25	-3	-139	18	-68
49 WYOMING	0	100	0	100	0	100	100	100	0
50 ALASKA	0	0	0	0	0	0	0	0	0
51 HAWAII	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	28 NEW HAMPSHIRE	29 NEW JERSEY	30 NEW MEXICO	31 NEW YORK	32 NORTH CAROLINA	33 NORTH DAKOTA	34 OHIO	35 OKLAHOMA	36 OREGON
1 ALABAMA	-341	45	86	16	-116	-772	23	35	-8
2 ARIZONA	-1806	-741	-1543	9	-4677	0	-513	-753	-2658
3 ARKANSAS	-575	-87	-12	29	-35	-293	-31	-40	50
4 CALIFORNIA	-1395	39	27	29	-12	46	61	-6	63
5 COLORADO	-473450	44	-215	33	91	-1007	-234	21	-488
6 CONNECTICUT	-1691	-77	-8	-55	-6	58	-2	16	29
7 DELAWARE	-1751	-790	100	-540	-358	100	-66	-1763005	-3072757
8 DISTRICT OF COLUMBIA	0	0	0	0	0	0	0	0	0
9 FLORIDA	-442	-83	5	-90	-109	-1	-168	-47	-118
10 GEORGIA	-1386	-298	-1214	-152	-201	-43	-156	-205	-402
11 IDAHO	0	-334	-239	63	-90	78	15	-31	-12
12 ILLINOIS	-4738	-367	-373	-290	-160	-49	-322	-150	-7
13 INDIANA	-1932	-442	-881	-583	-271	-379	-640	-455	-546
14 IOWA	-2250	-338	-28	-532	-15	-4	-315	-9	-209
15 KANSAS	-1744	-207	-356	-1367	-809	48	-37	-533	95
16 KENTUCKY	-4960	-394	-41	-153	-150	39	-587	-343	-153
17 LOUISIANA	-464	-7	-8	-19	62	-234	-261	-73	66
18 MAINE	-11035	-20	0	-15	-8	0	30	-3058	-22
19 MARYLAND	-140	-311	-3376	-278	-30	-663	-37	-58	-37
20 MASSACHUSETTS	-899	-22	-275	5	27	-96	29	43	58
21 MICHIGAN	-287	-390	-28	-679	-20	3	-470	-328	-8
22 MINNESOTA	-553	-219	-82	-227	-164	-51	-219	-39	-16
23 MISSISSIPPI	-348	-1927	-185	-362	13	0	-143	-1477	-54501
24 MISSOURI	-199	-81	-30	10	-32	62	-193	-123	17
25 MONTANA	0	0	0	0	0	0	0	0	0
26 NEBRASKA	0	-1271	-396	-792	-357	-198	-676	-151	0
27 NEVADA	0	0	0	0	0	0	0	0	0
28 NEW HAMPSHIRE	-121	-400	100	42	-14	100	-262	89	100
29 NEW JERSEY	-309	-124	-140	-22	3	-92	17	11	-4
30 NEW MEXICO	100	0	100	100	100	100	100	100	100
31 NEW YORK	-280	-40	50	-35	24	28	54	9	64
32 NORTH CAROLINA	-807	-300	-200	-41	-205	74	-92	-44	30
33 NORTH DAKOTA	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	28 NEW HAMPSHIRE	29 NEW JERSEY	30 NEW MEXICO	31 NEW YORK	32 NORTH CAROLINA	33 NORTH DAKOTA	34 OHIO	35 OKLAHOMA	36 OREGON
34 OHIO	-929	-39	-217	10	10	-30	34	14	-127
35 OKLAHOMA	0	95	45	-46	-3478	91	78	54	-113
36 OREGON	-415	30	-106	38	52	36	40	5	-38
37 PENNSYLVANIA	-492	-17	-169	1	45	63	52	26	-74
38 RHODE ISLAND	-276	3	-26	34	6	-27	-56	69	77
39 SOUTH CAROLINA	-1931	-499	-4	-166	-147	98	-351	-215	87
40 SOUTH DAKOTA	0	-2326	100	-536	87	95	-138	0	100
41 TENNESSEE	-3532	-520	-12	-376	-210	42	-492	-269	-240
42 TEXAS	99	57	4	66	81	-259	-166	-75	-98
43 UTAH	0	0	0	0	0	0	0	0	0
44 VERMONT	100	100	0	100	100	100	100	0	100
45 VIRGINIA	-2081	-293	36	-172	-112	-1207	-117	-146	36
46 WASHINGTON	-330	-74	24	-32	-44	36	-46	-121	-49
47 WEST VIRGINIA	-805	-474	-520	-387	-550	-1081	-439	-746	-470
48 WISCONSIN	-431	-172	-388	-100	16	15	-104	78	-82
49 WYOMING	0	0	0	0	0	100	100	0	100
50 ALASKA	0	0	0	0	0	0	0	0	0
51 HAWAII	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	37 PENNSYL-VANIA	38 RHODE ISLAND	39 SOUTH CAROLINA	40 SOUTH DAKOTA	41 TENNESSEE	42 TEXAS	43 UTAH	44 VERMONT	45 VIRGINIA
1 ALABAMA	43	72	19	-324	-37	-3	-17	-25	-13
2 ARIZONA	-8243	0	0	0	-114	-43	-67	100	-481
3 ARKANSAS	-99	-2464	19	-888	-406	-93	71	-97	-462
4 CALIFORNIA	28	-31	55	27	42	29	45	25	54
5 COLORADO	46	-270	70	-562	-419	-316	7	-7	-575
6 CONNECTICUT	-78	23	-86	86	-29	5	64	-162	25
7 DELAWARE	-517	-725	-68	100	-350	-28	38	-725578	-39
8 DISTRICT OF COLUMBIA	0	0	0	0	0	0	0	0	0
9 FLORIDA	-184	17	-49	30	-182	-140	-53	33	-134
10 GEORGIA	-185	-79	-57	-559	-132	-428	-7	25	-127
11 IDAHO	3	0	-348	55	-196	-417	71	0	78
12 ILLINOIS	-571	-111	-67	-71	-309	-163	-78	-285	-68
13 INDIANA	-465	-328	-117	11	-426	-298	-773	-102	-220
14 IOWA	-304	-188	-38	-16	-224	-140	-38	-2125	-8
15 KANSAS	-108	-6	-6	-126	-963	-166	-327	33	21
16 KENTUCKY	-1175	-1112	-22	-9	-279	-338	-1383	-65	-35
17 LOUISIANA	90	-2400	72	24	57	18	92	0	65
18 MAINE	-49	-169	-63	-1493	-332	-35	44	17	-869
19 MARYLAND	-299	-40	33	-284	42	11	99	81	-126
20 MASSACHUSETTS	-8	-112	44	73	-38	8	-36	3	-11
21 MICHIGAN	-287	-16	-25	-175	-113	-72	46	6	-77
22 MINNESOTA	-142	-150	56	-20	1	-24	55	-2	40
23 MISSISSIPPI	-901	-114736	-9	-32136	-111	-871	0	0	52
24 MISSOURI	-80	91	10	37	-202	-244	27	97	24
25 MONTANA	0	0	0	0	0	0	0	0	0
26 NEBRASKA	-1174	-501	-931	-66	-1315	-647	-298	-649	-9572
27 NEVADA	0	0	0	0	0	0	0	0	0
28 NEW HAMPSHIRE	-323	92	-1062	100	84	-19	-79	94	-1836
29 NEW JERSEY	0	-28	75	78	23	27	49	71	23
30 NEW MEXICO	100	100	0	100	100	100	100	100	0
31 NEW YORK	-10	-45	42	86	52	43	-16	28	25
32 NORTH CAROLINA	-162	-3	-105	-86	-51	-35	-67	17	-103
33 NORTH DAKOTA	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	37 PENNSYL-VANIA	38 RHODE ISLAND	39 SOUTH CAROLINA	40 SOUTH DAKOTA	41 TENNESSEE	42 TEXAS	43 UTAH	44 VERMONT	45 VIRGINIA
34 OHIO	-48	-77	33	-55	-23	35	-115	-202	-32
35 OKLAHOMA	-249	-1798	65	42	91	74	70	0	-59
36 OREGON	41	-174	66	-54	40	34	-180	30	76
37 PENNSYLVANIA	-13	-37	58	-203	28	10	46	-24	10
38 RHODE ISLAND	-92	19	54	79	-183	-19	53	-108	-1
39 SOUTH CAROLINA	-250	-43	-86	38	-171	-126	-457	-226	-150
40 SOUTH DAKOTA	-45	55	47	37	88	-112	65	0	0
41 TENNESSEE	-697	-243	-244	-309	-417	-406	-17	-76	-282
42 TEXAS	30	11	-161	-48	-108	4	-36	-33403	26
43 UTAH	0	0	0	0	0	0	0	0	0
44 VERMONT	100	100	100	0	100	100	0	100	100
45 VIRGINIA	-216	-56	-3	-8123	-35	-115	-389	-597	-210
46 WASHINGTON	34	-142	16	-85	35	-10	46	-111804	26
47 WEST VIRGINIA	-743	-109	-232	0	-283	-148	-523	-10851	-296
48 WISCONSIN	-118	-70	12	-87	-55	-125	2	-66	-18
49 WYOMING	0	0	0	100	0	0	100	0	0
50 ALASKA	0	0	0	0	0	0	0	0	0
51 HAWAII	0	0	0	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	46 WASHINGTON	47 WEST VIRGINIA	48 WISCONSIN	49 WYOMING	50 ALASKA	51 HAWAII
1 ALABAMA	-15	-429	79	-21622	0	82
2 ARIZONA	-1359	100	87	0	0	0
3 ARKANSAS	89	-41	23	-5426	0	41
4 CALIFORNIA	67	5	60	-164	80	-9
5 COLORADO	-410	56	35	20	0	99
6 CONNECTICUT	59	-130	51	-23278	78	15
7 DELAWARE	-1142	-625	22	0	0	0
8 DISTRICT OF COLUMBIA	0	0	0	0	0	0
9 FLORIDA	-161	-186	24	100	-221	-4525
10 GEORGIA	-149	-883	-41	-1988	-19957	-2099
11 IDAHO	93	-254	95	-15423	0	100
12 ILLINOIS	-182	-849	-40	-24	-1438	10
13 INDIANA	21	-360	-442	-198	-18413	71
14 IOWA	-113	-863	-163	-477	-12	97
15 KANSAS	-41	-25651	47	-332	-1405507	-178
16 KENTUCKY	-640	-964	-22	-872	-30509	-4190
17 LOUISIANA	85	93	44	-96	-13	21
18 MAINE	-1031	-126	67	-38115	100	0
19 MARYLAND	-47	-558	30	-39	0	-75
20 MASSACHUSETTS	62	24	84	-541	-262	-305
21 MICHIGAN	-131	-150	-13	14	-163	35
22 MINNESOTA	-28	-633	-19	-142	-1757	13
23 MISSISSIPPI	-601	-4005	-189	0	0	0
24 MISSOURI	-249	1	42	-172	-474	-287
25 MONTANA	0	0	0	0	0	0
26 NEBRASKA	-1997	-1985	-339	-4	-2785	-745
27 NEVADA	0	0	0	0	0	100
28 NEW HAMPSHIRE	100	-547	87	100	-18422	0
29 NEW JERSEY	43	-385	46	-2137	-745	71
30 NEW MEXICO	100	100	100	0	0	100
31 NEW YORK	34	0	72	-945	46	-192
32 NORTH CAROLINA	29	-608	61	-5578	-13485	-8
33 NORTH DAKOTA	0	0	0	0	0	0

TABLE F.2

PERCENTAGE CHANGES IN AGGREGATE TRADE COEFFICIENTS
1967 TO 1972

	46 WASHINGTON	47 WEST VIRGINIA	48 WISCONSIN	49 WYOMING	50 ALASKA	51 HAWAII
34 OHIO	-118	-108	67	-643	-132	-109
35 OKLAHOMA	72	-333	83	-52	76	100
36 OREGON	-27	19	27	90	-68	-928
37 PENNSYLVANIA	1	-102	58	-229	87	-46
38 RHODE ISLAND	-124	-200	13	98	41	-637
39 SOUTH CAROLINA	-124	-1585	12	76	-916	-82
40 SOUTH DAKOTA	-152	0	-216	100	100	0
41 TENNESSEE	-3234	-885	-155	-754	-7201	92
42 TEXAS	-111	-364	45	-41	-3105	100
43 UTAH	0	0	0	0	0	0
44 VERMONT	100	100	100	0	0	0
45 VIRGINIA	-4	-324	58	-2082	0	37
46 WASHINGTON	-141	-6	86	-359	-19	-29
47 WEST VIRGINIA	-201	-2683	30	0	99	54
48 WISCONSIN	-53	-593	-66	-146	49	-1120
49 WYOMING	100	0	100	100	0	0
50 ALASKA	0	0	0	0	0	0
51 HAWAII	0	0	0	0	0	0

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	1 ALABAMA	2 ARIZONA	3 ARKANSAS	4 CALIFORNIA	5 COLORADO	6 CONNECTICUT	7 DELAWARE	8 DISTRICT OF COLUMBIA	9 FLORIDA
1 ALABAMA	0.166	0.001	0.064	0.004	0.009	0.002	0.003	0.0	0.014
2 ARIZONA	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.0	0.000
3 ARKANSAS	0.001	0.007	0.148	0.001	0.014	0.000	0.000	0.0	0.001
4 CALIFORNIA	0.010	0.762	0.021	0.758	0.135	0.004	0.003	0.0	0.006
5 COLORADO	0.000	0.007	0.000	0.003	0.044	0.000	0.0	0.0	0.000
6 CONNECTICUT	0.001	0.000	0.002	0.001	0.002	0.006	0.001	0.0	0.000
7 DELAWARE	0.000	0.000	0.001	0.000	0.000	0.000	0.006	0.000	0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	0.011	0.008	0.010	0.002	0.005	0.002	0.003	0.0	0.009
10 GEORGIA	0.025	0.002	0.014	0.001	0.005	0.002	0.003	0.0	0.008
11 IDAHO	0.001	0.002	0.0	0.002	0.010	0.000	0.001	0.0	0.000
12 ILLINOIS	0.017	0.015	0.046	0.007	0.057	0.004	0.015	0.0	0.006
13 INDIANA	0.007	0.004	0.010	0.003	0.016	0.001	0.012	0.0	0.002
14 IOWA	0.004	0.001	0.007	0.002	0.008	0.002	0.001	0.0	0.001
15 KANSAS	0.001	0.002	0.010	0.000	0.017	0.001	0.000	0.0	0.001
16 KENTUCKY	0.002	0.001	0.005	0.000	0.001	0.000	0.003	0.0	0.001
17 LOUISIANA	0.373	0.002	0.098	0.007	0.013	0.056	0.010	0.0	0.467
18 MAINE	0.002	0.004	0.002	0.000	0.005	0.005	0.003	0.0	0.000
19 MARYLAND	0.002	0.000	0.000	0.000	0.000	0.001	0.014	0.0	0.001
20 MASSACHUSETTS	0.003	0.001	0.003	0.003	0.005	0.017	0.008	0.0	0.001
21 MICHIGAN	0.003	0.006	0.008	0.003	0.016	0.003	0.048	0.0	0.002
22 MINNESOTA	0.003	0.002	0.005	0.001	0.012	0.001	0.000	0.0	0.001
23 MISSISSIPPI	0.011	0.000	0.005	0.000	0.001	0.000	0.000	0.0	0.002
24 MISSOURI	0.008	0.012	0.036	0.002	0.021	0.001	0.000	0.466	0.002
25 MONTANA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 NEBRASKA	0.000	0.002	0.002	0.000	0.008	0.000	0.0	0.0	0.000
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.001
29 NEW JERSEY	0.009	0.010	0.006	0.007	0.005	0.097	0.423	0.0	0.007
30 NEW MEXICO	0.000	0.000	0.008	0.000	0.003	0.000	0.0	0.255	0.001
31 NEW YORK	0.009	0.010	0.012	0.006	0.019	0.042	0.073	0.248	0.006
32 NORTH CAROLINA	0.004	0.001	0.004	0.001	0.005	0.002	0.003	0.0	0.002
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 OHIO	0.052	0.018	0.039	0.005	0.034	0.015	0.092	0.0	0.010

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	1 ALABAMA	2 ARIZONA	3 ARKANSAS	4 CALIFORNIA	5 COLORADO	6 CONNECTICUT	7 DELAWARE	8 DISTRICT OF COLUMBIA	9 FLORIDA
35 OKLAHOMA	0.005	0.003	0.073	0.000	0.034	0.000	0.000	0.0	0.000
36 OREGON	0.019	0.040	0.031	0.044	0.043	0.003	0.010	0.0	0.005
37 PENNSYLVANIA	0.047	0.012	0.050	0.014	0.022	0.058	0.196	0.0	0.012
38 RHODE ISLAND	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.0	0.000
39 SOUTH CAROLINA	0.004	0.001	0.002	0.001	0.001	0.001	0.003	0.0	0.001
40 SOUTH DAKOTA	0.000	0.000	0.0	0.000	0.000	0.000	0.000	0.0	0.000
41 TENNESSEE	0.010	0.000	0.022	0.001	0.004	0.000	0.002	0.0	0.001
42 TEXAS	0.172	0.026	0.240	0.087	0.281	0.663	0.038	0.0	0.424
43 UTAH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44 VERMONT	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
45 VIRGINIA	0.003	0.000	0.003	0.001	0.005	0.002	0.011	0.0	0.001
46 WASHINGTON	0.005	0.025	0.003	0.027	0.038	0.003	0.002	0.0	0.001
47 WEST VIRGINIA	0.000	0.0	0.002	0.000	0.000	0.001	0.005	0.0	0.000
48 WISCONSIN	0.009	0.007	0.008	0.003	0.020	0.003	0.005	0.0	0.003
49 WYOMING	0.0	0.0	0.0	0.000	0.082	0.000	0.0	0.0	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	10 GEORGIA	11 IDAHO	12 ILLINOIS	13 INDIANA	14 IOWA	15 KANSAS	16 KENTUCKY	17 LOUISIANA	18 MAINE
1 ALABAMA	0.067	0.000	0.026	0.024	0.023	0.026	0.059	0.018	0.003
2 ARIZONA	0.000	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.0
3 ARKANSAS	0.003	0.004	0.007	0.005	0.038	0.013	0.005	0.012	0.000
4 CALIFORNIA	0.024	0.201	0.041	0.031	0.025	0.077	0.013	0.013	0.003
5 COLORADO	0.000	0.004	0.005	0.000	0.002	0.007	0.000	0.001	0.000
6 CONNECTICUT	0.006	0.000	0.006	0.005	0.002	0.001	0.003	0.001	0.000
7 DELAWARE	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	0.014	0.000	0.006	0.008	0.017	0.012	0.012	0.004	0.003
10 GEORGIA	0.046	0.000	0.008	0.005	0.004	0.004	0.014	0.004	0.000
11 IDAHO	0.000	0.088	0.002	0.002	0.007	0.016	0.000	0.000	0.000
12 ILLINOIS	0.024	0.041	0.075	0.072	0.127	0.070	0.059	0.016	0.002
13 INDIANA	0.008	0.004	0.025	0.033	0.023	0.018	0.026	0.003	0.000
14 IOWA	0.005	0.000	0.008	0.004	0.072	0.011	0.004	0.004	0.002
15 KANSAS	0.002	0.001	0.002	0.001	0.013	0.039	0.001	0.002	0.000
16 KENTUCKY	0.003	0.001	0.004	0.005	0.003	0.004	0.018	0.002	0.000
17 LOUISIANA	0.035	0.004	0.142	0.136	0.050	0.032	0.024	0.402	0.372
18 MAINE	0.002	0.000	0.012	0.007	0.003	0.000	0.007	0.000	0.004
19 MARYLAND	0.005	0.0	0.002	0.002	0.001	0.001	0.002	0.000	0.002
20 MASSACHUSETTS	0.007	0.001	0.012	0.005	0.006	0.002	0.007	0.002	0.019
21 MICHIGAN	0.017	0.015	0.025	0.028	0.022	0.025	0.020	0.003	0.002
22 MINNESOTA	0.004	0.004	0.010	0.004	0.037	0.010	0.002	0.002	0.001
23 MISSISSIPPI	0.004	0.001	0.003	0.008	0.004	0.001	0.003	0.004	0.000
24 MISSOURI	0.006	0.025	0.011	0.009	0.023	0.035	0.014	0.007	0.001
25 MONTANA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 NEBRASKA	0.001	0.001	0.001	0.000	0.007	0.007	0.000	0.000	0.000
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.001
29 NEW JERSEY	0.021	0.003	0.025	0.021	0.012	0.022	0.012	0.004	0.017
30 NEW MEXICO	0.0	0.039	0.001	0.000	0.001	0.004	0.001	0.000	0.002
31 NEW YORK	0.026	0.026	0.049	0.033	0.019	0.016	0.031	0.007	0.032
32 NORTH CAROLINA	0.016	0.001	0.006	0.005	0.009	0.003	0.008	0.002	0.001
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 OHIO	0.071	0.018	0.146	0.255	0.090	0.064	0.197	0.026	0.004

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	10 GEORGIA	11 IDAHO	12 ILLINOIS	13 INDIANA	14 IOWA	15 KANSAS	16 KENTUCKY	17 LOUISIANA	18 MAINE
35 OKLAHOMA	0.002	0.000	0.021	0.003	0.026	0.104	0.004	0.010	0.0
36 OREGON	0.018	0.323	0.032	0.030	0.051	0.078	0.015	0.007	0.003
37 PENNSYLVANIA	0.061	0.005	0.106	0.192	0.099	0.085	0.150	0.039	0.020
38 RHODE ISLAND	0.002	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000
39 SOUTH CAROLINA	0.010	0.000	0.002	0.001	0.000	0.003	0.003	0.001	0.001
40 SOUTH DAKOTA	0.0	0.0	0.000	0.000	0.004	0.001	0.0	0.000	0.000
41 TENNESSEE	0.009	0.001	0.002	0.002	0.002	0.003	0.007	0.002	0.000
42 TEXAS	0.457	0.023	0.125	0.027	0.102	0.144	0.247	0.397	0.497
43 UTAH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44 VERMONT	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000
45 VIRGINIA	0.010	0.001	0.003	0.004	0.002	0.001	0.005	0.000	0.002
46 WASHINGTON	0.006	0.117	0.017	0.011	0.025	0.024	0.010	0.003	0.004
47 WEST VIRGINIA	0.001	0.0	0.001	0.002	0.001	0.003	0.004	0.001	0.001
48 WISCONSIN	0.008	0.017	0.029	0.017	0.047	0.031	0.012	0.003	0.001
49 WYOMING	0.0	0.025	0.000	0.001	0.002	0.0	0.0	0.000	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	19 MARYLAND	20 MASSA-CHUSETTS	21 MICHIGAN	22 MINNESOTA	23 MISSISSIPPI	24 MISSOURI	25 MONTANA	26 NEBRASKA	27 NEVADA
1 ALABAMA	0.012	0.007	0.015	0.028	0.043	0.031	0.000	0.016	0.000
2 ARIZONA	0.001	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.001
3 ARKANSAS	0.001	0.003	0.002	0.004	0.012	0.022	0.006	0.024	0.0
4 CALIFORNIA	0.015	0.014	0.020	0.053	0.034	0.046	0.231	0.057	0.717
5 COLORADO	0.001	0.000	0.001	0.001	0.001	0.002	0.001	0.012	0.008
6 CONNECTICUT	0.003	0.011	0.002	0.004	0.001	0.011	0.001	0.001	0.000
7 DELAWARE	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.001	0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	0.009	0.006	0.005	0.012	0.005	0.011	0.002	0.006	0.003
10 GEORGIA	0.009	0.006	0.005	0.005	0.016	0.007	0.001	0.005	0.013
11 IDAHO	0.000	0.000	0.003	0.008	0.000	0.001	0.002	0.003	0.001
12 ILLINOIS	0.020	0.011	0.038	0.134	0.037	0.084	0.052	0.112	0.024
13 INDIANA	0.011	0.004	0.018	0.030	0.010	0.025	0.006	0.027	0.011
14 IOWA	0.003	0.003	0.003	0.024	0.005	0.013	0.022	0.037	0.000
15 KANSAS	0.001	0.001	0.001	0.009	0.005	0.011	0.004	0.034	0.000
16 KENTUCKY	0.003	0.003	0.003	0.003	0.005	0.004	0.001	0.002	0.001
17 LOUISIANA	0.003	0.008	0.009	0.009	0.396	0.060	0.254	0.022	0.003
18 MAINE	0.008	0.015	0.003	0.001	0.000	0.002	0.000	0.001	0.0
19 MARYLAND	0.016	0.003	0.001	0.001	0.000	0.001	0.000	0.002	0.001
20 MASSACHUSETTS	0.010	0.091	0.007	0.008	0.004	0.007	0.000	0.003	0.000
21 MICHIGAN	0.013	0.007	0.044	0.040	0.013	0.026	0.008	0.024	0.006
22 MINNESOTA	0.004	0.003	0.006	0.093	0.002	0.006	0.023	0.016	0.000
23 MISSISSIPPI	0.002	0.000	0.002	0.001	0.046	0.002	0.000	0.000	0.0
24 MISSOURI	0.004	0.003	0.006	0.019	0.012	0.025	0.010	0.035	0.013
25 MONTANA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 NEBRASKA	0.001	0.001	0.001	0.004	0.000	0.002	0.006	0.014	0.004
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.001
29 NEW JERSEY	0.134	0.081	0.019	0.012	0.006	0.015	0.006	0.013	0.066
30 NEW MEXICO	0.003	0.002	0.000	0.002	0.004	0.000	0.000	0.0	0.007
31 NEW YORK	0.052	0.092	0.062	0.041	0.015	0.026	0.009	0.012	0.006
32 NORTH CAROLINA	0.011	0.008	0.004	0.006	0.008	0.007	0.001	0.003	0.000
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 OHIO	0.092	0.044	0.503	0.103	0.041	0.098	0.019	0.053	0.007

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	19 MARYLAND	20 MASSA-CHUSETTS	21 MICHIGAN	22 MINNESOTA	23 MISSISSIPPI	24 MISSOURI	25 MONTANA	26 NEBRASKA	27 NEVADA
35 OKLAHOMA	0.000	0.000	0.001	0.022	0.010	0.051	0.013	0.025	0.000
36 OREGON	0.119	0.011	0.018	0.084	0.017	0.041	0.057	0.100	0.056
37 PENNSYLVANIA	0.312	0.105	0.145	0.064	0.044	0.050	0.069	0.077	0.016
38 RHODE ISLAND	0.001	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.002
39 SOUTH CAROLINA	0.004	0.004	0.001	0.003	0.005	0.002	0.001	0.001	0.000
40 SOUTH DAKOTA	0.000	0.000	0.000	0.006	0.0	0.000	0.002	0.002	0.001
41 TENNESSEE	0.002	0.002	0.001	0.003	0.011	0.003	0.000	0.005	0.001
42 TEXAS	0.076	0.421	0.021	0.042	0.171	0.270	0.021	0.150	0.004
43 UTAH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44 VERMONT	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.000	0.0
45 VIRGINIA	0.018	0.005	0.002	0.003	0.003	0.004	0.001	0.002	0.001
46 WASHINGTON	0.008	0.009	0.016	0.033	0.004	0.011	0.131	0.018	0.019
47 WEST VIRGINIA	0.004	0.001	0.001	0.001	0.002	0.001	0.0	0.005	0.000
48 WISCONSIN	0.014	0.010	0.014	0.074	0.008	0.022	0.015	0.044	0.007
49 WYOMING	0.0	0.000	0.0	0.007	0.0	0.000	0.024	0.037	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	28 NEW HAMPSHIRE	29 NEW JERSEY	30 NEW MEXICO	31 NEW YORK	32 NORTH CAROLINA	33 NORTH DAKOTA	34 OHIO	35 OKLAHOMA	36 OREGON
1 ALABAMA	0.008	0.008	0.017	0.007	0.022	0.002	0.013	0.022	0.002
2 ARIZONA	0.000	0.000	0.000	0.000	0.000	0.0	0.000	0.000	0.000
3 ARKANSAS	0.000	0.000	0.003	0.001	0.002	0.002	0.002	0.014	0.002
4 CALIFORNIA	0.002	0.012	0.058	0.015	0.008	0.059	0.021	0.018	0.380
5 COLORADO	0.000	0.000	0.006	0.002	0.001	0.001	0.000	0.005	0.000
6 CONNECTICUT	0.001	0.002	0.000	0.004	0.004	0.001	0.002	0.002	0.001
7 DELAWARE	0.000	0.001	0.000	0.001	0.002	0.000	0.001	0.000	0.000
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	0.002	0.003	0.003	0.004	0.013	0.043	0.004	0.008	0.001
10 GEORGIA	0.001	0.003	0.000	0.004	0.029	0.002	0.004	0.004	0.001
11 IDAHO	0.0	0.000	0.000	0.001	0.000	0.005	0.001	0.001	0.002
12 ILLINOIS	0.001	0.006	0.005	0.010	0.017	0.113	0.019	0.026	0.017
13 INDIANA	0.001	0.002	0.001	0.002	0.005	0.027	0.008	0.005	0.002
14 IOWA	0.001	0.001	0.002	0.002	0.008	0.038	0.002	0.008	0.001
15 KANSAS	0.000	0.000	0.002	0.000	0.001	0.009	0.001	0.011	0.002
16 KENTUCKY	0.000	0.001	0.001	0.001	0.003	0.007	0.003	0.001	0.002
17 LOUISIANA	0.001	0.090	0.006	0.018	0.071	0.004	0.012	0.014	0.004
18 MAINE	0.001	0.003	0.0	0.008	0.001	0.0	0.007	0.000	0.000
19 MARYLAND	0.001	0.002	0.000	0.002	0.007	0.000	0.002	0.000	0.000
20 MASSACHUSETTS	0.022	0.007	0.000	0.017	0.008	0.001	0.005	0.001	0.002
21 MICHIGAN	0.003	0.004	0.003	0.006	0.011	0.016	0.016	0.003	0.004
22 MINNESOTA	0.001	0.001	0.000	0.002	0.002	0.116	0.002	0.001	0.003
23 MISSISSIPPI	0.000	0.000	0.001	0.000	0.008	0.0	0.002	0.000	0.000
24 MISSOURI	0.001	0.001	0.008	0.002	0.004	0.055	0.003	0.014	0.005
25 MONTANA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 NEBRASKA	0.0	0.000	0.001	0.000	0.001	0.006	0.000	0.002	0.0
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.001	0.000	0.002	0.002	0.000	0.005	0.000	0.000	0.002
29 NEW JERSEY	0.014	0.104	0.001	0.168	0.050	0.002	0.017	0.009	0.004
30 NEW MEXICO	0.006	0.0	0.018	0.001	0.000	0.111	0.000	0.000	0.007
31 NEW YORK	0.030	0.043	0.003	0.134	0.019	0.027	0.039	0.007	0.007
32 NORTH CAROLINA	0.001	0.003	0.001	0.006	0.066	0.005	0.004	0.002	0.001
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 OHIO	0.010	0.030	0.006	0.071	0.055	0.032	0.528	0.034	0.009

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	28 NEW HAMPSHIRE	29 NEW JERSEY	30 NEW MEXICO	31 NEW YORK	32 NORTH CAROLINA	33 NORTH DAKOTA	34 OHIO	35 OKLAHOMA	36 OREGON
35 OKLAHOMA	0.0	0.000	0.018	0.000	0.000	0.008	0.001	0.501	0.000
36 OREGON	0.004	0.007	0.010	0.012	0.023	0.049	0.013	0.025	0.404
37 PENNSYLVANIA	0.012	0.115	0.003	0.136	0.104	0.058	0.227	0.030	0.013
38 RHODE ISLAND	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000
39 SOUTH CAROLINA	0.001	0.001	0.000	0.002	0.025	0.001	0.001	0.001	0.000
40 SOUTH DAKOTA	0.0	0.000	0.000	0.000	0.001	0.006	0.000	0.0	0.000
41 TENNESSEE	0.000	0.001	0.001	0.001	0.012	0.001	0.001	0.003	0.000
42 TEXAS	0.868	0.538	0.811	0.338	0.369	0.019	0.024	0.167	0.010
43 UTAH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44 VERMONT	0.000	0.000	0.0	0.000	0.000	0.000	0.000	0.0	0.000
45 VIRGINIA	0.002	0.002	0.001	0.003	0.028	0.000	0.002	0.002	0.001
46 WASHINGTON	0.002	0.003	0.007	0.008	0.004	0.036	0.003	0.005	0.102
47 WEST VIRGINIA	0.000	0.001	0.000	0.001	0.003	0.000	0.002	0.001	0.000
48 WISCONSIN	0.003	0.002	0.001	0.006	0.010	0.072	0.007	0.054	0.004
49 WYOMING	0.0	0.0	0.0	0.0	0.0	0.063	0.000	0.0	0.003
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	37 PENNSYL-VANIA	38 RHODE ISLAND	39 SOUTH CAROLINA	40 SOUTH DAKOTA	41 TENNESSEE	42 TEXAS	43 UTAH	44 VERMONT	45 VIRGINIA
1 ALABAMA	0.011	0.002	0.051	0.004	0.042	0.011	0.008	0.008	0.020
2 ARIZONA	0.000	0.0	0.0	0.0	0.000	0.003	0.001	0.000	0.000
3 ARKANSAS	0.000	0.000	0.002	0.001	0.004	0.005	0.017	0.001	0.000
4 CALIFORNIA	0.012	0.002	0.022	0.022	0.019	0.032	0.487	0.014	0.015
5 COLORADO	0.001	0.000	0.000	0.000	0.000	0.001	0.006	0.000	0.000
6 CONNECTICUT	0.002	0.005	0.003	0.000	0.001	0.001	0.002	0.004	0.003
7 DELAWARE	0.001	0.000	0.002	0.000	0.001	0.000	0.001	0.000	0.002
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	0.003	0.001	0.010	0.018	0.006	0.003	0.007	0.004	0.004
10 GEORGIA	0.004	0.001	0.059	0.002	0.013	0.002	0.004	0.017	0.014
11 IDAHO	0.001	0.0	0.000	0.003	0.000	0.000	0.009	0.0	0.001
12 ILLINOIS	0.008	0.002	0.020	0.107	0.022	0.012	0.041	0.031	0.018
13 INDIANA	0.003	0.001	0.007	0.019	0.008	0.003	0.009	0.012	0.005
14 IOWA	0.002	0.001	0.006	0.075	0.004	0.002	0.006	0.001	0.005
15 KANSAS	0.001	0.000	0.001	0.035	0.001	0.002	0.001	0.004	0.001
16 KENTUCKY	0.001	0.000	0.005	-0.004	0.003	0.001	0.002	0.006	0.006
17 LOUISIANA	0.254	0.002	0.305	0.004	0.588	0.087	0.005	0.0	0.123
18 MAINE	0.005	0.001	0.001	0.000	0.001	0.000	0.000	0.052	0.001
19 MARYLAND	0.003	0.001	0.005	0.000	0.001	0.000	0.001	0.009	0.011
20 MASSACHUSETTS	0.007	0.014	0.011	0.002	0.003	0.002	0.001	0.077	0.006
21 MICHIGAN	0.004	0.002	0.008	0.013	0.007	0.005	0.017	0.017	0.013
22 MINNESOTA	0.002	0.001	0.002	0.104	0.002	0.002	0.011	0.004	0.004
23 MISSISSIPPI	0.000	0.000	0.002	0.000	0.007	0.001	0.0	0.0	0.004
24 MISSOURI	0.002	0.002	0.004	0.043	0.007	0.004	0.011	0.024	0.005
25 MONTANA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 NEBRASKA	0.000	0.000	0.000	0.008	0.000	0.000	0.001	0.001	0.000
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NEW HAMPSHIRE	0.000	0.003	0.000	0.020	0.000	0.000	0.000	0.055	0.000
29 NEW JERSEY	0.091	0.016	0.038	0.018	0.006	0.010	0.009	0.105	0.070
30 NEW MEXICO	0.000	0.002	0.0	0.006	0.001	0.000	0.000	0.030	0.0
31 NEW YORK	0.052	0.019	0.018	0.019	0.013	0.008	0.020	0.348	0.032
32 NORTH CAROLINA	0.004	0.003	0.054	0.001	0.007	0.002	0.002	0.007	0.033
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 OHIO	0.088	0.007	0.060	0.024	0.042	0.038	0.038	0.031	0.048

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	37 PENNSYL-VANIA	38 RHODE ISLAND	39 SOUTH CAROLINA	40 SOUTH DAKOTA	41 TENNESSEE	42 TEXAS	43 UTAH	44 VERMONT	45 VIRGINIA
35 OKLAHOMA	0.000	0.000	0.000	0.018	0.007	0.022	0.015	0.0	0.000
36 OREGON	0.008	0.002	0.023	0.049	0.015	0.015	0.069	0.025	0.030
37 PENNSYLVANIA	0.358	0.017	0.077	0.007	0.050	0.022	0.029	0.090	0.124
38 RHODE ISLAND	0.000	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.001
39 SOUTH CAROLINA	0.002	0.002	0.058	0.001	0.003	0.001	0.000	0.001	0.008
40 SOUTH DAKOTA	0.000	0.000	0.000	0.037	0.000	0.000	0.001	0.0	0.0
41 TENNESSEE	0.001	0.000	0.014	0.001	0.008	0.001	0.004	0.001	0.005
42 TEXAS	0.050	0.884	0.090	0.016	0.083	0.694	0.025	0.000	0.329
43 UTAH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44 VERMONT	0.000	0.000	0.000	0.0	0.000	0.000	0.0	0.001	0.000
45 VIRGINIA	0.004	0.003	0.026	0.000	0.004	0.001	0.001	0.002	0.029
46 WASHINGTON	0.013	0.001	0.007	0.018	0.010	0.003	0.108	0.000	0.018
47 WEST VIRGINIA	0.001	0.001	0.002	0.0	0.002	0.001	0.002	0.000	0.006
48 WISCONSIN	0.005	0.001	0.006	0.039	0.007	0.004	0.009	0.020	0.007
49 WYOMING	0.0	0.0	0.0	0.260	0.0	0.0	0.018	0.0	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	46 WASHINGTON	47 WEST VIRGINIA	48 WISCONSIN	49 WYOMING	50 ALASKA	51 HAWAII
1 ALABAMA	0.001	0.002	0.039	0.000	0.0	0.009
2 ARIZONA	0.000	0.000	0.000	0.0	0.0	0.0
3 ARKANSAS	0.009	0.000	0.004	0.000	0.0	0.000
4 CALIFORNIA	0.536	0.004	0.035	0.061	0.582	0.636
5 COLORADO	0.000	0.000	0.001	0.014	0.0	0.001
6 CONNECTICUT	0.002	0.000	0.006	0.000	0.001	0.001
7 DELAWARE	0.000	0.000	0.001	0.0	0.0	0.0
8 DISTRICT OF COLUMBIA	0.0	0.0	0.0	0.0	0.0	0.0
9 FLORIDA	0.002	0.003	0.010	0.004	0.000	0.000
10 GEORGIA	0.001	0.001	0.007	0.001	0.000	0.001
11 IDAHO	0.019	0.000	0.004	0.001	0.0	0.000
12 ILLINOIS	0.012	0.008	0.138	0.042	0.002	0.017
13 INDIANA	0.003	0.004	0.043	0.010	0.000	0.004
14 IOWA	0.003	0.000	0.020	0.002	0.000	0.001
15 KANSAS	0.001	0.000	0.004	0.001	0.000	0.000
16 KENTUCKY	0.000	0.002	0.003	0.001	0.000	0.000
17 LOUISIANA	0.019	0.689	0.027	0.006	0.005	0.000
18 MAINE	0.000	0.001	0.007	0.000	0.000	0.0
19 MARYLAND	0.000	0.002	0.002	0.000	0.0	0.000
20 MASSACHUSETTS	0.002	0.002	0.010	0.000	0.000	0.001
21 MICHIGAN	0.003	0.008	0.049	0.009	0.004	0.004
22 MINNESOTA	0.003	0.001	0.039	0.001	0.000	0.000
23 MISSISSIPPI	0.000	0.000	0.002	0.0	0.0	0.0
24 MISSOURI	0.002	0.003	0.012	0.009	0.006	0.002
25 MONTANA	0.0	0.0	0.0	0.0	0.0	0.0
26 NEBRASKA	0.000	0.000	0.001	0.008	0.000	0.002
27 NEVADA	0.0	0.0	0.0	0.0	0.0	0.003
28 NEW HAMPSHIRE	0.000	0.000	0.000	0.000	0.000	0.0
29 NEW JERSEY	0.005	0.007	0.013	0.001	0.001	0.021
30 NEW MEXICO	0.003	0.000	0.000	0.0	0.0	0.001
31 NEW YORK	0.006	0.014	0.027	0.002	0.004	0.002
32 NORTH CAROLINA	0.002	0.002	0.008	0.001	0.000	0.001
33 NORTH DAKOTA	0.0	0.0	0.0	0.0	0.0	0.0
34 OHIO	0.009	0.104	0.152	0.013	0.017	0.006

TABLE F.3

AGGREGATE 1967 TRADE COEFFICIENTS

	46 WASHINGTON	47 WEST VIRGINIA	48 WISCONSIN	49 WYOMING	50 ALASKA	51 HAWAII
35 OKLAHOMA	0.000	0.000	0.009	0.009	0.003	0.000
36 OREGON	0.111	0.004	0.029	0.071	0.026	0.013
37 PENNSYLVANIA	0.011	0.100	0.090	0.025	0.144	0.004
38 RHODE ISLAND	0.000	0.000	0.001	0.000	0.000	0.000
39 SOUTH CAROLINA	0.000	0.000	0.003	0.001	0.000	0.000
40 SOUTH DAKOTA	0.000	0.0	0.000	0.001	0.003	0.0
41 TENNESSEE	0.000	0.001	0.002	0.001	0.000	0.001
42 TEXAS	0.007	0.028	0.030	0.103	0.007	0.212
43 UTAH	0.0	0.0	0.0	0.0	0.0	0.0
44 VERMONT	0.000	0.000	0.000	0.0	0.0	0.0
45 VIRGINIA	0.001	0.003	0.004	0.000	0.0	0.004
46 WASHINGTON	0.215	0.001	0.064	0.010	0.187	0.050
47 WEST VIRGINIA	0.000	0.003	0.002	0.0	0.001	0.000
48 WISCONSIN	0.004	0.002	0.096	0.006	0.007	0.000
49 WYOMING	0.007	0.0	0.006	0.586	0.0	0.0
50 ALASKA	0.0	0.0	0.0	0.0	0.0	0.0
51 HAWAII	0.0	0.0	0.0	0.0	0.0	0.0

BIBLIOGRAPHY

Ara, Kenjiro. 1959. "The Aggregation Problem in Input-Output Analysis." Econometrica, Vol. 27, No. 2, pp. 257-262.

Batten, David. 1981. "The Use of Information Theory in Interregional Input-Output Models." Paper Presented at the Italien-Swedish Colloquium in Regional Economics (May).

Bon, Ranko. 1975. "Some Conditions of Macroeconomic Stability in Multiregional Models." Report No. 10. Cambridge, Massachusetts: Department of Urban Studies and Planning, Massachusetts Institute of Technology (September).

Bozdogan, Kirkor. 1969. "Studies On The Structure Of Input-Output Models For National, Regional, And Multiregional Economic Analyses." Ph.D. dissertation. Cambridge, Massachusetts: Department of Urban Studies and Planning, Massachusetts Institute of Technology (June).

Crown, William. 1981a. "Intertemporal Stability of Trade Relationships." Report No. 25. Cambridge, Massachusetts: Massachusetts Institute of Technology, Department of Urban Studies and Planning.

Crown, William. 1981b. "Interregional Feedback Effects, Aggregation Bias, Information Loss, and Trade Stability Issues." Report No. 27. Cambridge, Massachusetts: Department of Urban Studies and Planning, Massachusetts Institute of Technology.

Czmanski, S., and E. Malizia. 1969. "Applicability and Limitations in the Use of National Input-Output Tables for Regional Studies." Papers and Proceedings of the Regional Science Association. Vol. 23, pp. 65-77.

DiPasquale, Denise and Karen R. Polenske. 1977. "Output, Income, and Employment Input-Output Multipliers." Report No. 16. Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology (April).

Doeksen, Gerald, and Charles Little. 1968. "Effect of Size of the Input-Output Model on the Results of an Impact Analysis." Agricultural Economics Research. Vol. 20, No. 4 (October), pp. 134-138.

Dorfman, Robert, Paul Samuelson, and Robert Solow. 1958. Linear Programming and Economic Analysis. New York: McGraw-Hill, Inc.

Fei, John. 1956. "A Fundamental Theorem for the Aggregation of Input-Output Analysis." Econometrica. Vol. 24, No. 4 (October), pp. 400-412.

Fisher, Walter. 1969. Clustering and Aggregation in Economics. Baltimore: The Johns Hopkins Press.

Giddy, Ian. 1978. "The Demise of the Product Cycle Model in International Theory." Columbia Journal of World Business. (Spring), pp. 90-97.

Greytak, David. 1970. "Regional Impact of Interregional Trade in Input-Output Analysis." Papers and Proceedings of the Regional Science Association. Vol. 25, pp. 203-217.

Greytak, David. 1974. "Regional Interindustry Multipliers." Regional and Urban Economics. Vol. 4, pp. 163-172.

Harrigan, F., J.W. McGilvray, and I.H. McNicoll. 1981. "The Estimation of Interregional Trade Flows." Journal of Regional Science. Vol. 21, No. 1 (February), pp. 65-78.

Hatanaka, M. 1952. "Note on Consolidation Within a Leontief System." Econometrica. Vol. 20, No. 2 (April), pp. 301-303.

Hawkins, David, and Herbert Simon. 1949. "Note: Some Conditions of Macro-Economic Stability." Econometrica. Vol. 17, pp. 245-248.

Heckscher, Eli. 1950. "The Effects of Foreign Trade on the Distribution of Income." In Howard S. Ellis and Lloyd A. Metzler, eds. Readings in the Theory of International Trade. Homewood, Illinois: Richard D. Irwin, Inc.

Hewings, Geoffrey. 1971. "Regional Input-Output Models in the UK: Some Problems and Prospects for the Use of Nonsurvey Techniques." Regional Studies. Vol. 5, pp. 11-22.

Hewings, Geoffrey. 1972. "Input-Output Models: Aggregation for Regional Impact Analysis." Growth and Change. Vol. 3, No. 1 (January), pp. 15-19.

Horiba, Yutaka. 1973. "Factor Proportions and the Structure of Interregional Trade: The Case of Japan." The Southern Economic Journal. Vol. 39, No. 3 (January), pp. 381-388.

Horiba, Yutaka, and Richard Kirkpatrick. 1979. "Labor Skills, Human Capital, and the Pattern of U.S. Interregional Trade." In William C. Wheaton, ed. Interregional Movements and Regional Growth. Washington, DC: The Urban Institute, pp. 197-235.

Horiba, Yutaka, and Richard Kirkpatrick. 1981. "Factor Endowments, Factor Proportions, and the Allocative Efficiency of U.S. Interregional Trade." The Review of Economics and Statistics. Vol. 63, No. 2 (May), pp. 178-187.

Interstate Commerce Commission, Bureau of Economics. 1966. Carload Waybill Statistics, 1963. Statements 552, 553, and 555. Washington, DC.

Isard, Walter. 1953. "Regional Commodity Balances and Interregional Commodity Flows." American Economic Review. Vol. 43, No. 1 (March), pp. 167-180.

Isard, Walter. 1960. Methods of Regional Analysis. Cambridge, Massachusetts: The MIT Press.

Isard, W. and E. Romanoff. 1968. "The Printing and Publishing Industries of Boston SMSA, 1963: and Comparison with the Corresponding Philadelphia Industries." Cambridge, Massachusetts: Regional Science Research Institute, mimeo.

Jordan, L., G. Crutchfield, and D. Wright. 1977. Standardized Commodity Transportation Survey CTS Data Base: User's Manual. Cambridge, Massachusetts: Transportation Systems Center, U.S. Department of Transportation (August).

Khinchin, A. 1957. Mathematical Foundations of Information Theory. New York: Dover Publications, Inc.

Leontief, Wassily. 1956. "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis." The Review of Economics and Statistics. Vol. 38, No. 4 (November), pp. 386-407.

Miller, Ronald. 1966. "Interregional Feedback Effects in Input-Output Models: Some Preliminary Results. Papers and Proceedings of the Regional Science Association. Vol. 17, pp. 105-125.

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

Miller, Ronald, and Peter Blair. 1980. "Spatial Aggregation in Interregional Input-Output Models." Working Paper No. 35. Philadelphia, Pennsylvania: University of Pennsylvania (October).

Miller, Ronald, and Peter Blair. 1981. "Spatial Aggregation in Multiregional Input-Output Models." Working Paper No. 52. Philadelphia, Pennsylvania: University of Pennsylvania (July).

Mizrahi, Lorris. 1981. "Treatment of Secondary Production in Input-Output Models." Report No. 28. Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology (December).

Morimoto, Y. 1969. "On Aggregation Problems in Input-Output Analysis." Review of Economic Studies. Vol. 37, pp. 119-126.

Moroney, John, and James Walker. 1966. "A Regional Test of the Heckscher-Ohlin Hypothesis." Journal of Political Economy. Vol. 74, No. 6 (December), pp. 573-586.

Moses, Leon. 1955. "The Stability of Interregional Trading Patterns and Input-Output Analysis." American Economic Review. Vol. 45, No. 5 (December), pp. 803-832.

Moses, Leon. 1980. "Regional Analysis: The Search for a Model of Intranational Trade and Factor Mobility." Paper presented at the Conference on An Assessment of the State of the Art of Regional Modeling. Cambridge, Massachusetts: MIT/Harvard Joint Center for Urban Studies (April).

Norton, R.D., and J. Rees. 1979. "The Product Cycle and the Spatial Decentralization of American Manufacturing." Regional Studies. Vol. 13, No. 2, pp. 141-151.

Ohlin, Bertil. 1933. Interregional and International Trade. Cambridge, Massachusetts: Harvard University Press.

Polenske, Karen R. 1974. State Estimates of Technology, 1963. Lexington, Massachusetts: Lexington Books, D.C. Heath and Company.

Polenske, Karen R. 1980. The U.S. Multiregional Input-Output Accounts and Model. Lexington, Massachusetts: Lexington Books, D.C. Heath and Company.

Ricardo, David. 1971. The Principles of Political Economy and Taxation. New York: Penquin Press.

Richardson, Harry. 1972. Input-Output and Regional Economics. New York: John Wiley & Sons.

Riefler, Roger, and Charles Tiebout. 1970. "Interregional Input-Output: An Empirical California-Washington Model." Journal of Regional Science. Vol. 10, No. 2 (August), pp. 135-152.

Samuelson, Paul. 1947. Foundations of Economic Analysis. Cambridge, Massachusetts: Harvard University Press.

Sato, Ryuzo, and Rama Ramachandran. 1980. "The Impact of Technical Progress on Demand: A Survey." Journal of Economic Literature. Vol. 18, No. 3 (September), pp. 1003-1024.

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

Schaffer, W. A., and K. Chu. 1969b. "Simulating Regional Interindustry Models for Western States." Discussion Paper 14, Georgia Institute of Technology.

Scheppach, Raymond, Jr. 1972. State Projections of the Gross National Product, 1970, 1980. Lexington, Massachusetts: Lexington Books, D.C. Heath and Company.

Schwartz, Leonard. 1963. Principles of Coding, Filtering, and Information Theory. New York: New York University.

Shalizi, Zmarak. 1979. "Multiregional Input-Output Multipliers and the Partitioned Matrix Solution of the Augmented MRIO Model." Ph.D. dissertation. Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology (October).

Skolka, Jiri. 1964. "The Aggregation Problem in Input-Output Analysis." Prague: Czechoslavakian Academy of Sciences.

Smith H. T. 1960. "The Kalamazoo County Economy." Kalamazoo, Michigan: The W.E. Upjohn Institute for Employment Research.

Smith, P., and W. Morrison. 1974. Simulating the Urban Economy. London: Pion Limited.

Social Welfare Research Institute, Multiregional Planning Staff, and Systemas, Inc. 1981. MRPIS: Research Strategy. Boston, Massachusetts: Boston College.

Suzuki, Keisuki. 1971. "Observations on the Stability of the Structure of the Interregional Flow of Goods." Journal of Regional Science. Vol. 11, No. 2, pp. 187-209.

Theil, Henri. 1957. "Linear Aggregation in Input-Output Analysis." Econometrica. Vol. 25, No. 1 (January), pp. 111-122.

Theil, Henri. 1967. Economics and Information Theory. Chicago: Rand McNally & Company.

Theil, Henri, and Pedro Uribe. 1967. "The Information Approach to the Aggregation of Input-Output Tables." The Review of Economics and Statistics. Vol. 49., No. 3 (August), pp. 451-462.

Tilanus, C.B., and H. Theil. 1965. "The Information Approach to The Evaluation of Input-Output Forecasts." Econometrica. Vol. 32, No. 4 (October).

U.S. Bureau of the Census. 1966. Census of Commercial Fisheries, 1963. Series F C 63-1, Washington, DC.

U.S. Bureau of the Census. 1967. Census of Mineral Industries, 1963. Vol. I, "General Summary and Industry Statistics," and Vol. II, "Area Statistics." Washington, DC.

U.S. Department of Commerce, Bureau of the Census. 1970. 1967 Census of Transportation, Vol. 3, Commodity Transportation Survey, Part 3, Commodity Groups.

U.S. Department of Commerce, Bureau of the Census. 1976. 1972 Census of Transportation, Vol. 3, Commodity Transportation Survey, Part 3, "Area Statistics, South and West Regions and U.S. Summary."

U.S. Department of Commerce, Office of Business Economics. 1965. Survey of Current Business, No. XLV, Washington, DC. (September).

U.S. Department of the Interior, Bureau of Mines. 1964. Minerals Yearbook. Vol. II, "Fuels" and Vol. III, "Area Statistics." Washington, DC.

Vernon, Raymond. 1979. "The Product Life Cycle Hypothesis in a New International Environment." Cambridge, Massachusetts: Harvard University (July).

Wells, Louis. 1972. _The Product Life Cycle and International Trade_. Cambridge, Massachusetts: Harvard University Press.

Williamson, Robert. 1971. "Simple Input-Output Models for Area Economic Analysis." _Land Economics_. Vol 46, No. 3 (August), pp. 333-338.