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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

Embedding Regional Input-Output and Econometric Models

A Dynamic Integration Approach (DIA)

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

By

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Norman, Oklahoma
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Embedding Regional Input-Output and Econometric Models A Dynamic Integration Approach (DIA)

A Dissertation APPROVED FOR THE
DEPARTMENT OF ECONOMICS

BY

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This dissertation is dedicated to Mina, Houman, and Mogdeh.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

ABSTRACT

Embedding input-output characteristics into an econometric specification at regional level has recently gained popularity. The focus of attention has been directed toward the methodology with which the input-output characteristics can be incorporated into an econometric specification.

The embedding integration approach is classified as embedding-partitive and embedding-holistic. While partitive approach incorporates some selected interindustry relationship into an econometric specification, the holistic approach accounts for total intersectoral demand for output of a sector originating from all industries in a region.

Although the interdependency of a region's economic sectors through time has gained considerable attention, yet the dynamic properties of the intersectoral relationship has not been fully incorporated into the current integrated models. Moreover, much of the attention has been on the partial interindustry relationship rather than accounting for all economic sectors of a region or state.

The purpose of this dissertation was to investigate the implications of integrating inter-sectoral relationships to a state level econometric employment model. The focus of this investigation was on incorporating a dynamic, rather than static, intersectoral relationship into the integrated model. A unique cost adjustment factor (CAF) was constructed to account for dynamic structural change

in the region's economy. The study also focused on the inclusion of all major macro economic sectors of the state, rather than partial industries.

First, regional integration strategies were discussed and a theoretical framework was developed to compare current embedded integration strategies. Second, a dynamic integrated model, DIA, was build upon the theoretical framework. Then alternative model specifications were constructed by using the DIA model, and based on the theoretical framework that was developed. Finally the properties of the DIA were compared with other model specifications.

This dissertation resulted into a unique integration approach that was used to construct a dynamic integration (DIA) model. While this model, with a better predictive accuracy, accounts for structural change in the economy, it can estimate the values of the region's input-output coefficients through time.

Embedding Regional Input-Output and Econometric Models
A Dynamic Integration Approach (DIA)

CHAPTER I

INTRODUCTION

Economic development efforts and regional policy making are intensely affected by regional economic impact and forecasting models. The most effective empirical techniques that have been historically used for regional projects, policy evaluations, and impact analyses have, to a large extent, been econometric or input output techniques. However the development of these techniques have evolved independently. The inter-industry relationship, which is associated with the input and output relationship of local industries purchasing and selling from and to other local and national industries, are best captured in an input-output model specification. However, this type of modeling is not well capable of explaining the exogenous local or national disturbances that are produced either by policy makers or other economic variables. Such disturbances are best explained by econometric model specifications. In turn, econometric models are not capable of explaining the inter-industry relationship that is captured by input-output model specification.

In order to take the advantages of the inter-industry structure of input-output specification as well as the flexibility of econometric modeling, during the last two decades a great deal of attention has been given to integrated models of input-output and econometric techniques, especially at regional levels (Conway 1990, Coomes, Olson & Glennon 1991, Glennon & Lane 1990, Israilevich, et al. 1997, Israilvech & Mahidhara 1991, Magura 1990, Rey, S. J. 1994, Treyz, Rickman, and Shao 1992). The focus of this attention has been on two issues. First, the methodology with which the input-output specification is integrated with an econometric model, and, second, the extent to which the advantages of the inter-industry focused structure of input-output can be incorporated with the dynamic flexibility of the econometric (time series) modeling approach.

An input-output model emphasizes the inter-industry technology that determines the level of output and employment in a region. The development of input-output models originated in the early 50's with the development of methodologies by Leontief (1953), Chenery (1953), and Moses (1955). Regional analysts, who were in need of formulating and evaluating policies with a more complete view of local economic interrelationships, turned to input-output modeling for impact analysis where detailed inter-industry analysis are of importance (Isard , and Kuenne 1953, Miller 1957, and Moore, and Peterson

1955). These models have gone through many stages of development (Richardson 1985). They started from pure survey based input-output models to more popular non-survey techniques (Treyz 1993). A market for ready-made regionally customized model system was developed for impact analysis. Examples include RIMS II (Cartwright, Beemiller, and Gustely 1981), ADOTMATR (Lamphear & Konecny 1983), RSRI (Stevens 1983), and IMPLAN (Palmer, Siverts, & Sullivan 1985).[1]

The input-output techniques have extended to more sophisticated and complex models (Batey & Rose 1990). They include a combination of input output specification and econometric estimation, often as a forecasting technique. They use the demand forecasts of the econometric model as input for forecasting input-output tables. Examples include Kushnirsky (1982), Stevens, Treyz, and Kindhal (1981), and L'Esperance, King and Sines (1977). However, it has been difficult to make the technical coefficients of the input output tables dynamic, which limits their usefulness for impact analysis and, in general, precludes their use as forecasting tools (Perryman & Schmidt 1986).

Econometric as a subject is older than macro-econometric model building. However, development of econometric models goes back to the early efforts of Jan Tinbergen for the Netherlands and the United States before the Second World War and continues to date (Klein 1991). The econometric models were originally nationally oriented and consisted of many equations designed to describe and predict the economic structure of complete nations. Some of the macro-econometric models that have been updated through time and exist today include: the Bureau of Economic Analysis model, the Fair Model (Constructed by Ray Fair in 1976), Federal Reserve Board Model, the Michigan Quarterly Econometric Model (MQEM), and the Wharton Economic Forecasting Associates Model (WEFA).

Regional econometric models have evolved as a result of research, forecasting, and policy evaluation in regional economics. Their origin goes back to the 1950's and 1960's (Bolton 1985, Glickman 1971, Richardson 1985). Since the late 1960's there has been growing interest in building regional econometric models of the Keynesian demand-oriented type. Many of these models are similar (at least in intent) to some of the national econometric models which were developed from the now classic Klein-Goldberger (1955) model.[2] A regional econometric model is a set of equations, in some cases highly simultaneous, describing the economic structure of a regional economy, usually a state or province or metropolitan area. The parameters of the equations are estimated econometrically, largely by regression equations, as distinct from an input-output model in which parameters are based on single-point observations. Glickman (1971) argues that the usefulness of econometric models for analyzing regional development is clearly limited since no interaction is allowed among local variables.

Neither the input-output based nor econometric based modeling systems alone can adequately capture and represent a region's or state's economic activities. It is then very important in economic development project design and evaluation to consider the effects generated by both aspects of the region's economic system.

Since the pioneering work of Glickman's model of Philadelphia[3] in 1971, increasingly more studies have been dealing with the integration of the input-output and econometric models (Duobinis 1981). Examples include Lesage & Magura, 1986, Glennon et al., 1986, 1987, Moghadam & Ballard, 1988, Conway 1990, Glennon & Lane 1990, Magura 1990, Coomes Olson, & Glennon 1991, Israilvech & Mahidhara 1991, Treyz, Rickman, and Shao 1992, Rey 1994, and Israilevich, et al. 1997.

The channels of integration between input-output and econometric models at regional levels are built upon the basis of the channels of integration in national models. Chowdhury (1984) presents a generalization of the channels of integration. However, the methodology and the extent of integration are different among current regional integrated models.

Although no standard classification has been introduced across the current integrated models, different classifications have been used at different times. The classifications have adopted labels such as unified, embedded, modular, linked, and composite (Anselin & Ray 1989, Chowdhury 1984, Kort & Cartwright 1981, Kort

& Cartwright 1981, Rey 1994, and Wegener 1986). Following Rey 1994, Chowdhury 1984, and Kort & Cartwright 1981, the integrated models can be classified into three distinct group of embedded, linking, and composite formation[4]. In the embedded formation the specification of one model (commonly an input-output model) is embedded into another (commonly an econometric model) to form a comprehensive integrated model specification. The integrity of either of the individual models (the input-output or the econometric) can, however, be lost in the process (Moghadam & Ballard 1988). The embedding formation results in a model that is simultaneous in its input-output and econometric aspects. The linking formation, on the other hand, uses the output of one model as input to another. The linking formation is not necessarily simultaneous in input-output and econometric aspects (Kort & Cartwright 1981, Rey 1997). The composite strategy (Conway 1990, Treyz 1993) is composed of a combination of several features of each model. These formations usually involve several channels of integration such as demographic or geographical.

SHORT COMINGS

The focus of the integrated embedding approach is the methodology with which the intersectoral characteristics of input-output model specification can be embedded with an econometric model. Some of the short comings of this class of models is associated with the stability of the intersectoral structure of regional economics and, consequently, the assumptions regarding the stability of the regional input-output coefficients in particular and national technical coefficients in general. Although this issue has been addressed in theory in many current integrated models, it has not yet been dealt with in practice (Cooms, Olson, & Glennon 1991, Conway 1990, Magura 1990, Moghadam & Ballard 1988). Additionally, unavailability of regional output at sectoral levels has restricted these models to being models of primarily employment (Glennon & Lane 1990). In addition to those deficiencies associated with the embedding formation, one of the major short-coming of the linking models is the unavailability of the final demand and output data, especially at sector levels.

As discussed by L'Esperance (1981), the most technically advanced regional econometric model is one with a well-integrated and fully developed set of specifications dealing with all of the important sectors of the region. The specifications themselves should reflect the latest theoretical models of disaggregated regional economic behavior. In addition the estimation procedure should recognize the behavior of the disturbances of the model and the character of the identification of the system of equations. The current integrated models, however, cannot be considered comprehensive and technically advanced regional impact models due to their shortcomings as discussed above although many of these models have very large and sophisticated structure. Israilevich (1997) argues that "the sophistication of regional economic models have been demonstrated in several ways, most recently in the form of linking several modeling systems or in the expansion in the number of equations that can be manipulated successfully to produce impact analysis or forecasts"[5]. Israilevich (1997) suggests an alternative methodology for forecasting detailed structural changes in the inter-industry relations in an economy. Consequently, these practical and methodological issues that were discussed above should be understood and considered when constructing new regional impact and forecasting models.

PURPOSE AND MOTIVATION

The purpose of this study is to examine the effect of introducing a dynamic embedding approach on two related issues of concern:

1. The predictive accuracy of the existing embedded integrated approaches
2. Lack of Dynamic inter-sectoral relationship in current regional—integrated models.

The main aspects of these concerns can be outlined as follows:

1. Integrating input-output and econometric models are gaining popularity, yet they are in the early stages. Input-output models capture the local inter-industry relationships, however, they cannot explain changes in macroeconomics variables. Econometric models are more flexible and are able to account for exogenous shocks and equilibrium adjustment through time, yet they do not adequately account for the existing inter-industry relationship among economic sectors (Moghadam & Ballrd 1988, Rey 1994). Integrating the input-output relationship into an econometric model (additional prior information) thus provides a potentially useful source for modeling a regional economy (Glennon & Lane 1990).
2. Concern over the problems arising in the scope and methodology of integration. The current embedded integrated models are either partitive (Glennon & Lane 1990), or Holistic (Conway 1990), yet none of these models have fully accounted for the intersectoral relationship in a region. The extent to which the inter-industry relationships should be incorporated into an econometric model depend on the approach (formation) of the integrated model (partitive vs. holistic). Then the performance and usefulness of the models should be measured against the integration formation.
3. Concern over the assumptions regarding the dynamic vs. static

structure of the regional economy and the effects of technological change on the inter-industry relations of the region. Glennon & Lane (1990) have addressed this issue to a limited basis. However, it has not been fully developed and requires additional research.

4. Time series data for output (based on the input-output definition of output[6]), and the components of final demand at sectoral levels are required to form an integrated model. Lack of these data at regional levels has limited these models in many ways. For example, the embedded models are limited to employment data that are often available at little cost.
5. A regional integrated model should at least set the stage for the possibility of constructing a comprehensive and technically advanced low cost regional model. Such models would greatly benefit regional policy makers, forecasters and economic impact analysts.

THE SCOPE AND LIMINTATIONS

Input-output and econometrically integrated modeling is explored and attention is concentrated on the embedding-partitive and embedding-holistic formations. A Dynamic Integrated Approach (DIA) model is then constructed based on the concerns discussed under "purpose and motivation." The DIA model is constructed for the state of Oklahoma for the period of 1969 - 1994. Other current approaches and methodologies, such as partitive, holistic, simple econometric, etc. are then compared and evaluated against the performance of the DIA model. Finally, the regional input-output coefficients are estimated for the period of 1971-1994.

Channels of Integration

The theoretical basis on which input-output and econometric models can be integrated is discussed in chapter two. Channels of integration between the two specifications of input-output and econometrics is identified and the possibilities of different integration methodologies are discussed. A great deal of this discussion is referenced to Rey (1994), and Chowdhurry (1984).

Regional Integrated Models:

Regional integration methodologies are divided into three classes of Embedding, Linking, and composite formations. Of the current models in these classifications, those integrated models that fall into the definition of embedding-partitive and embedding-holistic formations are isolated for closer attention and more detailed analysis. This is due in part to the purpose and motivation of this study. A general framework based on this classification is established to account for the foundation of the DIA model.

The Methodology of Regional Integration

The methodology of integration for the DIA model is discussed in great detail in chapter four. The major point of concern is the approach with which the input-output characteristics are embedded into an econometric model. and the extent with which inter-sectoral relationships are accounted for. This attention is in line with the objectives and motivation for this study.

The selection of an input-output model and an econometric model is hence of less importance. However, a general input-output model specification is used along with an econometric model specification similar to the model specification selected by Glennon & Lane (1990). The econometric model is based on an equilibrium model in goods and an equilibrium model in labor markets. The performance of the DIA model is also evaluated against an integrated model of the Glennon and Lane (1990) approach.

The selection of the state of Oklahoma was based on the following. First, more background and understanding of the state economic foundations was available to the author. Second, better and more cost efficient data was readily available through the Center for Economic and Management Research institution and the libraries of the, University of Oklahoma and the Oklahoma department of commerce. Finally, the lack of adequate economic research and model building for the state of Oklahoma to contribute to better economic planning and policy evaluations for the state created a need in this area.

The predictive accuracy and performance of the DIA model will be compared with other methodologies in the embedding class in chapter five. This is done by constructing several models for the state of Oklahoma and using different modeling approaches. These models are then compared based on the Percent Mean Square Error (PMSE), Mean Absolute Error, and Theil's Inequality Measure (U). These measures are most commonly used in performance evaluation of regional integrated models.

Finally, a summary and conclusion will follow as chapter six. This chapter consists of final concluding remarks as well as summary conclusions of various sections of the study. Future directions for research will follow the concluding remarks.

NOTES

Chapter One

[1]. For description of these models see Brucker, Hastings, and Latham. 1987.
[2]. see L'Esperance (1981)

3 . Glickman (1971) in his work "Econometric Forecasting Model for the Philadelphia Region," argues for the usefulness of including interactions among local variables in econometric models.

4 . This classification is not necessarily in confirmation with other existing classifications. The intent is merely to distinguish one group from another based on the given definition of each.

5 . This reference was obtained from Federal Reserve Bank of Chicago -- Academic Working papers Abstract, Internet Site, working paper WP-96-2

6 . There are two distinct definitions of output, one in input-output modeling framework, and one in econometric. The input-output definition includes the total output including the intermediate output, whereas output in econometric refers to total value-added output which is total GDP, or GSP.

CHAPTER II

REGIONAL INTEGRATION STRATEGIES

Introduction

Policy analysis and economic impacts at regional level have for long been dominated by either input-output model specification or econometric approach. The usefulness and efficiency of either one of these approaches, however, have been subject to great a deal of criticism. According to Klein (1969), the question becomes one of whether we should concentrate on a detailed analysis of final demand or of intermediate demand, or of whether we ought to try to build a more general system encompassing both the traditional econometric model and the input-output model.

Although the integration of input-output specification with econometric models at regional, state, or sub-state levels is relatively young and goes back only to the 1980's, the integration strategy, in general, is not new. Form, style, regional level, or methodology of integration is what distinguishes one strategy from another. Once the channels of integration are established, different integration strategies can be defined and applied to a specific region or a group of defined regions. Integration of input-output and econometric specifications can be at the national level, sub-national regions, state level or one or more sub-state regions.

This chapter discusses the alternative channels of integration between input-output specification and econometric models. While a general methodological framework will be defined, some issues in national vs. regional integration will also be addressed.

CHANNELS OF INTEGRATION BETWEEN INPUT-OUTPUT AND MACRO ECONOMETRIC MODELS

As discussed in Chowdhury (1984)[1], the accounting relationship between inter-industry transactions, final demand and factor payments along with the input-output balance equation can be used to establish the channels of integration between input-output and econometric models.

The concentration of macro-econometric models is, in general, on the relationship between a final demand block (which represent the total expenditure side of the macro-economic measurement) and a factor payment block (which represent the total income side of the macro-economic measurement). On the other hand, the concentration of input-output models is, in general, on the final demand block and an inter-industry transaction block (which represents the intermediate demand and purchases). Figure 2.1 shows such a relationship, where X_{ij} is the intermediate purchases of sector j (j=1....n) from sector i (i=1....n), f_{im} is the final purchases from sector i for component m (m = C, I, G, EX = 1......m), and Y_{kj} is the payment to factor k (k=1.....k = labor, capital, rent, etc.) by sector j.

Figure 2.1
Channels of Integration

j / i	Intermediate Use by sector j	Final Demand Use of C, I, G, and $\bar{X}$	Total Growth Output
Intermediate Sales by sector I	X_{ij}	f_{im}	X_i
Payment to All factors	Y_{kj}	$\sum_i \sum_j f_{im} = GDP$ $\sum_k \sum_j Y_{kj} = GNI$	
Total Input	X_j		$\sum X_j = \sum X_i$

The final demand block in this figure is a common block in both econometric and input-output models. This common block can be used to link the input-output with the econometric models. Chowdhury argues:

> However, there is a lack of harmony between the usual categorization of final demands in the macro econometric models (C, I, G, EX-M) and the final demand deliveries by sector in the I-O model (C_i, I_i, ...). Therefore, if I-O final demand deliveries can be linked to the components of aggregate demand, then the impacts of macro policy variables can be traced to the individual producing sectors and the income propagation mechanism will have a complete loop. Thus both the Keynsian demand model and the Leontief I-O system together may form a complete macro model with proper feedback between demand and supply. (Chowdhury 1984, 99).

Alternative Integration Strategies

According to Chowdhury (1984). The link between both demand and supply can be readily established if time series data on sectoral final demand deliveries were available[2]. In this case, based on Klein (1965), sectoral final demand deliveries are treated as the endogenous function of aggregate components of Growth National Expenditure from a macro econometric model. Doing this will endougenize the GNE components for each sector which were assumed exogenous in the input-output model. For example, assuming that the aggregate expenditure is limited only to consumption, and investment:

$$(2.1) \quad C_i = C_i\,(Yd)$$

$$(2.2) \quad I_i = I_i\,(Y)$$

C_i and I_i are all elements of the final demand component matrix with n row sectors and m final demand categories. C_i is consumption demand for ith sector's output, and I_i is investment demand for the ith sector's output. Y is GNP, and Yd is disposable income.

In an alternative approach developed by Fisher, Klein, and Shinkai (1965)[3], final demand deliveries can be extracted from the input-output basic balance equation provided time series data on sectoral gross output (X_i) is available.

The well-known input-output balance equation can be written as:

(2.3) $X = AX + F$

Where X is a n x n matrix of gross output, A is a n x n matrix of input-output technical coefficients, and F is a n x m final demand matrix.

Solving equation (2.3) for F, we get:

(2.4) $F = (I-A) X$

Equation (2.4) explains final demand deliveries (F_i) in terms of sectoral gross output (X_i)[4]. Once final demand deliveries (F_i) are obtained, they can be linked to national expenditure categories (e.g. C, I, etc). This can be done by regressing the F_i's on the national expenditure categories. Thus:

(2.5) $F_i = \phi_{i1} C + \phi_{i2} I + U_i$

In matrix form, equation (2.5) can be written as:

$$(2.6)\quad \begin{bmatrix} F_1 \\ F_2 \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} * \begin{bmatrix} C \\ I \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

In other words:

$$(2.7)\quad F1 = \phi_{11} C + \phi_{12} I + U_1$$

$$(2.8)\quad F2 = \phi_{21} C + \phi_{22} I + U_2$$

Alternatively this can be written as:

$$(2.9)\quad F = \Phi G + U$$

where Φ is an n x m matrix of regression coefficients for the n sectors and m components of aggregate demand, G is a m x 1 column vector of Gross National Expenditure, and U is an n component stochastic disturbance term.

Having developed a relationship between G and F, we can now use the input-output balance equation to convert Gross National Expenditure to sectoral gross output. That is:

$$(2.10)\quad X = (I-A)^{-1} F = (I-A)^{-1} (\Phi G + U) = (I-A)^{-1} \Phi G + (I-A)^{-1} U$$

Given the estimates of the gross sectoral output (X), the estimates of value-added can now be obtained, assuming a constant share of value-added in the sectoral gross output. That is:

$$(2.11)\quad Y = BX$$

where B is an n x n diagonal matrix with diagonal elements equal to $(1 - \sum_i a_{ij})$, and off diagonal elements equal to zero.

Generally speaking, many variations of such methodologies can be employed to construct an integrated model. The applicability of any one alternative depends on the specific situation to which the model is applied. For instance, the alternative associated with Klein (1965), is applicable if time series data on final demand components at sector level are available. That is if the matrix of the coefficients representing the proportion of each expenditure category (eg. C) demanded from all sectors,[5] can be known. The construction of sectoral final demand (F_i) from sectoral gross output, in turn, is possible if time series data on gross output at sector level (X_i) is available.

A General Framework

According to Rey (1994), and Chowdhury (1984), alternative integration methodologies such as the methodologies discussed above, can be summarized into a generalized integration strategy, which explicitly incorporates the input-output relations with an econometric specification. In this procedure the categories of national expenditure is linked to the I-O sectoral final demand deliveries and to sectoral value-added which is summarized as follows[6]:

Based on the static input-output framework, relationships between gross output and value-added in each sector is transparent. This relationship can be summarized as follows:

(2.12) $Y_j = X_j - (a_{i1} + a_{i2} + .. + a_{ij}) X_j = X_j - \sum_i a_{ij} X_j = (1 - \sum_i a_{ij}) X_j$

For $\forall$ i = 1, 2, ..., n

This relationship can be expressed in matrix form:

(2.13) $Y = BX$

where Y is n x 1 column vector of sectoral value-added, and B is an n x n matrix with off-diagonal elements equal to zero and diagonal elements equal to one minus the column sum of the direct requirement matrix A. The diagonal element of B can be expressed as:

(2.14) $b_{ij} = 1 - \sum_j a_{ij}$ for j = 1,2, ..., n

Solving equation (2.13) for X in terms of value-added Y results in:

(2.15) $X = B^{-1} Y$

Substituting equation (2.15) into the input-output balance equation (2.3) and solving for F we get:

(2.16) $F = (I-A) B^{-1} Y$

Alternatively:

(2.17) $F = DY$

The properties of A and B ensure that matrix $D = (I-A) B^{-1}$ has the property of adding to unity column-wise. Otherwise, if d_{ij} is a typical element of the D matrix, then:

(2.18) $\sum_i d_{ij} = 1$, for $\forall$ $j = 1,2, \ldots\ldots, n$

Equation (2.17) explains the link between value-added and final demand deliveries. Now we need to show a relationship between final demand deliveries

(F)[7] to national expenditure components (C, I, G, X-M)[8]. If we assume that each producing sector's delivery (f_{ij}) to a national expenditure component (G_j) is a constant proportion (h_{ij}) of G_j then we can calculate a matrix of coefficients (H) which provide the link between the components of national expenditure (NE) and the I-O sectoral final demand deliveries. Thus:

(2.19) $h_{ij} = \frac{f_{ij}}{G_j}$ is a constant such that:

(2.20) $\Sigma_i h_{ij} = 1$

so the link between final demand delivery with GNE components (G) will be

(2.21) $F_i = \Sigma_j h_{ij} G_j$

Alternatively, assuming C and I to be the only compnent of aggregate expenditure, in a two sector economy:

(2.22) $\begin{bmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} * \begin{bmatrix} C \\ I \end{bmatrix}$ or

(2.23) $F = HG$

Where H is an n x m industrial distribution of final demand matrix. and G is an m x 1 matrix of GNE components. Substituting equation (2.23) into equation (2.16) we get:

$$(2.24)\quad HG = (I\text{-}A)\, B^{-1}\, Y$$

Now solving Y in terms of G (Growth National Expenditure components) we obtain:

$$(2.25)\quad Y = B(I - A)B^{-1}HG \qquad \text{or}$$

$$(2.26)\quad Y = EG$$

Based on the properties of D and H matrices. matrix E will satisfy:

$$(2.27)\quad \textstyle\sum_i e_{ij} = 1 \qquad \text{for } \forall\, i = 1, 2, \ldots, n,$$

where e_{ij} is an element of matrix E.

From this condition it is also transparent that:

$$(2.28)\quad \sum_{i}^{n} Y_i = \sum_{j}^{m} G_j$$

Alternatively

(2.29) GNP = GNE

The sum of sectoral value-added (Growth National Product) equals the sum of final demands by expenditure categories (chowdhury 1984).

Given the technical coefficient matrix, A, and the sectoral distribution of final demand matrix, H, one can establish a relationship between the gross national expenditure categories (G = C, I, etc.) and sectoral value-added as Y = EG. Given this relationship along with a final demand model, one can construct a macro model that will have "full feedback" between supply and demand.

The relationship established by equation (2.26) could now be seen as replacing the aggregate production function of the macro-econometric model. Further, several final demand components, which were originally treated as exogenous in the input-output model become endogenous to the generalized system as they are determined in the macro-econometric model (Rey, 1994).

REGIONALIZING NATIONAL INPUT-OUTPUT TABLES

There is a growing belief that regional economic development should and must be viewed as a strictly integrated process. The integration process should not only utilize the strengths of the inter-industry relationship but should also take the advantage of the flexibility of time series -- econometric modeling specification

(Clickman 1977, Beaumont 1990, Israilevich 1997). In doing so, a general framework for establishing the integration channels was developed in previous sections. The use of input-output tables was referred to as national input-output tables or input-output technical coefficients which apply to a closed economy. To develop regional models, the national input-output tables, which are the core of the input-output models, should be transformed to regional input-output relationships.

Originally, applications of input-output models were carried out at national levels. Increasing attention to regional problems has led to modification of the national models to reflect and cast the peculiarities of regional economies. Recent data processing advances and availability of advanced personal computers reduce the previous impediments to input-output use in general, and construction of input-output information at the regional level in particular (Tzouvelekas 1995).

The development of regional input-output models can be traced back to the early 1950's (Moore & Peterson 1955). Ever since, the demand for a wider application of the input-output approach in regional planning has led to extensive utilization of such analysis into applied work as a principal component in integrated modeling ventures (Tzouvelekas, 1995).

The generation of input-output tables, or what is known as input-output technical coefficients is classified into two broad categories of survey and non-survey techniques. There have been several survey-based regional input-output models since 1960. Examples[9] include Bourque and Conway (1979) and Hirsch

(1959). However, no other major survey based model has been constructed since the late seventies.

On theoretical grounds, a well designed survey input-output model would be superior to a non-survey one. Nevertheless, survey-based regional input-output models require collecting enormous amounts of data. Additionally, survey based regional input-output models need enormous amount of time and financial resources to complete the survey. Yet the accuracy of the survey based models are yet subject to criticism. It would be misleading, argues Twomey & Tomkins (1998), to assume that survey estimates are necessarily more accurate representations of a local or regional economy. Twomey & Tomkins (1998) go on to quote Willis (1987) that the statistical properties of the sampling process and the nature of the professional judgment used to construct regional linkages may not only lead to significant errors and bias, but tables may also become dated relatively quickly. Hence, developments of non-survey input-output techniques have gained considerable attention and are often favored over the survey-based techniques (Martin et al. 1988). However, even though many authors have cited the deficiencies of the non-survey mehtod, they have not dismissed it altogether as an entirely useless method. (Twomey & Tomkins, 1998)

NON-SURVEY INPUT-OUTPUT TECHNIQUES

Non-survey techniques often use a national input-output table as a basis for regional technology and then make adjustments that take into account various differences between the region's economy and that of the nation. These techniques can be classified into different categories based on the type of data required by each technique (Cartwright, Beemiller, & Gustely, 1981). According to Richardson (1985), methods of converting national input-output coefficients are of two types, which may be used either separately or jointly. The first type involves some method of adjustment for the possibility that the regional technical coefficient is not the same as its national counterpart. In other words, ($a_{ij}^r \neq a_{ij}^n$). The second type modifies the regional technical coefficient to take account of imported as well as local inputs. That is:

(2.30) $r_{ij} = t_{ij}\, a_{ij}^r$

Where r_{ij} is the regional input-output coefficient and t_{ij} is the share of requirements of commodity i by sector j supplied locally, and a_{ij}^r is the regional technical coefficient[10].

According to Richardson (1985), most of the models which estimate r_{ij} assume that $a_{ij}^r = a_{ij}^n$. It is possible that some of the poor results with non-survey models are the result of the failure to correct for differences between regional and national technologies or for differences in product mix" (Richardson, 1985). "In general, however, there has been relatively little research into techniques for modifying national technical coefficients to adjust for regional specific technological differences" (Richardson 1985).

The techniques used to regionalize national input-output coefficients[11] include the Location Quotient (LQ) and Supply-Demand Pool (SDP) techniques. (Cartwright, et al. 1981, Richardson 1985, and Tzouvelekas 1995). The latest entry in the list of non-survey techniques is the regional purchase coefficient (rpc) developed by (Treyz, Freidlander, and Stevens 1980, Stevens, et. al. 1983.) at the Regional Science Research Institute. These techniques make use of generally available, published data on industry-specific employment or earnings to estimate the level of industry-specific imports. The national table is then adjusted to the regional level by taking these imports into account. Two major advantages of these techniques are their low application cost and their applicability to state as well as sub-state levels.

The derivation of the SDP approach is based on the concept of regional commodity balance, which was developed by Isard (1951). This approach is similar to the location quotient method and results in similar regional input-output tables. In this method the regional commodity balance (RCB) is compared with the regional input required for production and consumption (demand). That is:

$$(2.31)\ Q^r_i = Q^n_i * \frac{E^r_i}{E^n_i}$$

Where Q^r_i is the regional output of sector i, and Q^n_i is the corresponding sector's national output, E^r_i is the employment for sector i, and E^n_i is the national employment for sector i. Once the regional output is calculated, the RCB can be obtained as follows:

$$(2.31)\quad RCB \equiv Q^r_i - X^r_i$$

Where X is the local input requirement for production and consumption. If RCB ≥ 0, then national I-O coefficients can be used as estimates of regional ones. On the other hand, if RCB < 0, then a share of regional output is allocated to each purchasing industry j based on the needs of the purchasing industry relative to total needs for output i, while the remainder of total production requirements for each sector is imported (Moore & Peterson 1955).

In the absence of survey-based data, the regional modeller oftern has to use location quotients, (LQs), along with regional and national sectoral employment figures, in deriving estiamtes of regional input-output coefficients from national tables (Flegg & Webber, 1997). The Location Quotient approach, according to Richardson (1985), is the most widely used approach to measure the economic base.[12] This approach can be used to generate regional input-output tables. The idea is to use location quotients as a proxy for t_{ij} in the equation 2.30. For example, based on the work of Jensen, Mandeville, & Karunarante (1979), in order to generate regional input-output tabels for the regions of Queensland, Australia, the flow of intermediate demand is estimated by an employment-based, cross industry location quotient to the corresponding elements of the national matrix, which compares the proportion of national employment in selling industry i in the region to that of purchasing industry j. Further data manipulation and use of other survey or non-survey data can be utilized at the analyst's discretion (Tzouvelekas 1995).

According to Richardson (1985) several different types of location quotients have been devised to adjust for regional trade patterns. The most common approaches include purchase only method, the expenditure quotient, the cross-industry quotient, and the consumption-based quotient.[13] Studies by Schaffer and Chu (1969), Schaffer (1972), and Morrison and Smith (1974), are examples of location quotitent (LQ) technique to convert national coefficients to regional estimates. Richardson (1985) argues that estimated multipliers by these techniques are systematically higher than the same estimates using survey-based techniques. Additionally the estimated methods that use variables other than output as the denominator have no theoretical rationale. Yet there are no sound theoretical grounds for setting LQ_{ij} to t_{ij}. The choice of the technique according to Round (1983), Richardson (1985) argues, is merely practical expediency. The most recent location quotient based techniques are FLQ technique by Flegg & Webber (1996), and Semi-logarithmic location quotients by Round (1978).

The conventional menu of location quotients facing the analyst includes the simple location quotient (SLQ), cross-industry location quotient (CILQ). Rounds Semi-logarithmic location quotient, and FLQ (Flegg & Webber, 1997). The basic location quotient approach is based on comparison of the region-sector's proportion of total regional activity with the nation-sector's proportion of total national activity. That is:

$$(2.32)\quad LQ_i = \frac{E_i^r / E^r}{E_i^n / E^n}$$

Where E^r_i is local employment for i sector, E^n_i is national employment for i sector, and E without the i subscript refers to total regional and national employment.

If LQ > 1, then it is assumed that sector i is more concentrated in the region than in the nation. It is further assumed that the region is specializing in the output of sector i and, therefore, it exports some of its output to the rest of the nation and the world.

On the other hand, if LQ < 1, it is assumed that sector i is less concentrated in the region than in the nation. It is further assumed that the region imports product from sector i which is located outside the region.

The calculated values of LQ can now be used to adjust the national input-output coefficient to regional input-output coefficients. LQ $\geq$ 1 implies regional self-sufficiency and, in this case, national I-O coefficients can be used as estimates of regional ones. LQ < 1 implies the region's lack of capability to satisfy its entire demand for its output. In this case, national I-O coefficients should be adjusted downward. The adjustment coefficient would be the calculated LQ for each sector.

NOTES

Chapter Two

[1] . This section is in part owed to Rey (1994) who did extensive research on the subject as well as to Chowdhury (1984).

[2] Time series data on the components of the aggregate expenditure at sectoral level is not readily available except for the years for which an input-output table has been compiled. One could estimate or construct such data by using the data available for the benchmark years, or assume that the H matrix remains constant through time.

[3] This approach refers to an earlier version of the Brookings Model, where Fisher, Klein, and Shinkai (1965) tackled the lack of time series data on sectoral final demand deliveries. This is discussed in Chowdhury (1984).

[4]. In other words if you had time series data for X, then you could obtain time series data for F (using equation 2.4). Now you could predict sectoral final demand as functions of major expenditure variables.

[5] . The matrix of the coefficients representing the proportion of each expenditure category demanded from all sectors is referred to as H matrix in Chowdhury (1984).

[6] . This summary is based to Chowdhury (1984) which refers to (1) evolution of the Brookins model based on Preston (1972), and (2) what was followed in constructing econometric models such as Wharton, CANDIDE, and the Bank of Finland Model.

[7]. for example $F = \begin{bmatrix} C_1 & I_1 & G_1 \\ C_2 & I_2 & G_2 \\ C_3 & I_3 & G_3 \end{bmatrix}$

[8]. This is necessary because in contrast to the ready availability of time series data on national expenditure components, we do not have time series data on I-O sectoral final demand deliveries (F_i).(Chowdhury, 1984 p. 103).

[9]. For a complete listing see Richardson (1985), pp. 621.

[10]. Stevens et al. (1988) calls this the t_{ij} variable, the regional purchase coefficient (rpc).

[11]. Other techniques include: Regional Weights (Shen 1960, Round 1978). RAS Iteration (Czamanski and Mlizia 1969, Hewing 1984). For more sources see Richardson (1985).

[12] . The approach implies four assumtions: equal productivity per employee in the region and the nation; equal consumption per employee in the region and the nation; if region exports commodity i, all consumption is locally produced; and the nation neither imports nor exports i in net terms (Richardson 1985). These assumptions, Richardson (1985) argues, are not likely to hold.

[13] . Richardson (1985) argues that many of the methods measure LQ_i rather than LQ_{ij}, adopting the convention that imports of commodity i are distributed among local purchasing sectors in the same way as local supplies.

CHAPTER III

INPUT-OUTPUT AND ECONOMETRIC INTEGRATION STRATEGIES DEVELOPING A METHODOLOGICAL FRAMEWORK

INTRODUCTION

The integration of input-output models with econometric specification at the regional level follows the same methodologies that have been employed at the national level models. A general framework of national integration methodology was discussed in Chapter II.

Depending on the extent of incorporation of the two specifications, regional level or regional characteristics, and the restrictive assumptions regarding the coefficient of inter-sectoral components, the approach and the specification of the regional integrated models are varied and, in many cases, are uniquely designed to fit a specific region. In the following section, a general classification for the integrated models will be developed. Next, the development of a general framework will be used to compare existing regional integration strategies.

REGIONAL INTEGRATION STRATEGIES

The regional integrated models can be classified in several different ways. One alternative classification is to group these models based on the strategy of the integration. Although certain methodology classifications have been defined differently by different researchers (Chowdhury 1984, Glennon & Lane 1990, Kort & Cartwright 1981, and Rey 1997), three general integrated model strategies can be identified for our purpose. They include embedding, composite, and linking model formations.

The embedding models include those models that incorporate the specifications of an econometric model with an input-output model or combine an input-output specification with an econometric model. Depending on the treatment of inter-sectoral linkages and the degree to which the characteristics of the models are incorporated, the embedding approach can be further classified to partitive and holistic. The partitive approach (Chalmers & Beckhelm 1976, Glennon & Lane 1990, Glennon, Lane, & Johnson 1987, Hewings 1984, Magura 1987, 1990) accounts for partial inter-industry relationship versus holistic approach (Coomes, Olson, & Glennon 1991, Moghadam & Ballard 1988, Stover 1994) that accounts for all inter-sectoral relations as a whole.

The composite strategy (Conway 1990, Treyz 1993) is composed of a combination of several features of each model. These formations usually involve other channels of integration such as demographic or geographical.

The linking approach (Kort & Cartwright 1981, L'Esperance 1981, Stevens, Treyz, & Kindahl 1981), on the other hand, retains the integrity of either the econometric or input-output modeling specification and uses the output of one model as the input for the other.

EMBEDDING APPROACH

The embedding approach incorporates the characteristics of one model into the other. Most commonly the intermediate demand characteristics of the input-output specification are embedded into an econometric model (Rey 1997). The intermediate demand characteristics embedded into the econometric model represent the inter-industry relations within the region which serve as prior information. The use of such prior information in the econometric model should increase the predictive accuracy of the econometric model. The models in this class retain their econometric characteristics while they emphasize the inter-industry relationship which forms the core of a regional economy (Magora 1987, Moghadam & Ballard 1988).

In terms of the general integration framework developed in the earlier chapter, this approach can be regarded as a simplified version of the integration formation. These models have been developed mostly for a single region such as a state, a region of one or more counties, or a metropolitan area, and for the purpose of forecasting and impact analyses (Glennon & Lane 1990). Table 3.1 exhibits the models that fit our description of the embedding formation:

Table 3.1
Region Integrated Models
Embedded Approach

Author	Year	Scope
Chalmers & Beckhelm	1976	5 multi county areas
Coomes, Olson & Glennon	1991	Louisville
Duobinis	1981	Chicago
Fawson & Criddle	1994	Northeastern Utah
Glennon and Lane	1990	Kentucky
Glickman	1977	Philadelphia
Magura, Michael	1987	Toledo-Ohio
Magura, Michael	1990	Toledo-Detroit
Moghadam & Balard	1988	Northern California
Prastacos and Brady	1985	9 San Francisco counties
White & Hewings	1982	5 county area

This approach has been used for modeling employment and output. Since employment is a key policy variable and an important component of the income variable, and output data are less widely available than employment data at regional, state or sub-state levels, employment modeling has gained more popularity than output modeling (Glennon and Lane 1990).

The core of the embedding modeling approach is the methodology with which the input-output characteristic is incorporated into an econometric specification. The scope of the model, the level of the industrial detail, and treatment of the input-output coefficients, in turn, determine the integration methodology within the class of the embedded approach (Rey 1994, 1997).

A METHODOLOGICAL FRAMEWORK

A basic embedded model includes an intermediate input demand term in addition to typical national or local final demand variables such as income, labor force, output, etc. Following Glennon and Lane (1990) a general mathematical formulation of this framework can be represented as follows:

$$(3.1) \quad X_i = \beta_0 + \beta_1 \, IID_i + \beta_2 \, FD_{ij} + \varepsilon$$

where X_i is either an output or employment variable, β_0 is the intercept, IID_i is the intermediate input demand term for sector i, and FD_{ij} is a final demand term j for sector i, and ε is an error term.

The β IID_i is the core of the embedded integrated approach and is the term that incorporates the input-output modeling characteristics with an econometric specification. Depending on the modeling methodology, the number of inter-industry relationship included, and the level of industrial detail, the IID_i will take different forms.

The embedding methodology can be regarded as either holistic, or Partitive. In the holistic methodology the intermediate input demand includes the intermediate demand originating in all j sectors for each i sector. In the partitive methodology, on the other hand, intermediate demand includes the intermediate demand originating in only some specific sectors j, which are regarded significant, for output of any sector i.[1] The logical explanation of this methodology is that output or employment in each sector can be explained by those sectors that have significant inter-industry relationships with that sector (Glennon & Lane 1990). The contributions of other sectors in explaining the changes in that sector are simply insignificant.

A. The case of holistic approach

In this approach, the IID_i term is treated as one whole variable which represents the intermediate input demand for each sector i by all sectors j. This variable may be treated either as an endogenous or as an exogenous variable. In other words, the intermediate input demand for sector i is the sum of the intermediate input demand in sectors (j = 1,2, ..., n).

That is:

$$(3.2) \quad IID_i = \sum_{j=1}^{n} X_{ij}$$

Equation (3.2) can be rewritten as:

$$(3.3) \quad IID_i = \sum_{j=1}^{n} a_{ij} X_j$$

where a_{ij} is the technical input-output coefficient in the production of output for each sector i. This coefficient is assumed to remain constant[2].

In the context of a regional model, r_{ij} replaces the a_{ij} to represent a regional rather than a national input-output technical coefficient[3]. In other words r_{ij} is the regionalized input-output coefficient[4]. Consequently equation (3.3) must be replaced by a new equation to represent regional intermediate input demand. That is:

$$(3.4) \quad IID_i = \sum_{j=1}^{n} r_{ij} X_j$$

However, as economic composition and trading patterns of the region change over time, and as technology advances further, the inter-industry input-output relationship does not remain unaffected, as implied by a static, fixed-coefficient model (Moghadam & Ballard, 1988). In this case, equation (3.4) can be written as:

(3.5) $IID_i = \sum_{j=1}^{n} \theta_{ij} \dot{r}_{ij} X_j$ for all (j = 1, ..., n)

Where $\dot{r}_{ij}$ represents the regional input-output coefficient at a benchmark year. It is the proportion of the input requirement that is satisfied by local industries. In other words, in order to produce one dollar worth of output, industry j needs a_{ij} (input-output technical coefficient) dollars worth of input from industry i. To satisfy this requirement, industry j purchases $\dot{r}_{ij}$ of this requirement from local industry i at a benchmark year. θ_{ij} can be viewed as an adjustment coefficient that adjusts the benchmark input-output coefficients for changes in regional and national cost and technological changes through time. θ, can be a parameter, a variable, or an expression.

The equation (3.1) can then be rewritten as:

(3.6) $X_i = \beta_0 + \beta_1 \sum_{j=1}^{n} \theta_{ij} \dot{r}_{ij} X_j + \beta_2 FD_i + \varepsilon$

The Coefficient β_1 in equation (3.6) can then be regarded as an estimated coefficient that further adjusts the intermediate demand for a time trend.

In summary, it is assumed that a_{ij}, which is the technical input-output relationship, remains constant through time. However, θ_{ij} is added as an adjustment factor for the regional purchase coefficients (r_{ij}). This factor adjusts the regional purchase coefficient through time if needed. If we assume that the r_{ij} will also remain constant, then no adjustment factor is required and $\theta_{ij} = 1$ for $\forall$ j=1, .. n.

Assuming the IID_j as an explanatory variable, the coefficient β can be either estimated or it can be restricted to equal a certain value. Depending on how the β coefficient is treated, the methodology can be further classified as follow:

A.1. Fixed regional purchase coefficients--restricted β coefficient

If we assume that the regional purchase coefficients will remain constant through time and use IID_i as an independent variable, we can also assume that the β coefficient associated with this variable will remain constant, and, for instance restrict its value to equal one ($\beta_j = 1$). Consequently the IID_i is added to the econometric specification as prior information without adjustment for time trend. As a result we have the equation in the following form:

$$(3.7) \quad X_i = \beta_0 + IID_i + \beta_2 FD_i + \varepsilon$$

where $IID_i = \Sigma_j \hat{r}_{ij} X_j$ when $\theta = \beta = 1$.

Equivalently:

$$(3.8) \quad X_i = \beta_0 + \Sigma\ \hat{r}_{ij} X_j + \beta_2\ FD_i + \varepsilon$$

The second term in equation (3.7) and (3.8), can be viewed as purely input-output in character. It is in the input-output model specification that the inter-industry demand remains fixed. Hence assuming that regional purchase coefficients remain fixed and that restricting the beta coefficient to a value of one is input-output in character. However, this type of modeling specification has not been applied in any of the regional integrated models. This may be due to the fact that it is not realistic to assume that the regional purchase coefficients will remain unchanged through time. In cases where one does make such an assumption, such as Moghadam and Ballard (1988) or Conway (1990) where the r_{ij} remains constant, the β coefficient is estimated to indirectly account for the adjustment of the regional purchase coefficients through time.

A.2. Fixed regional purchase coefficients-unrestricted β coefficient

As was discussed earlier, it is not realistic to assume that the regional purchase coefficients remain fixed. An alternative methodology is to allow the β coefficient to be estimated by the model rather than restricting it to a constant. The motivation to do so is to allow the β coefficient to account for adjustment to the degree of openness of the targeted region. Although an econometric estimation obviously is not a perfect account of the degree of openness of the regional economy, it is nevertheless an improvement over a static case (Moghadam and Balard, 1988). Since the regional purchase coefficients are assumed fixed, the value of θ is assumed to be one.

The general form of the equation in this case becomes:

$$(3.9)\quad X_i = \beta_0 + \beta_1 \, IID_i + \beta_2 \, FD_{ij} + \varepsilon$$

where $IID_i = \Sigma \, \dot{r}_{ij} \, X_j$

Alternatively

$$(3.10)\quad X_i = \beta_0 + \beta_1 \Sigma_j \, \dot{r}_{ij} X_j + \beta_2 \, FD_{ij} + \varepsilon$$

"Once we have regionalized the input-output coefficient table and added a time element to it, the IID becomes stochastic, and the identities that held together the input-output coefficient table are no longer valid" (Moghadam & Ballard 1988).

Examples of these types of models include a model of Northern California by Moghadam & Ballard (1988), and a model of Louisville Metropolitan Statistical

Area by Coomes, Olson, & Glennon (1991).

A Model of Northern California

Moghadam and Ballard (1988) proposed a regional Integrated Small Area Modeling of Industrial Sector known as I-SAMIS model. The model is designed to incorporate the econometric and input-output techniques within a regional framework. The general form of the model is:

$$(3.11)\quad X_t = \beta_0 + \beta_1\, IDV_i + \beta_2\, Z_i + \beta_3\, V_t + \varepsilon$$

The value of output or employment in the industrial sectors, X, at time period t is determined by a combination of an Intermediate Demand Variable (IDV), a local variable (V), and an external demand variable (Z). (β_1 IDV_i) is the link between input-output and econometric specifications; and

$$(3.12)\quad IDV_i = \Sigma_j\, a_{ij}\, X_j$$

This term is what was previously referred to as IID. It measures the demand for the output of one industry i which is originated from other industries within the region. The regional purchase coefficients are not present in this model, and technical input-output coefficients a_{ji} are used instead as proxies to the regional purchases coefficients. This is due to unavailability of the regional purchase coefficients for northern California, which was the target area for this study. These values are assumed fixed through time. The β coefficient is, however, unrestricted. The estimated β coefficient in this model is expected to account for the following:

1. The degree of openness of the region. The more the industry relies on non-local demand, the smaller the estimated coefficient on the IDV will be.
2. The degree of regionalization or local self-sufficiency in the industry.
3. Change in the technical input-output relationship through time.

A Model of Louisville Metropolitan Statistical Area

Coomes, Olson & Glennon (1991) extended the work of Moghadam & Ballard (1988) to the Louisville Metropolitan Statistical Area and modified the IDV variable to a new IEDV (Inter-industry Employment Demand Variable) which reflects differences in labor productivity. The IDVs are calculated by using a regional, rather than national, input-output model. This modification takes the form of changing the regional coefficients (r_{ij}), and multiplying the r_{ij} by the ratio of the labor productivity[5] in industry i to that of the industry j.

(3.13) $IEDV_{it} = \Sigma(\Pi_i \, r_{ij} \, L_{jt}),$

where

$$(3.14)\ \Pi_i = (\pi_i / \pi_j)$$

and π is the fraction of a job required to produce one dollar of output in industry j. It is an inverse measure of labor productivity. Then, the equation (3.13) can be rewritten as:

$$(3.15)\ IEDV_{it} = \Sigma(\frac{\pi_i}{\pi_j} r_{ij} L_{jt.})$$

However ($\theta = 1$) and remains constant and does not vary with time, and Π_i simply transforms dollar values into employment. As a result, the productivity and input- output relationships remain constant over the life of the model. The $IEDV_{ij}$ can then be defined as:

$$(3.16)\ IEDV_i = \Sigma_j(e_{ij}\ L_{jt.})$$

Where e_{ij} can be interpreted as the fraction of a job in the input industry required to support a job in the output industry[6]. Additionally, the industry focus in this model is broadened to include non-manufacturing sectors, whereas only manufacturing sectors are included in the Moghadam & Ballard (1988) model.

The final form of the equation can be written as follows:

$$(3.17)\ L_i = \beta_0 + \beta_1\ \Sigma(e_{ij}\ L_{it.}) + \beta_2\ Z_t + \beta_3\ V_t + \varepsilon$$

Alternatively:

$$(3.18)\ L_{i,t} = \beta_0 + \beta_1\ IEDV_{i,t} + \beta_2\ Z_t + \beta_3\ V_t + \varepsilon$$

A.3. Variable regional purchase coefficients--unrestricted β coefficients

This case allows for the regional purchase coefficients to vary, and the β coefficient to equal unity or be estimated by the model. The values of r will be adjusted by the adjustment factor, (θ). The value of the "θ" depends on the process with which the regional purchase coefficients are allowed to adjust through time. This process can be a function of cost, technology, or any other factor that can affect the regional purchase coefficients. The general form of such equation would be as follows:

$$(3.19)\ X_i = \beta_0 + \beta_1\ \Sigma(\theta_{ij}\ r_{ij}\ X_{jt.}) + \beta_2\ Z_t + \beta_3\ V_t + \varepsilon \quad \text{for } \forall\ i = 1, 2, \ldots, n$$

Or alternatively:

$$(3.20)\ X_i = \beta_0 + \beta_1\ \Sigma(R_{ii}\ X_{jt.}) + \beta_2\ Z_t + \beta_3\ V_t + \varepsilon \qquad \text{for } \forall\ i = 1, 2, \ldots, n$$

where $R_{ij} = \theta_{ij}\, r_{ij}$

No model of holistic approach could be identified with this methodology.

B. The case of partitive approach

In this approach the Intermediate Input Demand term for each sector, (IID), consist of a set of one or more selected inter-industry variable(s). The basic form of the partitive approach can be written as:

$$(3.21)\quad X_i = \beta_0 + IID_i + \beta_2\, FD_{ik} + \varepsilon$$

where:

$$(3.22)\quad IID_i = \textstyle\sum_j \beta_{ij}\, \theta_{ij}\, r_{ij}\, X_j$$

for $\forall\ j \subseteq (1, \ldots\ldots, n)$, and n is the total number of industries or sectors. Then equation (3.21) can be written as:

$$(3.23)\quad X_{i,t} = \beta_0 + \textstyle\sum_j \beta_{ij}\, \theta_{ij}\, r_{ij}\, X_{j,t} + \beta_2\, FD_{ik} + \varepsilon$$

In this case j is only a subset of all sectors and so would only include one or more of the sectors that are considered significant or important relevant variable(s). In this partitive approach, the IID variable is often used in its disaggregated form rather than as a whole variable. That, in turn, requires the estimation of more than one β coefficient. The equation (3.23) can be written as:

$$(3.24)\quad X_i = \beta_0 + \beta_{11}\,\theta_{i1}\,r_{i1} + \beta_{12}\,\theta_{i2}\,r_{i2} + \ldots + \beta_{1j}\,\theta_{ij}\,r_{ij} + \beta_2\,FD_{ik} + \varepsilon$$

As can be seen here, the IID variable consists of other variables and requires the estimation of more than one coefficient, depending on the number of industries or sectors that are included in the estimation equation.

The coefficient θ is an adjustment coefficient for the regional purchase coefficient r. The value of this coefficient is either restricted to a fixed value or is allowed to change through time. It can take a value of one if no adjustment for r is assumed.

The β coefficient however is either restricted to a value of one or is allowed to be estimated.

B.1 Variable regional purchase coefficients--unrestricted β coefficients

This (partitive) case allows for the regional purchase coefficient to adjust through time. The change in the regional purchase coefficient is adjusted by the adjustment factor θ. The value of the β coefficient is, however, either restricted to one or is left to be estimated. The estimated β values can be interpreted as further adjustments that were not accounted for in the adjustment coefficient θ. The general form of the equation in this case can be written as:

$$(3.25)\ X_i = \beta_0 + \sum_j \beta_{ij}\, \theta_{ij}\, r_{ij}\, X_j + \beta_2\, FD_{ik} + \varepsilon$$

An Integrated Model of Kentucky

The term IID in Glennon and Lane (1990) consists of only one or more industries (sectors) that are selected in a two-step process. In the selection process only the column industries that are considered to be significant in relationship with the row industry are selected to be included in the inter-industry term. The process includes identifying the direct requirement coefficient from an I-O model and using them as inter-industry weights to determine the importance of including an inter-industry relationship in their equation. A restricted time-varying parameter approach is employed to account for changing regional input-output coefficients. In this model, employment is determined for the state of Kentucky, which is divided between 23 sectors and industries.

By transformation of output to employment, the IID (Intermediate Input Demand) in Glennon and Lane (1990), becomes the ILD (Intermediate Labor

Demand). That is:

$$(3.25)\quad ILD_i = \Sigma\, r_{ij}\; A\; L_j \quad \text{where } A = (L_j / X_j)^m \div (L_i / X_i)^m$$

Where A is the ratio of the labor proportion of the value of output in industries i and j, and the superscript m refers to the mean of the labor proportion of output ratio. This ratio in fact translates the quantities of output to labor, and does not account for the change in regional purchase coefficients. The regional purchase coefficients will remain constant throughout the life of the project.

Then:

$$(3.27)\quad E_i = \beta_0 + \Sigma_j\, \beta_{ij}\, A\, r_{ij}\, E_j + FD_i + \varepsilon \qquad \text{for } i \subseteq (1, 2, \ldots, n)$$

where n stands for number of sectors or industries. The value of $\beta = 1$, and the employment coefficients is restricted to a value equal to $A\ r_{ij}$. This equation can be written as:

$$(3.28)\quad E_i = \beta_0 + A\, \Sigma_j\, r_{ij}\, E_j + FD_j + \varepsilon$$

Only those industries that are considered important or relevant will enter the above equation. Glennon and Lane (1990) use a selection process to determine what industries should be included in that equation. Of course the larger the number of industries included, the larger the number of coefficients, and the lower the degrees of freedom. Using a 23 sector regional purchase coefficient matrix, the decision was made to key on the largest cells in the matrix and use those to determine the strongest interrelationships. The minimum magnitude acceptable for a cell to be considered significant was 0.03 (3 percent). If there were several cells in the row which were larger, only the largest two or three were included[7].

By using a "time varying parameter approach" Glennon and Land (1990) dynamize the regional purchase coefficients and allow them to change through time. The change is, however, restricted to only those coefficients that appear in the inter-industry relationship term. The changes in the input-output coefficients are due to factors such as wage and productivity. These measures appear as two additional explanatory variables in the estimating equation. The proposed formulation takes the following form:

$$(3.29)\quad r_{ij} = r_{ij}^{0} + \alpha_1 \mu_{i,t-1} + \alpha_2 \pi_{i,t-1}$$

where r stands for the regional purchase coefficients, μ refers to a four-quarter moving average of the difference between the ratio of regional wages to national wages in time t to that in the base year in industry j, and π refers to the similarly measured relative difference in productivity (Glennon and Lane, 1990).

Incorporating this equation into the model and assuming only one inter-industry relationship, one obtains:

$$(3.30)\quad E_i = \beta_0 + r_{ij}^{0} (A\, E_j) + \alpha_1\, \mu_{j,t-1} (A\, E_j) + \alpha_2\, \pi_{j,t-1} (A\, E_j) + \beta_2\, FD_i + \varepsilon$$

or a more general form:

$$(3.31)\quad E_i = \beta_0 + \Sigma_j\, AE_j\, (r_{ij,0} + (\alpha_1\, \mu_{i,t-1} + \alpha_2\, \pi_{i,t-1})) + \beta_2\, FD_i + \varepsilon$$

for all j values referring only to the sectors that are considered significant.

In this equation (3.31) $r_{i,0}$ is a regional input-output coefficient for a benchmark year, which will remain equal to its original values. The α coefficients will be estimated by the equation. These coefficients (α's) are expected to provide information about the degree to which the original input-output coefficient values change over time (Glennon & Lane, 1990).

B.2 Fixed Regional Purchase Coefficients

Assuming that the regional purchase coefficients associated with each inter-industry variable are fixed and remain constant through time, then $\theta_{ij} = 1$. Consequently, a set of IID variables (with constant inter-industry relationships) is added to the econometric specifications as prior information. In other words, θ=1 if the r values assumed to remain equal to their original values ($r_{ij} = \dot{r}_{ij}$); and ($\theta \neq 1$)

if the r values are taken to change through time ($r_{ij} \neq \dot{r}_{ij}$).

The general form of the equation in this case can then be written as:

$$(3.32)\ \mathbf{X}_{ik} = \beta_0 + \beta_{ij}\ \theta_{ij}\dot{\mathbf{r}}_{ij}\ \mathbf{X}_{i,t} + \beta_2 \mathbf{FD} + \varepsilon$$

In this case, for every intermediate demand variable that is included in IID, there is a β coefficient to be estimated. This is most useful when the number of the industries or sectors that are to be included in IID are very few and are sufficiently less than the number of observations. In cases where the number of industries are too large, the β coefficient can be assumed to equal unity. That is:

$$(3.33)\ X_{ij} = \beta_1 + \theta_{ij}\ r_{ij}\ X_j + \beta_2\ FD_{ik} + \varepsilon$$

<u>A Model of the Toledo Metropolitan Statistical Area</u>

Michael Magura (1990) used input-output tables as a source of Bayesian prior information in a metropolitan labor market forecasting model. This model showed that forecast errors can be reduced if the prior information contained in the input-output tables is incorporated in a Bayesian vector autoregressive (BVAR) model.

In this autoregressive model, employment in each industry i is also a function of employment in other industries j. The inclusion of industry j as explanatory variables depend on the significance of that industry in relation to the industry i.

Since I-O tables assume a fixed relationship between inputs and outputs, the interrelations among employment in various industries are likewise identified. Thus the proportion of industry i's output purchased by industry j can be a good measure of importance or weight to attach to industry j employment in explaining variations in that of industry i. The models based on these weighting assignments are referred to as the I-O BVAR models. The coefficients associated with each of these explanatory variables remain to be estimated. The general equation form can then be stated as follows:

$$(3.34) \quad \mathbf{E}_i = \beta_0 + \beta_{ij}\, \dot{r}_{ij}\mathbf{E}_j + \beta_2\mathbf{Z}_i + \varepsilon$$

where β_{ij} is the estimated coefficient for the E_j variable.

This study uses 11 industries with their associated input-output sectors for MSA of Toledo, Ohio. These industries were chosen because data for them were available. Since regional coefficients were not available for Toledo, Ohio, national I-O coefficients were used instead (Michael Magura 1990).

Prastacos and Brady (1985) have done Very similar studies, which they applied to all 9 counties of the San Fransisco Bay Area. In this study, not only the inter-industry relationship, but also the inter-regional / inter-county relationships were included.

COMPOSITE APPROACH

The Composite approach combines several features and characteristics of one model with another. This approach is generally more complex than the other approaches in the class of embedding formation and may involve more than one channel of integration such as demographic or transportation. Models that use this approach are often designed to be applicable to all states or regions as well as a single state or metropolitan area.

Table 3.2 displays the list of Composite models that have been developed up-to-date. Of these models, Treyz model (1993), that applies to all 53 states, Israilevich model (1991), which applies to the Chicago metropolitan area, and Conway model (1990), which applies to the state of Washington will be discussed.

REGIONAL ECONOMIC MODEL, INCORPORATED (REMI)

REMI is a forecasting and policy simulation model developed by George I. Treyz (1993). It can be applied to any sub-national region and is the most widely used modeling system in the United States today. This model is an integrated model which is comprised of five major blocks: output block; labor and capital demand block; population and labor supply block; wages, prices, and profits block; and market shares block. These blocks are linked to form an endogenous structure which is quite comprehensive. Exogenous national forecasts are used to drive the regional forecasting model, which is solved using the iterative Gauss-Seidel method. The integration strategy of this model includes not only input-output and econometric, but also demographic and transportation. The essence of the REMI model is the extent to which theoretical structural restrictions are used instead of individual econometric estimates based on single time-series observations for each region.

Table 3.2
Regional Integrated Models
Composite Approach

Author	Year	Scope
Treyz, George	1993	All 53 states
West, G.R.	1991	Queensland
Israilevich & Mahidhara	1991	Chicago area
Conway, R.S., Jr.	1990	Washington

In terms of the general methodological framework developed in the earlier sections. on the demand side, the final demand components of REMI, such as consumption, investment, and government expenditure are estimated by using identities that are related to mostly national ratios or variables. For example, consumption in each industry is proportional to real disposable income. The proportionality term, however, is related to the U.S. marginal propensity to consume and a regional specific adjustment factor to regionalize consumption patterns. The sectoral distribution of final demand components are, in turn, based on the national input-output table for the period. That is:

$$(3.35)\quad C_i = PCE_i \; Concol \; (C^u \div RYD^u) \; RYD$$

where C_i is consumption in sector i, PCE_i[8] is a coefficient denoting the proportion of consumption satisfied by industry i, Concol[9] is a location-specific differential consumption measure derived from a consumer expenditure survey. RYD is real disposable income in the region, and C^u and RYD^u are the consumption and real disposable income, respectively, in the United States (Treyz 1993).

The output linkages in block 1 forms the core of the model. An input-output structure represents the inter-industry linkages and final-demand linkages by industry. While the underlying regional technology is based on national input-output technical coefficients, a regional purchase coefficient (RPC) is used to regionalize the national input-output technical coefficients. Since the RPC represents the proportion of local demand supplied locally by industry i, the need for an explicit import component is eliminated. That is:

(3.36) $Q_i = \sum_j R_i a_{ij} Q_j + R_i (C_i + I_i + G_i) + EX_i$[10]

Where:

(3.37) $R_i = RPC_i$ and

EX is the region's export. This equation can be rewritten in the following form:

(3.38) $Q_i = \sum_j \theta_i a_{ij} Q_j + F_i$ Where:

(3.39) $\theta_i = R_i$. and

F_i is the final demand component of the output equation (3.38).

The RPCs in this model are endogenous. They are determined based on relative production costs[11]. The RPCs allow for updating the trade component of the model. The input-output technical coefficients are subject to change. However, they are treated as exogenous to the model, yet are determined based on interpolation between benchmark national input-output tables (Treyz 1993).

On the supply side of the general integration framework, the value-added output is related, via a Cobb-Douglas production function, to labor factor, a

Composite of capital factor, and a Composite of fuel factor. That is:

$$(3.40)\quad VA_i = A_i\,(E_i)^{\alpha i}\,(K_i)^{\beta i}\,(F_i)^{\gamma i}$$

where A_i is total factor productivity of sector i, E_i is employment in sector i, K_i is a Composite of capital factors, F_i is a Composite of fuel factor, and $\alpha + \beta + \gamma = 1$.

Assuming profit maximization, factor demands can be obtained which express factor intensities as functions of relative input cost and value-added. Therefore, the linearity assumption of a static input-output model which specifies employment demand as *proportional to output*, is replaced by a demand function allowing for price-induced factor substitution(Rey 1994).

Interaction between block 1 and the rest of the model is extensive. Most interactions flow both ways indicating a highly simultaneous structure.

THE WASHINGTON PROJECTION AND SIMULATION MODEL

The Washington Projection and Simulation Model (WPSM), which was originally built in 1977 by Richard Conway (1979), is a regional inter-industry econometric model designed for forecasting and impact analyses. The model recognizes external as well as internal demand. Export demand (which is the primary driving force behind regional economic growth) triggers internal and regional inter-industry demands. Further, intermediate demands are induced by induced output in local industries. These input-output relations which are modified over time (by projections of changes in inter-industry coefficients), constitute the core of the model (Conway, 1990).

The model offers three distinct blocks: Final demand block, output block (which is specified with an explicit input-output structure), and a demographic block.

1. The final demand block of the general integration framework[12] is estimated by endogenizing its final demand components. These components include consumption, investment, government expenditure, and exports. Personal income and population are in turn important variables explaining the final demand components.

   Lack of data for the estimation of the final demand component is a major obstacle of developing regional input-output models. Conway overcame this problem by using national variables and econometric estimation to determine the values of these components. For example the United States per capita consumption data are used to generate historical estimates of consumption in Washington.

2. The estimates of the final demand components obtained in the first step is used to estimate Washington's output. This estimate is called expected output (X^e). It implies that the expected output is based on the condition that the input-output technical coefficients (the A matrix)

will remain constant over time. Stating it mathematically:

$$(3.41)\quad X = (I - A)^{-1} F$$

Equation (3.41) is the basic input-output balance equation. Then:

$$(3.42)\quad X = X^e \mid_{A = \bar{A}}$$

where X is output, A is the regional input-output coefficient matrix. F is the final demand matrix. X^e is the expected output. | is a conditional operator, and $\bar{A}$ is constant input-output coefficients matrix through time.

The actual values of output (X) is then regressed against the obtained values of the expected output. That is:

$$(3.43)\quad X_i = \alpha_i X^e_i + U_i$$

where α is the regression coefficient. and is indicative of the extent to which the input-output coefficients change through time for each sector (row) of the input-output table.

3. In the demographic submodel, the predictions of employment and earnings, coupled with predictions of labor force participation, unemployment rate,

and total employment can be used to forecast population, from which other demographic information can be generated.

LINKING APPROACH

In a linking approach, the output of one model is used as input for the other. In this strategy one of the two models retains a greater degree of independence (Kort & Cartwright 1981).

In the first case, econometrically estimated final demand components can be used as exogenous inputs into an input-output model. This link can be established by using the input-output balance equation, which can be expressed as follows:

$$(3.44)\ X_i = \Sigma_j a_{ij} X_j + F_i$$

Then the final demand for each sector can be determined as:

$$(3.45)\ F_i = X_i - \Sigma_j a_{ij} X_j = \Sigma_h f_{ih} = \Sigma_h H_{ih} f_h$$

where X_i is the total gross output for sector i, f_{ih} is the final demand component h for industry i. H_{ih} is the proportion of the final demand component h that is satisfied by the industry i, and $F_i = \sum_h f_{ih}$ is the total final demand for industry i[13].

Equation (3.45) is the link between input-output and econometric in this case. That is, an econometric model can be employed to forecast the components of the total final demand F.

That is:

$$(3.46)\ \hat{f}_h = f_h (Z_1, \ldots. Z_n)$$

where Zs are exogenous and endogenous variables used to forecast f_h. The forecasted values of final demand components will then be used as an exogenous variables in the input-output equation (3.44).

Industry specific final demand can then be obtained by distribution of estimated final demand components based on H_{ih} distribution matrix. This distribution matrix can in turn be derived from the base-year ratios of industry-specific to total final demand obtained from an I-O table.

That is:

$$(3.47)\ H_{ih} = (f_{ih} / f_h)^{Base}$$

where Base refers to the benchmark year that an I-O table was derived.

Having thus forecasted final demand components, industry specific output forecasts can be obtained by the following equation:

(3.48) $\hat{X}_i = \sum_j a_{ij} X_j + \hat{f}_{ih}$

The second case involves linking input-output model outputs to an econometric model. This case is somewhat more complicated than the first case. It consists of several steps that are not necessarily standard in all approaches. Generally, the following steps are involved in this case.

First, using the input-output balance equation in matrix form, initial changes in output can be obtained from any changes in final demand matrix. That is, the basic input-output balance equation can be written as:

(3.49) $X = (I - A)^{-1} F = BF$

where

(3.50) $B = (I - A)^{-1}$

Then, we have:

(3.51) $\Delta X = B \, \Delta F$

In other words change in output (ΔX) is proportionally related to change in final demand (ΔF).

Second, initial output changes can be used to obtain changes in value-added. That is:

$$(3.52)\ \Delta VA = R\ B\ \Delta F$$

where VA is the value-added and

$$(3.52)\ R = \frac{VA}{X}$$

Third, the initial changes in value-added could be aggregated to the industrial detail of the econometric model. These aggregated values will be used as input into the econometric model.

Finally, a baseline econometric solution (based on normal growth trends in the regional economy) can be compared with an adjusted econometric solution (based on ΔV_is obtained from the I-O model). These solutions can, in turn, be compared to assess the total impact of the exogenous final demand changes.

An example of this case is the integrated model of Masschusetts by Stevens, Treyz, and Kindhal (1981).

Table 3.3 displays the list of Linking models that have been developed up-to-date. Of these models, L'Esperence model (1981), which applies to Massachusetts area, and Stevens, Treyz, and Kindahl model (1981), which applies to the state of Ohio, will be discussed.

An Integrated Model of Ohio

L'Esperence (1981) developed an input-output forecasting model for the state of Ohio. An already available econometric model for the state of Ohio estimated the final demand component of this model[14]. Transforming the output forecasts to employment made forecasts of employment.

Table 3.3
Regional Integrated Models
(Linking Methodology)

Author	Year	Scope
Sullivan & Gilless	1990	4 regions of N. Cal.
Stevens, Treyz, and Kindahl	1981	Massachusetts area
Kort & Carwright	1981	All states
L'Esperance	1981	State of Ohio

The Integrated Model of Massachusetts (Stevens et al, 1981)

In this model, a Massachusetts static input-output model (MIO) is linked with the Massachusetts Economic Policy Analysis model (MEPA). In this model. estimates of total direct and indirect effects of some initial change in final demand components of the input-output model are generated using the MIO model. These estimates are then used as input in the MEPA model to predict the effects of expansion of a container port facility in Boston.

A distinctive feature of this model is that it assumes the input-output technical coefficients to be dynamic. Treyz, Friedlander, and Stevens (1980) made this assumption possible by using the technical coefficient equation from an earlier study. The proportion of direct requirements satisfied by local producers, or what is called Regional Purchase Coefficients (RPC), were assumed constant.

A Model of Northern California

Sullivan and Gilless (1990) combine econometric and input-output methods to assess the multiforest personal income impacts of timber harvesting activities on regional economies in Northern California. They argue that the restrictive assumption of a fixed-factor production function may not provide an appropriate paradigm for the analysis of timber harvest impact in some situations. Thus, conditional factor demand relations obtained from a Cobb Douglass production function are estimated for important wood product industries (logging and sawmills) to obtain estimates of the elasticity of substitution between labor and nonlabor-nonwood inputs. The remaining industries are treated with the traditional input-output modeling approach.

The obtained elasticity of substitution is used to adjust for the labor and non-wood input coefficients. These coefficients are then used to get a vector of input demands. This is done by using exogenously determined output of the wood products industry. The input demands are then added to final demand deliveries.

NOTES

Chapter Three

[1] . According to Rey (1997) the terms holistic and partitive were originally used by Jensen (1980) to describe different types of accuracy in input-output models.

[2]. As discussed in chapter 2, this coefficient can be treated as variable.

[3]. The regional technical coefficients are derived from national technical coefficients.

[4]. The identities that held together the I-O table no longer are valid once we have regionalized the table and added a time element (Moghadam and Ballard, 1988)..

[5]. This is done to transform the input-output coefficient values to employment. That is the fraction of a job required to produce one dollar of output in industry j to that of industry i.

[6]. Comparing to Moghadam & Ballard (1988), e_{ji} in this model is what replaces the a_{ji}.

[7] . This is in contradiction with the rule; however, contradicting this rule may be unavoidable in cases where too many inter-industry variables are being added to the equation.

[8]. The PCE is the sectoral distribution of final demand matrix. These coefficients are assumed constant and are projected forward based on the Bureau of Labor Statistics projected values for the United States

[9]. The value of Concol is calculated from a survey of consumer expenditures. It indicates the amount of consumption purchased per dollar of disposable income in an area relative to that amount in the United States (Treyz 1993).

[10]. Since the RPC=R is the proportion of local use that is supplied locally, all exports are supplied locally, therefore X_i is not multiplied by R_i in this equation.

[11]. With respect to the estimation of RPCs, REMI has received a lot of criticism in the literature partly due to the use of old, 1977 census of transportation, and national input-output tables (West, 1994).

[12]. Refers to the general framework that was established in the Chapter Two.

[13]. h includes consumption, investment, government expenditure, and export.

[14]. The Ohio Econometric Model, known as OEM is explained in L'Esperance, Nestel, and Fromm (1969), and in L'Esperance, Nestel, and Fromm (1977).

CHAPTER IV

METHODOLOGY

INTRODUCTION

The model specified in this chapter employs a Restricted Time Varying parameter approach[1] to develop a Dynamic Integrated Model (DIA). This model allows the regional input-output coefficients to change through time. Unlike embedding-partitive models, which account for only partial interaction between sectors, DIA uniquely accounts for interaction amongst all major economic sectors. Unlike embedding holistic approach that treat the regional input-output coefficients as constant through time, in the DIA approach the intermediate input demand is allowed to be dynamically determined in the estimating model. Additionally, DIA employs a unique cost adjustment factor (CAF) to account for inter-sectoral and structural change in the economy of the region.

Alternative model specifications are discussed in this chapter.[2] They include Simple Holistic Approach (SHA), which is an static integrated model; Simple Econometric Approach (SEA), which does not include input-output relationship;

and Restricted Time Varying Parameter Approach (RTVPA), which is a partitive integrated approach[3]. The econometric results of the DIA model will then be compared with these alternatives in Chapter Five.

THE DYNAMIC INTEGRATED MODEL (DIA)

Following Coomes, Olson, and Glennon (1991), Glennon & Lane (1990), and Moghaddam & Ballard (1988) the general framework of an embedding approach can be expressed as the following equation:

(4.1) $E_i = f\ (IIDR_i, FD_i, Z_i)$

where IIDR is an intermediate input demand requirement, FD is a local and national final demand term, and Z is an other variables term.

The theoretical design of the IIDR portion of the above equation is, however, different from the theoretical specification presented by Glennon & Lane, (1990) and the econometric specification of the empirical model is modified to represent the DIA model.

The construction of the DIA model is based on the following specification. Local employment in each sector is a function of an intermediate input demand term, a final demand term, and other related explanatory variables.

$$(4.2) \quad E_i = \beta_0 + \beta_1\, IIDR_i + \beta_2\, FD_i + \beta_3\, Z_i + \varepsilon$$

where E_i is employment in sector i, β_1 $IIDR_i$ is the intermediate input demand requirement component, FD_i is a final regional demand component which consist of typical local and national final demand variables. These variables consist of the national and local activities that can explain variations in local employment in each sector. Z includes productivity, price, or other related variables.

Three features uniquely distinguish the DIA model from the other embedding models.

1. The Intermediate Input Demand Requirement (β_1 $IIDR_i$) for each sector i is related to intermediate input demand requirement originating in all sectors rather than only one or two selected (or so called significant) sectors. This, indeed, defines the holistic model. However, the (β_1 $IIDR_i$) component of the DIA model is simultaneously determined within the system rather than being treated as a single exogenous variable. This has not been the case in holistic models. Additionally, the input-output coefficients that determine the $IIDR_i$ are allowed to be dynamically determined in the DIA model. This is also unique in the DIA model.
2. To account for dynamic inter-industry relationships, the $IIDR_i$ of the DIA model formulates a unique methodology that adjusts the values of regional input-output coefficients through time. The adjustment process is based on the

construction and use of a unique Cost Adjustment Factor (CAF_i) term.

3. Following Glennon & Lane (1990), Coomes, Olson, and Glennon (1991), and other embedding models, standard final demand variables common in both embedding partitive, and embedding holistic approaches are also selected as potential explanatory final demand variables. These variables are modified or other variables are included as needed.

A. The Intermediate demand component of the DIA model

β_1 $IIDR_i$ is the link between the input-output and econometric model and is the core of the DIA model. The term $IIDR_i$ in equation (4.2) can be written as :

(4.3) $IIDR_i = \Sigma_j \, r_{ij} \, X_j$

Where X_j is total regional output of sector j, and r_{ij} is the regional input-output coefficient.

Cost Adjustment Factor (CAF)

Based on George Treyz (1993), and Stevens et al. (1983), variations in regional purchase coefficients can be explained by the relative national and local cost and productivity factors[4]. According to Treyz (1993) the proportion of local demand satisfied by local producers is determined in part by relative profitability. Relative profitability, in turn, depends on relative factor cost and factor productivity for each industry. "Assuming that one price prevails in all markets, given constant returns to scale for all inputs, and that profits or losses arise when the technology in a particular area differs from the average technology in the nation, we can then show that relative profitability depends on relative factor cost and productivity for each industry".[5] Also, according to Stevens et al. (1983) the regional purchase coefficient for a good in a given region is a function of relative local to national delivered costs, which in turn is a function of relative wages, other costs, the ratio of local to national output of that good or service, as well as relative cost of transportation. A profit maximizing firm would purchase its input needs from local manufacturers as long as it is relatively less costly to purchase locally due to technological differences. Relative costs in turn depend on relative wages paid relative productivity, and relative transportation costs.

Hence, it can be argued that, relatively speaking, technological and structural formations in a regional economy can be different from the average national economy in a given period. These differences are in part related to wage and productivity differences. Some of these differences may also be related to geographical, demographic, sociological, and other region-specific factors. Consequently, it can be argued that proportion of input demand required of all industries from an industry i depend on relative technological or structural differences.

An unique cost adjustment factor (CAF) is formulated to account for the relative wage and productivity differences between the region and the national economy relative to a benchmark year. Such measure would adjust the regional input-output coefficients to the degree to which regional economic structure and technology differ from the average national economy. A CAF can be defined as follows:

$$(4.4)\quad CAF_i = \frac{\left(\left[\frac{LPRO_t}{LW_t}\right] \div \left[\frac{LPRO_{87}}{LW_{87}}\right]\right)}{\left(\left[\frac{NPRO_t}{NW_t}\right] \div \left[\frac{NPRO_{87}}{NW_{87}}\right]\right)}$$

CAF (Cost Adjustment Factor) is the ratio of relative local productivity to the wage to that of its benchmark (1987) counterpart, to the ratio of relative national productivity to wage to that of its benchmark (1987) counterpart. Where $LPRO_i$ is a measure of local productivity for sector i, and is defined as per-employee value added. $NPRO_i$ is a measure of national productivity for sector i, and is defined as per-employee value added. LW is average local wage for sector i, and is defined as per-worker wage and salary disbursement. NW is average per-worker national wage and salary disbursement. The subscript 87, is the benchmark year for the input-output tables.

First, the relative differences in average productivity to wage in any given period accounts for differences in technology in a particular area relative to the average technology in the nation. Second, since the regional input-output coefficients are determined for a benchmark year, differences in those relative cost factors over time also explain changes in the input-output coefficient and hence in the local inter-industry relationship.

The values of CAF can be greater than one, one, or less than one. If CAF=1, then it implies that, in comparison with the benchmark year (1987), local productivity to wage ratio has changed in the same proportion as its national counterpart. No change in input-output requirement is expected.

If CAF>1, relatively more of the input requirements are expected to be purchased from national producers and the values of r_{ij} should be adjusted downward. Similarly, if CAF<1, more of the input requirements should be purchased from local producers, and the values of r_{ij} should be adjusted upward.

One explanation for this is that for example if relative local productivity to wage increase faster than that of the average nation, less local input is required to produce the same level of output[6]. So the input-output coefficients would adjust downward. In other words the value of CAF in this case would be greater than one. Changes in the values of regional input-output coefficients, also, are subject to region specific conditions and rigidities accounted for by α coefficient.

The behavior of regional input-output coefficients can then be explained by the following equation:

$$(4.5) \quad r_{ij} = \dot{r}_{ij} + \alpha_i (1 - CAF_i)\ \dot{r}_{ij} = [1 + \alpha_i (1 - CAF_i)]\ \dot{r}_{ij}$$

where $\dot{r}_{ij}$ is regional input-output coefficients at a benchmark year, and CAF_i is the Cost Adjustment Factor for sector i, and α is a coefficient.

Based on equation (4.5) regional input-output coefficients are proportional to the regional input-output coefficients at a benchmark year. The proportionality depends on the cost adjustment factor and a α coefficient. Based on the above discussion, when CAF >1, the value of r_{ij} should adjust downward, and vice versa. Hence the value of $\alpha > 0$ for the equation (4.5).

Inserting equation (4.5) into the equation (4.3) for r_{ij} will result:

$$(4.5\text{-a})\ IIDR_i = \Sigma_j [1 + \alpha_i (1 - CAF_i)]\ \dot{r}_{ij}\ X_j$$

Alternatively:

$$(4.5\text{-b})\ IIDR_i = \Sigma_j\ \theta_i\ \dot{r}_{ij}\ X_j = \theta_i\ \Sigma_j\ \dot{r}_{ij}\ X_j$$

where θ is the term by which regional input-output coefficients adjust through time.

The intermediate input demand component of equation (4.2) can then be written as[6]:

$$(4.6) \quad \beta_1 \, IIDR_i = \Sigma_j \left[(1 + \alpha\,(1 - CAF_i))\right] \dot{r}_{ij} \, A_{ij} \, E_j$$

The term A_{ij} converts the output values into employment and is the inverse ratio of productivity for sectors i and j, respectively, in a given benchmark year. That is:

$$(4.6\text{-a}) \quad A_{ij} = (E_{87i} \,/\, Q_{87i}) \div (E_{87j} \,/\, Q_{87j})$$

where Q_{87i} is total local gross output of industry i for 1987 benchmark year, and E_{87i} is local employment in industry i for 1987 benchmark year.

The process of obtaining these values has been a common practice, given the standard input-output balance equation. Obtaining the total gross output from the input-output balance equation is summarized in Chowdhury (1983, 103)[7]:

> If the static I-O framework is accepted, this implies a relationship between gross output and value-added in each sector. This relationship can be expressed as:
>
> $$VA = B\,Q$$

where B is a matrix with off diagonal elements equal to zero and diagonal elements equal to one minus the column sums of the direct requirement matrix A. A typical element of B on the main diagonal is then:

$$b_{jj} = 1 - \Sigma_i a_{ij}, \;\; j = 1, 2 \; .... \; n$$

Solving for sectoral gross output in terms of value-added results in:

$$Q = B^{-1} \, VA$$

The 1987 values of total gross output can then be obtained given the value added and regional input-output coefficients. That is:

$$(4.6\_b) \;\; Q_i = (1 - \Sigma_i a_{ij})^{-1} \, VA_i, \;\; i = 1, 2 \; .... \; n$$

Substituting (4.6) into equation (4.2) will result:

$$(4.7) \quad E_i = \beta_0 + IIDDOT_i + \alpha_1 \, IDE_i + \beta_2 \, FD_i + \beta_3 \, Z_i + \varepsilon$$

where α_1 is the degree (elasticity) with which change in CAF causes change in r_{ij}. The $IIDDOT_i$ and IDE_i are defined respectively as:

$$(4.7\text{-a}) \qquad IIDDOT_i = \Sigma_j \, \dot{r}_{ij} \, A_{ij} \, E_j$$

$$(4.8) \qquad IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij} E_j$$

β_1 $IIDR_i$ in equation (4.2), unlike intermediate input demand requirement in embedding-partitive models includes intermediate demand for i^{th} industry (selling industry), originating in all j^{th} (purchasing) industries. Equation (4.2) is further expanded to incorporate dynamic, rather than constant, regional input-output coefficients.

B. The final demand components of the DIA model

The second component of the DIA model specification includes the final demand and other related variables. The final demand variables include final local and national demand variables that help explain changes in local employment. The final demand and other related variables were selected based on first, standard final demand variables that are commonly used in embedding approach models [such as Coomes, Olson, & Glennon(1991), Glennon and Lane (1990) or Moghaddam & Ballard (1988)], second, theoretical knowledge of the structure of the regional economy and economic sectors, and third, variables that have been used by others as significant explanatory variables in the similar context[8].

The national variables, defined by Glennon and Lane (1990) as fairly standard variables in econometric modeling, include real wages, net exports, real GNP, and output of the relevant industry. The local variables included local income or earnings such as non-agricultural wage and salary income. Other variables included consumer price index, productivity, mortgage rate, Treasury bill rate, unemployment rate, and average hourly earnings. National variables included in Coomes, Olson, and Glennon (1991), include real output in the corresponding national industry, a moving average of national productivity, and mortgage rates, and local variables include local income, quarterly wages paid, and a time trend. A more detail of the selection process is given in Chapter V (The Econometric Results)

C. The econometric Specification of the DIA model

The full model specification and the econometric results associated with that is presented in tables 5.1, 5.2, and 5.3. Table 5.1 provides full specifications of the Dynamic Integrated Approach (DIA) model of equation (4.7). The selection of the explanatory variables were based on the following:

1. In addition to the intermediate input demand (IIDR) component, each equation consists of a basic section, and an other variables section.
2. The basic section of each equation include national activity variable, a national productivity variable, and a local activity variable. The standard national variable for each sector is the corresponding real

national output for that sector. The national productivity variable is the average of national private non-farm productivity. The standard local activity variable is the real local wage and salary disbursement. Changes in local employment in each sector was determined to be explained by real local earnings and the corresponding national output of that sector.

3. The other variables section include variables such as a 1973 dummy variable, a local unemployment rate variable, a 30-year mortgage rate variable, and a Treasury bill rate variable. The 1973 dummy variable accounts for the oil shocks of 1973-1975, and 1979-1983.
4. The lagged values of the dependent variables were tested for one and four lag significance. Since the data were quarterly data, a lag of length four accounts for the same period employment a year ago which could capture seasonality. The lag values that were not significant were dropped out of the equation. The same applied to national and local variables. If they were not significant, they were dropped out.
5. The mortgage rate was used in construction equation, local unemployment was used as a labor constraints variable in mining, and a treasury bill rate variable was used in manufacturing and in finance sector.

The DIA model consists of 15 equations which include seven stochastic equations, and 8 identities. The structure of the DIA model specification is given in Table 5.1.

ALTERNATIVE SPECIFICATIONS

Alternative specifications, which include current relevant regional model specifications, are constructed to be compared with the DIA model specification. These models include an embedded holistic model (SWH), an embedded partitive model (PAR), an embedded partitive time varying parameter approach (RTV), and a simple econometric model (SECON).

The specification for the simple holistic model which is the type of model used by Coomes, Olson, and Glennon (1991) is obtained by removing the dynamic properties of the Intermediate Input Demand Requirement component. Equation (4.7) can then be written as:

$$(4.9) \quad E_i = \beta_0 + \beta_1 \, IIDR_i + \beta_2 \, FD_i + \beta_3 \, Z_i + \varepsilon$$

where

$$(4.10) \quad IIDR_i = \Sigma_j \, A_{ij} \, \dot{r}_{ij} \, E_{ij}$$

where j = 2, 3, ... 8

The specification for the simple econometric model is obtained by dropping the intermediate input demand components from equation (4.7). That is:

$$(4.11)\quad E_i = \beta_0 + \beta_2\, FD_i + \beta_3\, Z_i + \varepsilon$$

The specification for the partitive, time-varying-parmaeter approach type (of Glennon and Lane 1990) (RTV) was obtained as follows:

- The IIDR component of equation (4.2) was limited to only those sectors that were considered important interactive sectors.
- The importance of each sector was, in turn, determined based on a minimum value of .05 in the direct requirement coefficient matrix as in table (4.2). If there were more than one cell in a row which were larger, two of the largest were included.[9]
- The values of r_{ij}, following Glennon & Lane (1990) were assumed to be determined as follows:

$$(4.12)\ r_{ij} = \dot{r}_{ij} + \alpha_1\, \mu_{i,\,t-1} + \alpha_2\, \pi_{i,\,t-1}$$

where μ refers to a four-quarter moving average of the difference between the ratio of average regional wages to average national wages in time t to that in the base year in industry i, and π refers to the similarly measured relative difference in a productivity measure.

The final form of this equation would be as follows:

$$(4.13)\quad E_i = \beta_0 + \dot{r}_{ij}\ A_{ij}\ E_j + \alpha_1\ \mu_i(-1)\ A_{ij}\ E_j + \alpha_2\ \pi_i(-1)\ A_{ij}\ E_j + \beta_2\ F^r_i + \beta_3\ F^z_i + \beta_4\ \Gamma_i + \varepsilon$$

The specification for the simple partitive approach (PAR) is similar to RTV, with the exception that no reservation is made for the behavior of the input-output coefficient change through time. The final form the equation in this case would be:

$$(4.14)\quad E_i = \beta_0 + \sum_j \beta_k\ \dot{r}_{ij}\ A_{ij}\ E_j + \beta_2\ F^r_i + \beta_3\ F^z_i + \beta_4\ \Gamma_i + \varepsilon$$

where j could take any value in the range of 2 to 8.

ESTIMATION METHODS AND MODLE SOLUTION

Estimation Methodology

Two estimation methods are used to test the DIA model: 2SLS (Two Stage Least Square), and OLS (Ordinary Least Square). The estimation results were obtained using the FAIR-PARK program.[10] All other model specifications were solved using OLS.

1. OLS

Based on Kennedy (1996), in a system of simultaneous equations, the endogenous variables used as regressors may not be distributed independently of the disturbance term. This means that they are contemporaneously correlated with the disturbance term. Hence the OLS estimator is biased, even asymptotically. Kennedy (1996) argues that it is possible to use *OLS* estimator and simply accept its asymptotic bias on the grounds that:

1. According to Monte Carlo studies, the properties of the OLS estimators are less sensitive than the alternative estimators to the presence of estimation problems such as multicollinearity, errors in variables or mis-specifications.
2. OLS can be useful as a preliminary or exploratory estimator.
3. If a simultaneous equation system is recursive, OLS is no longer asymptotically biased and is unbiased if there are no lagged endogenous variables and no correlation between disturbances in different equations.

2. <u>2SLS</u>

OLS estimators in a system of simultaneous equations, according to Kennedy (1996), where endogenous variables used as regressors might contemporaneously be correlated with the disturbance term, may be biased and an alternative estimator is necessary. The 2SLS approach can be selected as a special case of the *instrumental variable technique (IV)* in situations in which there is possibility that the independent variable is not independent of the disturbance term. or there are errors in variables. Kennedy (1996. 136) argues that the IV procedure produces a consistent estimator in a situation in which a regressor is contemporaneously correlated with the error term. The big problem with the use of IV approach, Kennedy (1996) argues. is finding appropriate instrumental variables. A natural suggestion is to combine all the exogenous variables to create a combined variable to act as a best instrumental variable. This defines the *2SLS* procedure.[11] This argument. following Kennedy (1996). can be defended in several ways:

1. Majority of equations in the DIA model include a lagged dependent variable that appear as an independent variable. Since a lagged dependent variable is. in turn determined by the previous period's disturbance. it is stochastic and cannot be considered fixed. This can cause the regressors to be contemporaneously correlated with the error term. In this case the *OLS* estimator is biased.

When there exist contemporaneous correlation between the disturbance and a regressor the search for alternative estimators is conducted on the basis of their asymptotic properties. The most common estimator used in this context is the *instrumental variable (IV)* estimator.

2. *Errors in measuring* the independent variables can make the independent variables stochastic which results in an estimating equation that has

a disturbance that is contemporaneously correlated with a regressor. Kennedy (1996) argues that there are two basic approaches to estimation in the presence of *errors in variables*. One is *Weighted Regression*, and the other is *Instrumental Variable (IV)*.

3. In a system of simultaneous equations, all the endogenous variables are random variables. A change in any disturbance term changes all the endogenous variables since they are determined simultaneously. This will make the disturbances to be positively correlated with the regressors which, in turn, result in a biased OLS estimator.

Simulation Technique

The DIA model, as well as the alternative specifications, is solved simultaneously using a *dynamic* methodology. According to Fair (1984, 248) a dynamic simulation is one in which the predicted values of the endogenous variables from the solutions for the previous periods are used for the values of the lagged endogenous variables for the solution for the current period. A static solution or simulation is one in which the actual values of the predetermined variables are used for the solution each period. Predetermined variables include both exogenous and lagged endogenous variables. The Gauss-Seidel technique is used to solve the such model[12].

Use of Durbin Watson Statistic (DW)

According to Kennedy (1996) the most popular way of detecting first order autocorrelation is the Durbin-Watson test (d statistics). When the parameter ρ of the first-order autocorrelation case is zero (no autocorrelation), the d statistic is approximately 2.0. The further away the d statistic is from 2.0, the less confident one can be that there is no autocorrelation in the disturbnace (Kennedy 1996, 121).

Although, based on Kennedy (1996)[13] the DW test is biased towards not finding autocorrelated errors whenever a lagged value of the dependent variable appears as a regressor, following Fair (1984) the DW test is still included in the presentation of results for each equation. "Since the DW statistic is biased toward acceptance of the hypothesis of no serial correlation when there are lagged dependent variables, a value that rejects the hypothesis indicates that there are likely to be problems. The DW test is thus useful for testing in one direction. (Fair 1984)."

Problem of Serial Correlation

To effectively deal with the problem of serial correlation, Fair (1984) treats serial correlation coefficients as structural coefficients which can be transformed into equations with serially uncorrelated error terms. "It will be useful to consider this transformation first because once it has been done, little more needs to be said about serial correlation (Fair 1984)". Each equation is estimated under the assumption of serial correlation. Then the hypothesis that the serial correlation coefficients are zero is tested. If the coefficients are insignificant, they are removed from the system.

Predictive Accuracy of the Model

The three most common measures of predictive accuracy[14], root mean squared error (RMSE), mean absolute error (MAE), and Theil's inequality coefficient (U) are used and compared across all models to evaluate the predictive accuracy of the models. These measure have been used to evaluate ex ante and ex post forecasts.

$$(4.26) \qquad RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_{it} - \hat{Y}_{it})^2}$$

$$(4.27) \qquad MAE = \frac{1}{T}\sum_{t=1}^{T}\left|Y_{it} - \hat{Y}_{it}\right|$$

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\Delta Y_{it} - \Delta\hat{Y}_{it})^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\Delta Y_{it})^2}} \tag{4.28}$$

If the forecasts are perfect, the values of all three measures are zero. If U=1, the forecast is no change, and U>1 indicates the forecast is less accurate than the simple forecast of no change (Fair 1984, Kennedy 1996).

DATA

This study emphasizes the quarterly levels of employment in seven major economic sectors of the state of Oklahoma. The data cover the period from 1969 to 1994. The major economic sectors of our interest are presented in table 4.1. An alphabetical list of raw data are given in appendix A. Table A1. An alphabetical list of model variables are given in appendix A, Table A2.

The local (state) data is regularly available from the ORIGINS data base system of the Center for Economic and Management Research (CEMR), the *University of Oklahoma*. The ORIGINS data base is regularly updated in cooperation with the department of commerce, Bureau of Economic Analysis (BEA). Other sources for regional and national data include BEA, US Department of Commerce; Bureau of Labor Statistics (BLS) publications: and STAT-USA internet site. Data for interest rates and prices were obtained from FAIRMODEL. a national econometric forecasting model[15]. The data for the direct requirement coefficient (regional input-output) were constructed in the Center for Economic and Management Research using version 5 of ADOTMATR.

Table 4.1

Major Economic Sectors
State of Oklahoma

SECTOR ID	SIC	NAME	ABBREVIATED
1	07 – 09	Agriculture	AG
2	10 – 14	Mining	MIN
3	15 – 17	Construction	CONS
4	20 – 37	Manufacturing	MAN
5	40 – 49	Tran, Comm, Pub U	TCPU
6	50 – 59	Trade	TRA
7	60 – 67	Fin, Ins, & R.E.	FIRE
8	70 – 89	Services	SER
9		Government	GOV

NOTES

Chapter Four

[1] . For a discussion of both "Time Varying Parameters," and "Restricted Parameters," see Fomby, Hill, and Johnson (1984).

[2] . For a detailed discussion of most of these alternative specifications refer to Chapter 3.

[3] . This approach is the approach used by Glennon & Lane (1990).

[4] . Notice that the word Regional Purchase Coefficients (RPC), and not regional input-output coefficients, has been used here. The two have different definition. RPC refers to a proportion of a good or service used to fulfill demands in a region which is supplied by the region to itself rather than being imported.

[5] See Treyz (1993) page 314.

[6] . This would occur if local producers do not attempt to satisfy more of their input requirement from local vs national producers. If more of the input required is purchased locally, however, the effect on wage and value added per employee would result in a CAF of less than one.

[7] . β_1 would have been an estimated average value of A_{ij}'s. when A_{ij}s are available for all the r_{ij}s then β_1 does not have to be estimated and can be assumed to take a value of one in equation (4.5). Equation (4.5) is also similar to equation (8.11) of

Glennon and Lane(1990). That is: β_l $IIR_j = r_{ij}$ A L_i where IIR is the intermediate input requirement, and L stands for employment.

[8] . I have used, in this quotation, symbol Q instead of X for total gross output, and VA in place of Y for value added output.

[9] . See Fair (1994, 73) for discussion of adding additional explanatory variables.

[10] . There is not any specific rule for the minimum value. Glennon and Lane (1990) have used .03 to be the minimum value. However, they would select the largest two if there was more than one cell that would qualify.

[11] . The Fair-Park Program allows one to estimate and analyze dynamic, nonlinear, simultaneous equations models. These models can be rational expectations models, and they can have autoregressive errors of any order. The estimation techniques include OLS, 2SLS, 3SLS, FIML, LAD, 2SLAD, and some versions of Hansen's method of moments estimator. Stochastic simulation is one of the key options available to analyze models. There are also a number of single equation testing options. All of the methods in the program are discussed in Fair (1984), and Fair (1994).

[12] . A good instrumental variable is one that is highly correlated with the regressor for which it is acting as an instrument. This suggest regressing each endogenous variable being used as a regressor on all the exogenous variables in the sstem and using the estimated values of these endogenous variables from this regression as the required instrumental variables. (Each estimated value is the best instrumental

variable int ehsense that, of all combinations of the exogenous variables, it has highest correlation with the endogenous variable.) (Kennedy 1996, 159)

[13] . see Fair (1984) for more a more detailed discussion of this subject.

[14] . See Kennedy (1996), page 128 for details.

[15] . For a discussion of Evaluation Predictive Accuracy, see Fair (1984)

[16] . FAIRMODEL is a macroeconometric model of the U.S. economy developed by professor Ray C. Fair of Yale University. It was developed in 1976 and has been used since then for research, forecasting, policy analysis, and teaching. The most recent description of the model is in Fair (1994).

CHAPTER V

ECONOMETRIC RESULTS

The full model specification and the econometric results associated with that is presented in tables 5.1. 5.2, and 5.3. Table 5.1 provides full specifications of the Dynamic Integrated Approach (DIA) model of equation (4.2). The selection of the explanatory variables were based on the following:

1. In addition to the intermediate input demand (IIDR) component. each equation consisted of a basic section, and an other-variables section.
2. The basic section of each equation includes a constant. a lagged value of the dependent variable, a national activity variable. a national productivity variable. and a local activity variable. The standard national variable for each sector is the corresponding real national output for that sector. The national productivity variable is the average of national private non-farm productivity. The standard local activity variable is the real local wage and salary disbursement.
3. The other variables section includes variables such as a 1973 dummy variable, a local unemployment rate variable, a 30-year mortgage rate variable, and a Treasury bill rate variable.
4. The lagged values of the dependent variables were tested for one and

four lag significance. Since the data were quarterly data, a lag of length four accounts for the same period employment a year ago which captures seasonality. The lag values that were not significant were dropped out of the equation. The same applied to national and local variables. If they were not significant were dropped out.

5. The mortgage rate was used in construction equation, local unemployment was used as a labor constraints variable in mining, and a treasury bill rate variable was used in manufacturing and in finance sector.

The DIA model consists of 15 equations which include seven stochastic equations, and 8 identities. The structure of the DIA model specification is given in Table 5.1.

Equations in the DIA model are numbered to represent the order of their corresponding SIC class. The equations were specified using a pool of standard national and local demand variables. Each equation was specified using knowledge of the structure of that industry and its relationship with other industries that is reflected in the input-output tables. The pool of explanatory (right hand side) variables were collected from Glennon & Lane (1990), Coomes, Olson, and Glennon (1991), and other standard local and national final demand variables.

Table 5.1
The structural model of
Dynamic Integration Approach (DIA)

$$E2 = IIDDOT2 + \beta_{21}\, E2(-1) + \alpha_2\, (1\text{-}CAF2)\, IIDDOT2 + \beta_{22}\, RGDP2 + \beta_{23}\, RLWSDT + \beta_{24}\, LU + \varepsilon_2$$

$$E3 = IIDDOT3 + \alpha_3\, (1\text{-}CAF3)\, IIDDOT3 + \beta_{31}\, NWPNF + \beta_{32}\, RLWSDT + \beta_{33}\, MR30 + \varepsilon_3$$

$$E4 = IIDDOT4 + \alpha_4\, (1\text{-}CAF4)\, IIDDOT4 + \beta_{42}\, RLWSDT + \beta_{42}\, RGDP4 + \beta_{43}\, NWPNF + \beta_{44}\, DTB63 + \varepsilon_4$$

$$E5 = IIDDOT5 + \beta_{50} + \beta_{51}\, E5(-1) + \alpha_5\, (1\text{-}CAF5)\, IIDDOT5 + \beta_{52}\, LOGNPRPNF + \beta_{53}\, RLWSDT + \varepsilon_5$$

$$E6 = IIDDOT6 + \beta_{60} + \beta_{61}\, E6(-4) + \alpha_6\, (1\text{-}CAF6)\, IIDDOT6 + \beta_{62}\, RGDP6 + \beta_{63}\, RLWSDT + \varepsilon_6$$

$$E7 = IIDDOT7 + \beta_{71}\, E7(-1) + \beta_{72}\, E7(-4) + \alpha_7\, (1\text{-}CAF7)\, IIDDOT7 + \beta_{73}\, RLWSDT + \beta_{74}\, TB3 + \varepsilon_7$$

$$E8 = IIDDOT8 + \beta_{80} + \beta_{81}\, E8(-1) + \alpha_8\, (1\text{-}CAF8)\, IIDDOT8 + \beta_{82}\, RGDP8 + \beta_{83}\, RLWSDT + \varepsilon_8$$

$$IDE2 = (1\text{-}CAF2)\, (A_{21}\, r_{21}\, E1 + A_{22}\, r_{22}\, E2 + A_{23}\, r_{23}\, E3 + A_{24}\, r_{24}\, E4 + A_{25}\, r_{25}\, E5 + A_{26}\, r_{26}\, E6 + A_{27}\, r_{27}\, E7 + A_{28}\, r_{28}\, E8 + A_{29}\, r_{29}\, E9)$$

$$IDE3 = (1\text{-}CAF3)\, (A_{31}\, r_{31}\, E1 + A_{32}\, r_{32}\, E2 + A_{33}\, r_{33}\, E3 + A_{34}\, r_{34}\, E4 + A_{35}\, r_{35}\, E5 + A_{36}\, r_{36}\, E6 + A_{37}\, r_{37}\, E7 + A_{38}\, r_{38}\, E8 + A_{39}\, r_{39}\, E9)$$

$$IDE4 = (1\text{-}CAF4)\, (A_{41}\, r_{41}\, E1 + A_{42}\, r_{42}\, E2 + A_{43}\, r_{43}\, E3 + A_{44}\, r_{44}\, E4 + A_{45}\, r_{45}\, E5 + A_{46}\, r_{46}\, E8 + A_{47}\, r_{47}\, E7 + A_{48}\, r_{48}\, E8 + A_{49}\, r_{49}\, E9)$$

$$IDE5 = (1\text{-}CAF5)\, (A_{51}\, r_{51}\, E1 + A_{52}\, r_{52}\, E2 + A_{53}\, r_{53}\, E3 + A_{54}\, r_{54}\, E4 + A_{55}\, r_{55}\, E5 + A_{56}\, r_{56}\, E8 + A_{57}\, r_{57}\, E7 + A_{58}\, r_{58}\, E8 + A_{59}\, r_{59}\, E9)$$

$$IDE6 = (1\text{-}CAF6)\, (A_{61}\, r_{61}\, E1 + A_{62}\, r_{62}\, E2 + A_{63}\, r_{63}\, E3 + A_{64}\, r_{64}\, E4 + A_{65}\, r_{65}\, E5 + A_{66}\, r_{66}\, E6 + A_{67}\, r_{67}\, E7 + A_{68}\, r_{68}\, E8 + A_{69}\, r_{69}\, E9)$$

$$IDE7 = (1\text{-}CAF7)\, (A_{71}\, r_{71}\, E1 + A_{72}\, r_{72}\, E2 + A_{73}\, r_{73}\, E3 + A_{74}\, r_{74}\, E4 + A_{75}\, r_{75}\, E5 + A_{76}\, r_{76}\, E6 + A_{77}\, r_{77}\, E7 + A_{78}\, r_{78}\, E6 + A_{79}\, r_{79}\, E9)$$

$$IDE8 = (1\text{-}CAF8)\, (A_{81}\, r_{81}\, E1 + A_{82}\, r_{82}\, E2 + A_{83}\, r_{83}\, E3 + A_{84}\, r_{84}\, E4 + A_{85}\, r_{85}\, E5 + A_{86}\, r_{86}\, E6 + A_{87}\, r_{87}\, E7 + A_{88}\, r_{88}\, E8 + A_{89}\, r_{89}\, E9)$$

$$EPNF = E2 + E3 + E4 + E5 + E6 + E7 + E8$$

The following is a description of variables used in this table in the order they were used in the equations. Subscripts 1-9 refer respectively to Agriculture, Mining, Construction, Manufacturing, TCPU, Trade, FIRE, Services, and Government. E_i refers to employment, and IIDDOT refers to Intermediate Input Demand for industry i generated from all j industries. IDE refers to adjusted intermediate input demand and equals (1-CAF_i) $IIDDOT_i$. RGDP is real gross domestic product, D73 is a dummy variable representing oil shock, NWPNF is average national private-non-farm wage, MR30 is 30 years mortgage rate, DTB63 is the difference of 6 months and 3 months T-bill), GDP is gross domestic product, NPRPNF is national private-non-farm productivity, RLWSDT is real total wage and salary disbursement, LU is local unemployment, TB3 is 3 month T-bill rate, and EPNF is total private-non-farm employment. r_{ij} is regional input-output coefficient for 1987. A_{ij} is the inverse value of gross output to employment in industry i, relative to industry j.

Equation 2: Local employment in Mining sector (SIC 10 – 14) is determined by the output of Mining industry and total real local earnings in addition to an intermediate input demand component. Additionally, a dummy variable was used to account for 1973 and 1979 oil shock, and local unemployment was used as a labor constraint variable.

Equation number = 2 (Mining)
****

Dependent variable = Local Employment-Mining

Explanatory Variables		**Coef est**	**SE**	**T statistic**
IEDDOT2	Intermediate Demand-1987	1.000	——	——
E2(-1)	Local Employment-Mining`	0.74	0.048	15.29
IDE2*	Intermediate Demand Term	2.69	1.761	1.68
RGDP2	Real GDP-Mining	1.1E-04	2.6E-5	4.20
RLWSDT	Real Local Earnings	0.02	0.008	1.75
D73	Dummy Variable	1.92	1.094	2.03
LU	Local Unemployment	-0.05	0.015	-2.98
RHO(-1)		0.47	0.119	3.97

SE of equation	=	1.71
Sum of squared residual	=	248.54
Average absolute error	=	1.09
Sum of ABS residuals	=	100.87
R squared	=	0.99
Durbin-Watson statistic	=	2.04
SMPL and No. Obs.	=	1972.1 1994.4 92

* $IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij}$ {CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

Equation 3: Local employment in construction (SIC 15-17) is determined by national average non-farm-wage, and local real earnings in addition to an intermediate input demand term. Average national wage was used, following Glennon & Lane (1990), since the real output of the national construction industry was not significant while average national wage rate was determined to be a significant factor. A 30 years mortgage rate was used to account for the effects of interest rate. The estimated coefficients and their corresponding signs were all significant.

Equation number = 3 (Construction)
****

Dependent variable = Local Employment-Construction

		Coef est	SE	T statistic
IEDDOT3	Intermediate Demand-1987	1.000	------	------
IDE3*	Intermediate demand term	0.89	0.309	2.86
NWPNF	Average national wage	- 0.93	0.197	-4.74
RLWSDT	Real local earnings	0.21	0.018	11.04
MR30	30 year mortgage rate	-0.17	0.137	-1.23
RHO(-1)		0.99	0.082	11.94
RHO(-2)		-0.78	0.109	-7.11
RHO(-3)		0.73	0.082	8.87

SE of equation	=	1.07		
Sum of squared residuals	=	97.97		
Average absolute error	=	.77		
Sum of ABS residuals	=	70.78		
R squared	=	0.94		
Durbin-Watson statistic	=	2.01		
SMPL and No. Obs.	=	1972.1	1994.4	92

* $IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij}$ [CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

Equation 4: Local employment in Manufacturing sector is determined by the corresponding national manufacturing industry, and national productivity in addition to an intermediate input demand term. Local basic variables were insignificant and difference between six and three month treasury bill was also used to account for the effect of change in rate of interest.

Equation number = 4 (Manufacturing)
****

Dependent variable = Local Employment-Manufacturing

		Coef est	SE	*T statistic*
IEDDOT4	Intermediate Demand-1987	1.000	——	——
E4(-1)	Employment_Manufacturing	0.55	0.019	28.66
IDE4*	Intermediate Demand Term	0.15	0.131	1.14
RGDP4	Real GDP-Manufacturing	1.8E-5	4.0E-6	4.58
NPRPNF	National Productivity	-5.4E-4	0.2440	- 2.50
DTB63	Measure of T-Bill rate	-2.18	0.871	- 2.51
RHO(-1)		0.39	0.109	3.62

SE of equation	=	1.56
Sum of squared residuals	=	211.07
Average absolute error	=	1.16
Sum of ABS residuals	=	107.39
R squared	=	0.97
Durbin-Watson statistic	=	2.09
SMPL and No. Obs.	=	1972.1 1994.4 92

* $IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij}$ [CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

Equation 5: Local Transportation, Communication & Public Utility employment is determined by the national output of the corresponding industry and national productivity in addition to an intermediate input demand term. This sector corresponds with the SIC (40-49).

Equation number = 5 (Transportation, Communication, Public Utility)
****

Dependent variable = Local Employment - TCPU

		Coef est	SE	T statistic
IEDDOT5	Intermediate Demand-1987	1.000	——	——
CNST	Constant	6.05	2.390	2.53
E5(-1)	Employment_TCPU	0.03	0.033	16.30
IDE5*	Intermediate Demand Term	0.10	0.101	2.48
LGNPRPN	LOG(National Productivity)	-0.29	0.299	-1.24
RLWSDT	Real Local Earnings	0.01	0.006	1.51

SE of equation	=	0.621
Sum of squared residual	=	33.571
Average absolute error	=	0.473
Sum of ABS residuals	=	43.56
R squared	=	0.969
Durbin-Watson statistic	=	1.997
SMPL and No. Obs.	=	1972.1 1994.4 92

* $IDE_i = \Sigma_j (1 - CAF_j) A_{ij} \dot{r}_{ij}$ [CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

Equation 6: Local employment in Trade sector is determined by real output of its corresponding national industry, and real local earnings in addition to an intermediate input demand term. A lagged value of the dependent variable was also significant and was not removed from the equation.

Equation number = 6 (Trade)
****

Dependent variable = Local Employment - Trade

		Coef est	SE	T statistic
IEDDOT6	Intermediate Demand-1987	1.000	------	------
E6(-4)	Employment-Manufacturing	0.50	0.062	8.11
IDE6*	Intermediate demand term	1.16	0.672	1.72
RLWSDT	Real local earnings-total	0.31	0.086	3.69
RGDP6	Real GDP - Manufacturing	3.1E-5	1.4E-5	2.23
RHO(-1)		0.521	0.113	4.62

SE of equation	=	3.367
Sum of squared residual	=	975.363
Average absolute error	=	2.285
Sum of ABS residuals	=	210.246
R squared	=	0.99
Durbin-Watson statistic	=	1.98
SMPL and No. Obs.	=	1972.1 1994.4 92

* $IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij}$ [CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

***Equation** 7:* Local employment in Finance, Insurance, and Real estate industry is determined by real output of the corresponding national industry, real local earnings, and 3 months treasury bill rate in addition to an intermediate input demand term. Additionally two lagged values of the dependent variables were significant and were not removed.

Equation number = 7 (Finance, Insurance, Real-Estate)
****

Dependent variable = Local employment - FIRE

		Coef est	SE	T statistic
IEDDOT7	Intermediate Demand-1987	1.000	——	——
E7(-1)	Employment-FIR	0.16	0.083	1.96
E7(-4)	Employment-FIR	0.43	0.064	6.70
IDE7*	Intermediate Demand	0.14	0.077	1.87
RLWSDT	Real Local Earnings	0.05	0.009	5.07
TB3	Treasury Bill rate	0.04	0.049	0.09
RHO(-1)		0.36	0.136	2.64

SE of equation	=	0.539
Sum of squared residuals	=	25.070
Average absolute error	=	0.421
Sum of ABS residuals	=	38.803
R squared	=	0.992
Durbin-Watson statistic	=	1.977

SMPL and No. Obs. = 1972.1 1994.4 92

* $IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij}$ [CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

Equation 8: Local employment in Services is determined by the real output of the corresponding national industry, and real local earnings in addition to an intermediate input demand term. Other variables include a constant and a one period lag.

Equation number = 8 (Services)
****

Dependent variable = Local Employment - Services

		Coef est	SE	T statistic
IEDDOT8	Intermediate Demand-1987	1.000	——	——
CNST	Constant	- 8.5	3.780	- 2.27
E8(-1)	Employment-Services	0.62	0.045	13.74
IDE8*	Intermediate demand term	0.06	0.028	2.19
RGDP8	Real GDP - Services	3.3E-5	9.80E-6	3.44
RLWSDT	Real Local Earnings	0.09	0.030	3.09

SE of equation	=	2.591
Sum of squared residual	=	584.216
Average absolute error	=	2.002
Sum of ABS residuals	=	184.185
R squared	=	0.997
Durbin-Watson statistic	=	1.815
SMPL and No. Obs.	=	1972.1 1994.4 92

* $IDE_i = \Sigma_j (1 - CAF_i) A_{ij} \dot{r}_{ij}$ [CAF is Cost adjustment Factor, r_{ij} is constant i-o values, and A is the ratio of inverse of productivity in i and j sectors.

The econometric results of the dynamic integrated approach are then compared with the econometric results obtained from alternative model specifications, which are presented in tables 5.2 and 5.3. Alternative model specifications include an Ordinary Least Square Estimation of the DIA, Simple Holistic (SWH), Simple Econometric, a partitive approach, and a Time Varying Parameter Approach (TVPA). The structural forms of these specifications are discussed in "Alternative Specifications" section presented earlier in this chapter.

With regard to the simple holistic specification, the SWH was first solved using the total output values to calculate A_{ij} values. Whenever the A_{ij} values were based on total output and not total value added, the intermediate input demand variable in a sector in the model of the simple holistic was almost perfectly correlated with employment in the corresponding industry, and was highly correlated with the lagged values of the dependent (employment) variable and other independent variables. Coomes, Olson, and Glennon (1991) seem to have avoided this problem by using value added to calculate the inverse productivity ratios (A_{ij}).

To avoid the statistical problems of model solution the intermediate input demand component of the SWH model was lagged at least one period, and the lagged values of the dependent variable were removed from the corresponding equations. However the problem of multicollinearity seem to have remained significant.

Second, the simple holistic model was solved using value added instead of total gross output (same specification given by Coomes, Olson, and Glennon 1991). No lagged values of the intermediate demand terms had to be selected and no lagged values of the independent variables had to be removed from the equations. The comparison across models was, however based on the second approach.

Similar problems appeared with the TVP Approach. Since this model was expected to be a model of the type introduced by Glennon and Lane (1990), a *mean value of productivity ratios* were calculated to determine the intermediate demands rather than individual A_{ij} measures. This was in line with Glennon & lane (1990) methodology.

The statistics used to compare and analyze each of the individual equations include Percentage Root Mean Square Error (PRMSE), R-Square (R^2), Durbin Watson Statistics (DW), and Theil's Inequality Statistic (U). Tables 5.2, 5.3, and 5.3-U compare these statistics obtained from the DIA approach with the same statistics obtained from alternative model specifications. Table 5.2, in turn, compares R^2 and Durbin Watson (DW) Statistics for all of the specifications.

Table 5.3 compares the predictive accuracy of the DIA with alternative specifications. Table 5.3 consistently attests the superiority of the dynamic integration approach (DIA) to alternative specifications. In terms of predictive accuracy, almost all measures point to the superiority of the DIA specification.

PRMSE was the lowest in all equations for the DIA specification. For Theil's Inequality (U), Table 5.3-U, DIA dominated other specifications. All of the other specifications have either higher PRMSE, or Theil's U statistic", which indicate the gain in predictive accuracy as a result of DIA adding additional structural information. Any form of embedding integration has clearly a better predictive accuracy than econometric model, which is in line with current theories. Additionally, the holistic approach exhibits a better predictive accuracy than the other embedding approaches except the DIA approach. This is also in line with current theories.

ESTIMATED INPUT-OUTPUT COEFFICIENTS:

As previously stated, one of the capabilities of the DIA is that the regional input-output coefficients (r_{ij}) can be updated through time. The updated average annual r_{ij} for some selected sectors are presented in Table 5.4. The r_{ij} updates for all sectors are given in appendix B, Table B1.

The calculation of the regional input-output coefficients is based on the equation (4.5). The 1987 values are equal to the given values for the benchmark year 1987.

As shown in table 5.6 and the table B1 of appendix B, the strength of the relationships between the industries in most cases have increased. For example, The values of r_{25} indicate that dependency of local transportation on local mining has risen since 1987, and the pattern for r_{42} (Manufacturing / Mining), suggests that the dependency of local mining on local manufacturing has increased at times and decreased at other times. During 1973-1975 the dependency of mining on manufacturing has slightly increased. After the oil shock of 1979 the dependency of mining on manufacturing has increased more dramatically and has tapered off after 1982.

Table 5.2
Comparison of R^2 and DW statistics across all model specifications

	R^2						DW					
	DIA		Alternative Specification				DIA		Alternative Specification			
	OLS	**2SLS**	**SWH**	**ECON**	**PAR**	**RTV**	**OLS**	**2SLS**	**SWH**	**ECON**	**PAR**	**RTV**
E2	0.992	0.992	0.989	0.992	0.992	0.992	2.04	2.04	1.54	2.07	2.07	2.07
E3	0.943	0.943	0.958	0.938	0.938	0.938	1.97	2.01	2.16	1.84	1.85	1.85
E4	0.968	0.968	0.966	0.967	0.963	0.974	2.09	2.09	1.79	1.86	2.20	1.98
E5	0.969	0.969	0.966	0.967	0.974	0.974	1.96	1.99	1.54	1.92	1.89	2.32
E6	0.986	0.986	0.986	0.986	0.988	0.978	1.98	1.98	1.92	1.99	2.06	1.96
E7	0.992	0.992	0.992	0.992	0.992	0.992	1.98	1.98	1.98	2.01	1.97	1.99
E8	0.997	0.997	0.997	0.996	0.997	0.997	1.83	1.82	1.64	1.85	1.70	1.84

Note: DIA is the Dynamic Integrated Approach model, SWH is a holistic model. Econ is an econometric model. PAR is a partitive approach model. and RTV is a time varying partitive model.

Table 5.3
Comparing the predictive accuracy across all model specification

	PRMSE						MAE %					
	DIA		Alternative Models				DIA		Alternative Models			
	OLS	**2SLS**	**SWH**	**ECON**	**PAR**	**RTV**	**OLS**	**2SLS**	**SWH**	**ECON**	**PAR**	**RTV**
E2	6.39	6.19	9.37	6.83	6.83	6.83	5.29	5.19	7.93	5.76	5.76	5.76
E3	5.68	5.43	5.86	11.94	11.94	11.94	4.40	4.24	4.72	9.31	9.31	9.31
E4	1.49	1.50	15.62	4.44	4.17	3.77	1.11	1.12	14.45	3.69	3.36	2.86
E5	1.14	1.14	1.55	4.58	2.12	2.61	0.98	0.97	1.27	3.83	1.78	2.07
E6	1.78	1.79	2.55	2.43	2.48	2.31	1.41	1.41	2.03	1.94	1.99	1.74
E7	1.20	1.19	1.67	1.84	1.61	1.79	0.95	0.93	1.31	1.42	1.28	1.38
E8	1.46	1.46	1.86	2.95	2.37	28.64	1.18	1.18	2.51	2.28	1.91	28.3
EPNF	1.31	1.31	1.92	2.69	2.47	4.84	3.14	3.11	1.56	2.09	1.94	7.84

Note: PRMSE is Percent Mean Square Error, and MAE is Mean Absolute Error. DIA is the Dynamic Integrated Approach model, SWH is a holistic model, Econ is an econometric model, PAR is a partitive approach model, and RTV is a time varying partitive model. All numbers in percent.

Table 5.3-U
Comparison of alternative specifications
Theil's Inequality (U)

	OLS	2SLS	SWH	ECON	PAR	TVP
E2	0.560	0.558	0.644	0.623	0.624	0.624
E3	0.533	0.533	1.000	0.870	0.871	0.871
E4	0.365	0.364	0.779	0.887	0.324	0.735
E5	0.674	0.674	1.201	0.910	0.885	0.877
E6	0.610	0.609	0.989	0.951	0.952	1.163
E7	0.710	0.709	1.039	0.964	0.961	0.963
E8	0.615	0.614	0.805	0.845	0.828	0.955
EPNF	0.491	0.490	0.825	0.803	0.811	0.875

Note: DIA is the Dynamic Integrated Approach model, SWH is a holistic model, Econ is an econometric model, PAR is a partitive approach model, and RTV is a time varying partitive model.

Table 5.4
Estimated Regional Input-Output Coefficients
for selected sectors
1987-1994

1972	0.0015	0.0004	0.0441	0.0405	0.0974	0.1751	0.1321	0.0512	0.0427	0.0078
1973	0.0049	0.0014	0.0441	0.0409	0.0973	0.1749	0.1320	0.0511	0.0426	0.0078
1974	0.0095	0.0027	0.0443	0.0414	0.0977	0.1757	0.1326	0.0514	0.0428	0.0078
1975	0.0076	0.0021	0.0443	0.0416	0.0978	0.1759	0.1328	0.0514	0.0429	0.0078
1976	0.0070	0.0020	0.0442	0.0420	0.0976	0.1754	0.1324	0.0513	0.0428	0.0078
1977	0.0092	0.0026	0.0442	0.0422	0.0975	0.1754	0.1324	0.0513	0.0428	0.0078
1978	0.0152	0.0042	0.0441	0.0422	0.0974	0.1751	0.1322	0.0512	0.0427	0.0078
1979	0.0163	0.0045	0.0439	0.0423	0.0970	0.1744	0.1316	0.0510	0.0425	0.0078
1980	0.0197	0.0055	0.0441	0.0422	0.0974	0.1752	0.1322	0.0512	0.0427	0.0078
1981	0.0270	0.0076	0.0442	0.0420	0.0976	0.1755	0.1325	0.0513	0.0428	0.0078
1982	0.0273	0.0076	0.0442	0.0420	0.0977	0.1756	0.1326	0.0513	0.0428	0.0078
1983	0.0273	0.0076	0.0445	0.0419	0.0984	0.1768	0.1335	0.0517	0.0431	0.0079
1984	0.0265	0.0074	0.0444	0.0419	0.0981	0.1764	0.1331	0.0516	0.0430	0.0079
1985	0.0268	0.0075	0.0439	0.0420	0.0969	0.1742	0.1315	0.0509	0.0425	0.0078
1986	0.0304	0.0085	0.0442	0.0423	0.0977	0.1756	0.1326	0.0513	0.0428	0.0078
1987	0.0261	0.0073	0.0441	0.0424	0.0973	0.1749	0.1320	0.0511	0.0427	0.0078
1988	0.0284	0.0079	0.0436	0.0420	0.0962	0.1729	0.1305	0.0505	0.0421	0.0077
1989	0.0297	0.0083	0.0435	0.0426	0.0960	0.1727	0.1303	0.0505	0.0421	0.0077
1990	0.0282	0.0079	0.0440	0.0428	0.0970	0.1745	0.1317	0.0510	0.0425	0.0078
1991	0.0323	0.0090	0.0440	0.0425	0.0971	0.1745	0.1317	0.0510	0.0426	0.0078
1992	0.0343	0.0096	0.0438	0.0428	0.0968	0.1741	0.1314	0.0509	0.0424	0.0078
1993	0.0349	0.0098	0.0441	0.0431	0.0974	0.1752	0.1322	0.0512	0.0427	0.0078
1994	0.0353	0.0099	0.0444	0.0431	0.0981	0.1764	0.1332	0.0516	0.0430	0.0079

Note: Subscripts refer to industries as follows: 2 is Mining, 4 is manufacturing, 5 is TCPU, 6 is Trade, 7 is FIRE, and 8 is Services.

CHAPTER VI

SUMMARY CONCLUSIONS, AND FUTURE RESEARCH

INTRODUCTION:

This study was designed to investigate the effect of integrating inter-sectoral relationships to a state level econometric employment model. The investigation aimed (1) to account for inter-sectoral and structural change in the regional economy, and (2) to include all major macro economic sectors of the state, rather than partial industries, into the theoretical design of the inter-sectoral relationship.

The study was directed toward an examination of the methodology of integration in general and integration approaches in practice at regional level. The study resulted to a unique approach which was used to construct a dynamic integration (DIA) model. While the predictive accuracy of the DIA models dominates other integrated methodologies such as holistic, partitive, and econometric, it can also estimate the values of the regional input-output coefficients through time.

BACKGROUND

Chapter 2 focused on the review of regional integration strategies and the development of a general framework to integrate input-output modeling with econometric specifications. This framework consists of a final demand block, an input-output transactions block, and a factor payment block. The final demand block is common in both econometric and input-output models which can be used to link the input-output models with econometric models. By linking input-output final demand deliveries to the components of aggregate demand, the impacts of macro policy variables can be traced to the individual sectors. Thus the Keynsian demand model and the Leontief input-output system together may form a complete macro model with proper feed-back between demand and supply.

Although the integration of econometric with input-output models follow the same principles that were discussed in chapter 2, the specification of the existing regional models vary across models. A general framework based on existing regional integrated methodologies was discussed in chapter 3. The methodological configurations of regional integrated models were classified as embedding, composite and linking formations. This classification is based on the extent to which the input-output components are integrated with econometric modeling specifications.

The embedding and composite formations combine specifications of one model with another while maintaining the integrity of one (e.g. econometrics). The linking formation uses the output of one as input to another either in a simultaneous fashion or without direct interaction.

The embedding formation can be further classified into partitive or holistic approaches. This approach is the most simplified and widely used approach of the integrated class. The embedding approach implants the core characteristics of one model into the other. Most commonly, the intermediate demand characteristics of the input-output are embedded into an econometric model. The embedding is either in the form of partitive, holistic, or composite depending on the extent to which inter-industry relations are incorporated into the econometric specification. The composite approach combines several features and characteristics of one model with another in a more complex and detailed fashion. The resulting models are larger and more comprehensive than the resulting models in the partitive or holistic approaches. Several existing models from the classes of embedding, composite and linking configuration were discussed and a general framework was constructed.

While current integrated models are discussed in general, more emphasis is given to the embedded approach which, is a more direct and simpler version of regional integrated models. The embedded approach has gained more popularity during recent years. Some of its popularity is because of the ease with which data can be obtained for regional, sub-regional, and state level models, especially employment data.

CHARACTERISTICS OF THE EMBEDDED APPROACH:

The main characteristic of the embedded approach in regional modeling is the methodology with which input-output is integrated with the econometric model. Since this class of integration commonly embeds the intermediate demand relationship of an input-output model with an econometric one, the core of such an approach is the extent and methodology with which the intermediate demand relationship is embedded in the econometric one.

The extent of the integration depends on the number of inter-sectoral linkages. The embedding approach is holistic when all inter-sectoral relationships are included in the model as a whole and is partitive when only a few inter-sectoral relationships are included in the model. In practice however, the number of inter-sectoral linkages in the embedding-partitive approach is restricted to very few, in most cases two or three sectors (industries). While the partitive approach simply adds additional variables to the estimating equation, at least equal to the number of linkages, the embedding-holistic approach is restricted to a single intermediate demand variable as the sum of all intermediate linkages combined.

THE METHODOLOGY OF EMBEDDING APPROACH AND INTER-SECTORAL LINKAGES

The methodology of the embedding approach in part depends on the treatment of regional input-output coefficients and assumptions regarding the structural changes in the regional economy. The later aspects are reflected in the type of restrictions that are imposed on the coefficients of the terms representing the inter-sectoral linkages.

Inter-sectoral linkages are assumed to be either static or dynamic. Static inter-sectoral linkages treat the regional input-output coefficients as constants while dynamic inter-sectoral linkages allow the regional input-output coefficients to change through time. The dynamic treatment of the regional input-output coefficients in both the partitive and holistic embedding approaches have been limited in the existing models. The existing embedded-holistic models use either constant *national* or constant *regional* input-output coefficients to construct the intermediate input demand variable. Some of the existing embedded-partitive models, however, accommodate for the dynamic input-output direct requirement coefficient matrix to the degree that linkages are included in the estimating equation, and they do not include all inter-sectoral relationships.

MOTIVATION FOR THE STUDY:

The embedding approach can be investigated as a technique that makes possible the construction of comprehensive regional level models that can be used for forecasting as well as impact analysis. Given the unavailability of exogenous data such as total output or components of final demand variables at sectoral levels, and budget limitations for construction of comprehensive models, the DIA model provides a less costly and a more accurate modeling approach for construction and analysis of such data. Yet, this is not limited to regional models and can also be applied to national or international models.

The inclusion of inter-sectoral relationships in an econometric specification has proved to increase the accuracy of the model predictions. The linkages act as additional information added to an econometric model of a region. The DIA approach adds additional structural information which should increase the predictive accuracy of the model beyond the current existing integrated models. Furthermore with dynamizing the inter-sectoral relationship and accounting for the effect of technological changes on the regional input-output coefficient matrix it is possible to estimate the change in value of the regional coefficients through time. One implication of this is that it will enable us to construct not only the total output values for the region, but also to estimate and construct the final demand component variable at industry or sector level.

Additionally, analysis of the resulting regional IO coefficients can help to study the structural change and interdependency of sectors through time in the local economy. For example the dependency of mining on local manufacturing increased during the period of 1973 to 1975-76 (during the first oil shock). The dependency declined after that and began climbing again during 1979 and up to 1984 (during the second oil shock) after which tapered off and declined ever since until 1988. After 1988 has been climbing back again.

THE DESIGN OF THE STUDY

An input-output and an econometric model specification were modified for the state of Oklahoma. The intermediate input demand characteristics of the input-output was then embedded into the econometric model using a Dynamic Integration Approach (DIA).

The intermediate input demand component of the DIA model reflect the assumption that the regional input-output matrix of the state is not constant and changes through time. Direction of this change depends on the structural / technological change. The following assumptions are made with respect to the technological change:

1. Change in technology results in changes in productivity, labor cost, and capital cost.
2. The effect of technology on the above variables is not the same in all regions with the exception of capital cost. The wage and productivity could vary across states or regions.
3. Wage and productivity have direct effect on the final prices of goods and services.
4. In terms of relative national/regional effects of technological change on productivity and cost, the relative capital and transportation costs are

assumed negligible.

An index variable (Cost Adjustment Factor) was developed to account for technological change and consequently the change in the input-output matrix through time. The direct requirement coefficients are used to estimate the intermediate input demand component of the integrated model. The Cost Adjustment Factor (CAF) is based on two stages of comparisons at the state and national level:

1. The relative change in wage and productivity at any given time is compared with the relative wage and productivity at a benchmark year. The benchmark year is selected to be the year at which the Department of Commerce. Bureau of Economic Analysis reports national input-output coefficients. This comparison is made at both regional (state) and national level.
2. The relative change in the regional productivity-to-wage ratio at any given time is compared with that of its national counterpart.

The resulting CAF is an index variable that is less than. equal to. or greater than one. At any given time the regional input-output coefficient equals to that of the benchmark year if CAF equals one. The local producers have no incentive to purchase any more or less of their input requirements from the local suppliers. On the other hand, if CAF is greater than one, the value of input-output coefficients should decrease. In that case the local producers have more incentive to purchase their input requirement from national suppliers than from local suppliers. Similar analysis applies when CAF is less than one.

The magnitude with which local producers purchase more or less of their input requirements from local suppliers depends on the flexibility of the substitution of local with national suppliers. This flexibility, in turn, depends on other factors including but not limited to region specific rigidities, transportation costs, and geographical locations.

The DIA model includes seven estimating equations representing seven major, non public, economic sectors of the state and seven identities. The sectors include Mining (MIN), Construction (CON), Manufacturing (MAN), Transportation-Communication and Public Utilities (TCPU), Wholesale and Retail trade (TRA), Finance-Insurance and Real Estate (FIRE), and Services (SER). The identities formulate the intermediate input demand component of the model.

The DIA model which is a dynamic holistic approach model in the embedding class, results in a better predictive accuracy compared with other integrated models in that class. This is due to additional dynamic inter-sectoral information that is incorporated into the model. While current embedding holistic models do not assume dynamic regional input-output coefficients, current embedding partitive models only account for partial incorporation of inter-sectoral relationships.

To examine the sensitivity of model performance to choice of integration strategy in the embedding class, several other models were constructed and compared with the DIA model. The comparison was intended to highlight the importance of static versus dynamic embedding in the first place, and the importance of adjusting for technological effects in the second place, and, finally, the effect of embedding all versus partial inter-sectoral relationships.

The alternative model specifications included the following components. A non-integrated econometric model as discussed in chapter 4 (constructed to account for the improvement in predictive accuracy as a result of adding additional information). A simple embedded-holistic model was constructed to account for dynamic vs static treatment of the regional input-output coefficients. An embedded partitive model was constructed to account for improvement in the predictive accuracy as a result of adding all inter-sectoral information rather than partial incorporation. Finally, an embedded-partitive model of the Glennon and Lane (1991) type was created to compare the DIA model with the "Time Variable Parameter Approach" of Glennon and Lane (1991). These models were solved using OLS, and a 2SLS estimators.

Four statistical measures were used to compare the performance of the DIA employment model with other integration strategies: R^2, Percent Mean Square Error (PMSE), Mean Absolute Error (MAE), and Theil's Inequality Coefficient (U).

THE DIA MODEL RESULTS AND IMPLICATIONS

1. Comparing the DIA employment model of the state of Oklahoma with alternative embedding models in terms of predictive accuracy:
   - The integrated model (DIA) dominated the non-integrated econometric model.
   - The simple static embedded-holistic approach was dominated by the DIA approach.
   - The DIA approach dominated both the embedded partitive approach as well as the embedded Time Varying Parameter Approach.
2. The DIA model accounts for the effect of technological change on the sectoral structure of the regional economy. Technological changes that have a more positive effect on the regional productivity than the national averages could result in a shift towards local versus national suppliers to satisfy the input requirements of regional producers. This process is reflected in the change in the direct requirement coefficient matrix. Using the DIA model, which was developed for the state of Oklahoma, derived input-output direct requirement tables are extracted for the period 1972-1994. The time span can also be extended to the year 2000 and beyond. This process makes possible the forecast of

detailed structural changes in a regional economy.

3. Using the derived input-output direct requirement coefficients one can construct not only the total output values but also the final demand values at sector levels. This is especially valuable for states and regions where total output and final demand variables are not available.
4. The DIA approach can be considered a positive step towards low cost, comprehensive, and more accurate economic development and impact models for a region.
5. An integrated econometric and input-output model with the DIA formation enables the analysts to take full advantage of both the inter-industry relationship of input-output specifications as well as the dynamic characteristics of econometric models.

DIRECTIONS FOR FUTURE RESEARCH:

Finally, this study reveals several possibilities for future research:

- The current regional integrated models do not account for the process of structural change in the economy. The extraction of the input-output direct requirement coefficients table for extended periods of time that is made possible in the DIA approach enables analysts to forecast detailed structural changes in the inter-industry relationship in a regional economy. No attempt has been made to verify the accuracy of the resulting input-output coefficients that can be obtained in this process.

- The DIA approach can be extended not only to incorporate and link several modeling systems but also to account for demographic and other important characteristics of regional economies to produce impact analysis and forecasts. This is possible because some of the final demand and output variables which were not readily available can be constructed using the estimated input-output coefficients. These possibilities should be attempted and verified.
- Further research should be conducted to account for the effect of technological change on the national technical coefficient matrix as well as regional input-output coefficients. Additionally no restrictions are imposed on the maximum values of the regional input-output coefficients. Such restrictions may be necessary.
- The DIA model should be applied to several other states and regions to explore the universality of the approach.

The above future possibilities for further research in this area are very broad. Hence additional research should set the stage for many more research opportunities in the future.

APPENDIX A

Table A-1
Alphabetical List of raw data

Name	Definition
CPI82	Consumer Price Index, 1982=100
CPI87	Consumer Price Index, 1987=100
DR	Discount Rate
E_1	Employment, Agricultural, in 000
E_2	Employment, Mining, in 000
E_3	Employment, Construction, in 000
E_4	Employment, Manufacturing, 000
E_5	Employment, Tran, Com, & P.U., in 000
E_6	Employment, Trade, in 000
E_7	Employment, FIRE, in 000
E_8	Employment, Services, in 000
E_9	Employment, Government, 000
FFR	Federal Funds Rate
GDPNF	GDP, Non-Farm,
GDPPNF	GDP, Private Non-Farm
GDP_2	Gross Domestic Product, Mining, 000$
GDP_3	Gross Domestic Product, Construction, 000$
GDP_4	Gross Domestic Product, Manufacturing, 000$
GDP_5	Gross Domestic Product, TCPU, 000$
GDP_6	Gross Domestic Product, Trade, 000$
GDP_7	Gross Domestic Product, FIRE, 000$
GDP_8	Gross Domestic Product, Services, 000$
GDP_9	Gross Domestic Product, Government, 000$
GDP	Gross Domestic Product, Total, 000$
GSP_1	Gross State Product, Agriculture, 000$
GSP_2	Gross State Product, Mining, 000$
GSP_3	Gross State Product, Construction, 000$
GSP_4	Gross State Product, Manufacturing, 000$
GSP_5	Gross State Product, TCPU, 000$
GSP_6	Gross State Product, Trade, 000$
GSP_7	Gross State Product, FIRE, 000$
GSP_8	Gross State Product, Services, 000$
GSP_9	Gross State Product, Government, 000$
GSP	Gross State Product, Total, 000$
GSPNF	Gross State Product, Non-Farm
GSPPNF	Gross State Product, Non-Farm, Private
MR30	Mortgage Rates, 30 years
NENF	National Employment, Non-Farm
NEPNF	National Employment, Private Non-Farm
NE2	National Employment, Mining
NE3	National Employment, Construction
NE4	National Employment, Manufacturing

Continued...

Name	Definition
NE5	National Employment, TCPU
NE6	National Employment, Trade
NE7	National Employment, FIRE
NE8	National Employment, Services
NE9	National Employment, Government
NWSD1	National Wage and Salary Disbursement, Agriculture
NWSD2	National Wage and Salary Disbursement, Mining
NWSD3	National Wage and Salary Disbursement, Construction
NWSD4	National Wage and Salary Disbursement, Manufacturing
NWSD5	National Wage and Salary Disbursement, TCPU
NWSD6	National Wage and Salary Disbursement, Trade
NWSD7	National Wage and Salary Disbursement, FIRE
NWSD8	National Wage and Salary Disbursement, Services
NWSD9	National Wage and Salary Disbursement, Government
NWSDPNF	National Wage and Salary disbursement, Private Non-Farm
TB3	Three month Treasury Bill rate
TB6	Six month Treasury Bill rate
WSD_2	Wage and Salary Disbursement, Mining, 000$
WSD_3	Wage and Salary Disbursement, Construction, 000$
WSD_4	Wage and Salary Disbursement, Manufacturing, 000$
WSD_5	Wage and Salary Disbursement, TCPU, 000$
WSD_6	Wage and Salary Disbursement, Trade, 000$
WSD_7	Wage and Salary Disbursement, FIRE, 000$
WSD_8	Wage and Salary Disbursement, Services, 000$
WSD_9	Wage and Salary Disbursement, Government, 000$
WSD	Wage and Salary Disbursement, Total, 000$

Table A-2
Alphabetical list of model variables

Name	Definition
$\dot{r}_{ij}$	regional I/O coefficient, 1987
τ_i	Average productivity, sector i
θ_i	An adjustment factor for I, sector i
η_i	A measure of relative local-national wage, sector i
π_i	A relative measure of local-national productivity.
A_{ij}	Output to employment convertor factor
CAF_i	Cost Adjustment Factor, sector i, 1987=1
CAF_2	Cost Adjustment Factor, Mining, 1987=1
CAF_3	Cost Adjustment Factor, Construction, 1987=1
CAF_4	Cost Adjustment Factor, Manufacturing, 1987=1
CAF_5	Cost Adjustment Factor, TCPU, 1987=1
CAF_6	Cost Adjustment Factor, Trade, 1987=1
CAF_7	Cost Adjustment Factor, FIRE, 1987=1
CAF_8	Cost Adjustment Factor, Services, 1987=1
c_i	Average cost of capital, sector i
CPI_{87}	Consumer Price Index, 1987 based
D73	A dummy variable, 1973
DTB63	Difference between 6 & 3 month T-Bill rates
E_2	Employment, Mining, in 000
E_3	Employment, Construction, in 000
E_4	Employment, Manufacturing, 000
E_5	Employment, Tran, Com, & P.U., in 000
E_6	Employment, Trade, in 000
E_7	Employment, FIRE, in 000
E_8	Employment, Services, in 000
E_9	Employment, Government, 000
E_i	Employment in sector i (i = 2, ..., 9)
E_i^d	Demand for Labor, sector i
E_i^s	Supply of labor, sector i
EPNF	Total Employment, Private Non-Farm
ESELF	Local Self employed
FD_i	Final Demand, sector i
F_i	Final demand for X_i, sector i
GDP_5	Gross Domestic Product, TCPU
GSP_i	Gross State Product, sector i
I	Intermediate input demand relation
$IIDDOT_i$	Intermediate Input Demand for sector i originating from all sectors j, fixed 1987 values.
$IIDDOT_1$	Intermediate Input Demand, Agriculture, based on fixed 1987 r_{ij} values.
$IIDDOT_2$	Intermediate Input Demand, Mining, based on fixed 1987 r_{ij} values.
$IIDDOT_3$	Intermediate Input Demand, Construction, based on fixed 1987 r_{ij} values.
$IIDDOT_4$	Intermediate Input Demand, Manufacturing, based on fixed 1987 r_{ij}
$IIDDOT_5$	Intermediate Input Demand, TCPU, based on fixed 1987 r_{ij}s *Continued..*

Name	Definition
$IIDDOT_6$	Intermediate Input Demand, Trade, based on fixed 1987 r_{ij} values.
$IIDDOT_7$	Intermediate Input Demand, FIRE, based on fixed 1987 r_{ij} values.
IIDDOT8	Intermediate Input Demand, Services, based on fixed 1987 r_{ij} values.
IIDDOT9	Intermediate Input Demand, Government, based on fixed 1987 r_{ij} values.
IIR_i	Intermediate input requirement for sector i
LOGNPRPNF	Log of NPRO, Private Non Farm
LOGTB3	Log of 3 month T-Bill rates
$LPRO_{87}$	Local average productivity, 1987
$LPRO_i$	Local average productivity, sector i
LU	Local Unemployment rate
LW_i	Local Wage, sector i, in 000
LW_4	Local Wage, Manufacturing, in 000
LW_8	Local Wage, Services, in 000
$LWSD_i$	Local Wage and Salary Disbursement for Sector i
MR30	30 year mortgage rates
N	Population
$NPRO_{87}$	National average productivity, 1987
$NPRO_i$	National Average Productivity, sec i
NW_i	National average wage, sector i
NWNF	National Wage, Non Farm
NWPNF	Average National Wage, Private Non-Farm
P_i	Average price of output in sector i
PIE_i	A ratio of local to national output, sector i
PIE_4	A ratio of local to national output, Manufacturing
$RGDP_i$	Real GDP, sector i, 87$
$RGDP_2$	Real GDP, Mining, 87$
r_{ij}	Regional Technical Coefficient
RLWSDT	Real Total Local Wage & Salary Disbursement, 87 prices
V_i	Value added output in sector i
W	Average Annual wage per worker
X_i	Output in sector i
X_i^d	Demand for output of sector i
X_{ij}	Intermediate demand for output of sector i, originating in sector j.
X_i^s	Supply of output, sector i
Z_i	Other variables

Appendix B

Table B1
The estimated Values of regional input-output coefficients
1972 - 1994

	r_{22}	r_{23}	r_{24}	r_{25}	r_{26}	r_{27}	r_{28}	r_{32}	r_{33}	r_{34}
1972	0.0015	0.0003	0.0001	0.0004	0.0000	0.0000	0.0000	0.0086	0.0009	0.0045
1973	0.0049	0.0010	0.0003	0.0014	0.0000	0.0000	0.0000	0.0089	0.0009	0.0046
1974	0.0095	0.0019	0.0006	0.0027	0.0000	0.0000	0.0000	0.0090	0.0010	0.0047
1975	0.0076	0.0015	0.0005	0.0021	0.0000	0.0000	0.0000	0.0090	0.0009	0.0047
1976	0.0070	0.0014	0.0005	0.0020	0.0000	0.0000	0.0000	0.0087	0.0009	0.0045
1977	0.0092	0.0018	0.0006	0.0026	0.0000	0.0000	0.0000	0.0085	0.0009	0.0045
1978	0.0152	0.0030	0.0010	0.0042	0.0000	0.0000	0.0000	0.0088	0.0009	0.0046
1979	0.0163	0.0032	0.0011	0.0045	0.0000	0.0000	0.0000	0.0088	0.0009	0.0046
1980	0.0197	0.0039	0.0013	0.0055	0.0000	0.0000	0.0000	0.0088	0.0009	0.0046
1981	0.0270	0.0054	0.0018	0.0076	0.0000	0.0000	0.0000	0.0087	0.0009	0.0045
1982	0.0273	0.0054	0.0018	0.0076	0.0000	0.0000	0.0000	0.0089	0.0009	0.0046
1983	0.0273	0.0054	0.0018	0.0076	0.0000	0.0000	0.0000	0.0089	0.0009	0.0047
1984	0.0265	0.0053	0.0018	0.0074	0.0000	0.0000	0.0000	0.0091	0.0010	0.0048
1985	0.0268	0.0053	0.0018	0.0075	0.0000	0.0000	0.0000	0.0090	0.0010	0.0047
1986	0.0304	0.0061	0.0020	0.0085	0.0000	0.0000	0.0000	0.0090	0.0010	0.0047
1987	0.0261	0.0052	0.0018	0.0073	0.0000	0.0000	0.0000	0.0090	0.0009	0.0047
1988	0.0284	0.0057	0.0019	0.0079	0.0000	0.0000	0.0000	0.0093	0.0010	0.0049
1989	0.0297	0.0059	0.0020	0.0083	0.0000	0.0000	0.0000	0.0093	0.0010	0.0049
1990	0.0282	0.0056	0.0019	0.0079	0.0000	0.0000	0.0000	0.0097	0.0010	0.0051
1991	0.0323	0.0064	0.0022	0.0090	0.0000	0.0000	0.0000	0.0091	0.0010	0.0048
1992	0.0343	0.0068	0.0023	0.0096	0.0000	0.0000	0.0001	0.0092	0.0010	0.0048
1993	0.0349	0.0070	0.0023	0.0098	0.0000	0.0000	0.0001	0.0097	0.0010	0.0051
1994	0.0353	0.0070	0.0024	0.0099	0.0000	0.0000	0.0001	0.0102	0.0011	0.0053

Continued ..

1972	0.0288	0.0052	0.0300	0.0137	0.0974	0.1751	0.1321	0.0512	0.0427	0.0078
1973	0.0295	0.0053	0.0307	0.0140	0.0973	0.1749	0.1320	0.0511	0.0426	0.0078
1974	0.0300	0.0054	0.0312	0.0143	0.0977	0.1757	0.1326	0.0514	0.0428	0.0078
1975	0.0298	0.0054	0.0310	0.0142	0.0978	0.1759	0.1328	0.0514	0.0429	0.0078
1976	0.0289	0.0052	0.0301	0.0137	0.0976	0.1754	0.1324	0.0513	0.0428	0.0078
1977	0.0283	0.0051	0.0295	0.0135	0.0975	0.1754	0.1324	0.0513	0.0428	0.0078
1978	0.0293	0.0053	0.0306	0.0140	0.0974	0.1751	0.1322	0.0512	0.0427	0.0078
1979	0.0294	0.0053	0.0306	0.0140	0.0970	0.1744	0.1316	0.0510	0.0425	0.0078
1980	0.0292	0.0052	0.0304	0.0139	0.0974	0.1752	0.1322	0.0512	0.0427	0.0078
1981	0.0289	0.0052	0.0301	0.0137	0.0976	0.1755	0.1325	0.0513	0.0428	0.0078
1982	0.0295	0.0053	0.0308	0.0140	0.0977	0.1756	0.1326	0.0513	0.0428	0.0078
1983	0.0296	0.0053	0.0308	0.0141	0.0984	0.1768	0.1335	0.0517	0.0431	0.0079
1984	0.0304	0.0055	0.0316	0.0144	0.0981	0.1764	0.1331	0.0516	0.0430	0.0079
1985	0.0301	0.0054	0.0313	0.0143	0.0969	0.1742	0.1315	0.0509	0.0425	0.0078
1986	0.0299	0.0054	0.0312	0.0142	0.0977	0.1756	0.1326	0.0513	0.0428	0.0078
1987	0.0299	0.0054	0.0311	0.0142	0.0973	0.1749	0.1320	0.0511	0.0427	0.0078
1988	0.0309	0.0056	0.0322	0.0147	0.0962	0.1729	0.1305	0.0505	0.0421	0.0077
1989	0.0310	0.0056	0.0323	0.0147	0.0960	0.1727	0.1303	0.0505	0.0421	0.0077
1990	0.0321	0.0058	0.0335	0.0153	0.0970	0.1745	0.1317	0.0510	0.0425	0.0078
1991	0.0302	0.0054	0.0315	0.0144	0.0971	0.1745	0.1317	0.0510	0.0426	0.0078
1992	0.0307	0.0055	0.0320	0.0146	0.0968	0.1741	0.1314	0.0509	0.0424	0.0078
1993	0.0322	0.0058	0.0336	0.0153	0.0974	0.1752	0.1322	0.0512	0.0427	0.0078
1994	0.0338	0.0061	0.0352	0.0161	0.0981	0.1764	0.1332	0.0516	0.0430	0.0079

1972	0.0441	0.0456	0.0131	0.0405	0.1153	0.0390	0.0147	0.0306	0.0246	0.0664
1973	0.0441	0.0461	0.0132	0.0409	0.1165	0.0393	0.0148	0.0309	0.0251	0.0677
1974	0.0443	0.0466	0.0134	0.0414	0.1179	0.0398	0.0150	0.0312	0.0253	0.0683
1975	0.0443	0.0469	0.0134	0.0416	0.1186	0.0400	0.0151	0.0314	0.0251	0.0676
1976	0.0442	0.0474	0.0136	0.0420	0.1197	0.0404	0.0153	0.0317	0.0260	0.0701
1977	0.0442	0.0476	0.0136	0.0422	0.1203	0.0406	0.0153	0.0319	0.0254	0.0684
1978	0.0441	0.0476	0.0136	0.0422	0.1203	0.0406	0.0153	0.0319	0.0257	0.0691
1979	0.0439	0.0476	0.0137	0.0423	0.1204	0.0407	0.0153	0.0319	0.0259	0.0697
1980	0.0441	0.0476	0.0136	0.0422	0.1202	0.0406	0.0153	0.0319	0.0261	0.0703
1981	0.0442	0.0474	0.0136	0.0420	0.1197	0.0404	0.0153	0.0317	0.0261	0.0704
1982	0.0442	0.0473	0.0136	0.0420	0.1195	0.0404	0.0152	0.0317	0.0262	0.0706
1983	0.0445	0.0472	0.0135	0.0419	0.1194	0.0403	0.0152	0.0316	0.0264	0.0711
1984	0.0444	0.0472	0.0135	0.0419	0.1193	0.0403	0.0152	0.0316	0.0259	0.0697
1985	0.0439	0.0474	0.0136	0.0420	0.1198	0.0405	0.0153	0.0318	0.0254	0.0684
1986	0.0442	0.0477	0.0137	0.0423	0.1206	0.0407	0.0154	0.0320	0.0247	0.0665
1987	0.0441	0.0478	0.0137	0.0424	0.1209	0.0408	0.0154	0.0321	0.0244	0.0657
1988	0.0436	0.0474	0.0136	0.0420	0.1198	0.0404	0.0153	0.0317	0.0242	0.0651
1989	0.0435	0.0480	0.0138	0.0426	0.1213	0.0410	0.0154	0.0321	0.0240	0.0648
1990	0.0440	0.0483	0.0138	0.0428	0.1221	0.0412	0.0156	0.0324	0.0240	0.0647
1991	0.0440	0.0479	0.0137	0.0425	0.1211	0.0409	0.0154	0.0321	0.0245	0.0661
1992	0.0438	0.0482	0.0138	0.0428	0.1219	0.0412	0.0155	0.0323	0.0254	0.0685
1993	0.0441	0.0486	0.0139	0.0431	0.1229	0.0415	0.0157	0.0326	0.0260	0.0700
1994	0.0444	0.0486	0.0139	0.0431	0.1227	0.0414	0.0156	0.0325	0.0268	0.0722

1972	0.0481	0.0163	0.0352	0.0119	0.0243	0.0175	0.0072	0.0084	0.0183	0.0346
1973	0.0490	0.0166	0.0359	0.0121	0.0247	0.0175	0.0072	0.0084	0.0183	0.0345
1974	0.0494	0.0167	0.0362	0.0122	0.0249	0.0175	0.0072	0.0084	0.0182	0.0345
1975	0.0489	0.0166	0.0359	0.0121	0.0247	0.0175	0.0072	0.0084	0.0182	0.0345
1976	0.0507	0.0172	0.0372	0.0125	0.0256	0.0175	0.0072	0.0084	0.0183	0.0346
1977	0.0495	0.0168	0.0363	0.0122	0.0250	0.0174	0.0072	0.0083	0.0181	0.0342
1978	0.0500	0.0169	0.0367	0.0124	0.0253	0.0174	0.0072	0.0083	0.0181	0.0343
1979	0.0504	0.0171	0.0370	0.0125	0.0255	0.0173	0.0071	0.0083	0.0180	0.0341
1980	0.0509	0.0172	0.0373	0.0126	0.0257	0.0172	0.0071	0.0082	0.0179	0.0339
1981	0.0509	0.0173	0.0373	0.0126	0.0257	0.0171	0.0071	0.0082	0.0178	0.0337
1982	0.0511	0.0173	0.0375	0.0126	0.0258	0.0171	0.0071	0.0082	0.0179	0.0338
1983	0.0515	0.0174	0.0377	0.0127	0.0260	0.0173	0.0071	0.0083	0.0180	0.0341
1984	0.0505	0.0171	0.0370	0.0125	0.0255	0.0172	0.0071	0.0083	0.0180	0.0340
1985	0.0495	0.0168	0.0363	0.0122	0.0250	0.0172	0.0071	0.0083	0.0180	0.0340
1986	0.0481	0.0163	0.0352	0.0119	0.0243	0.0173	0.0072	0.0083	0.0181	0.0342
1987	0.0476	0.0161	0.0349	0.0118	0.0240	0.0172	0.0071	0.0082	0.0179	0.0339
1988	0.0471	0.0160	0.0345	0.0116	0.0238	0.0171	0.0071	0.0082	0.0178	0.0337
1989	0.0469	0.0159	0.0344	0.0116	0.0237	0.0171	0.0071	0.0082	0.0179	0.0337
1990	0.0468	0.0159	0.0343	0.0116	0.0236	0.0171	0.0071	0.0082	0.0178	0.0337
1991	0.0479	0.0162	0.0351	0.0118	0.0242	0.0177	0.0073	0.0085	0.0185	0.0350
1992	0.0496	0.0168	0.0363	0.0122	0.0250	0.0180	0.0074	0.0086	0.0188	0.0355
1993	0.0506	0.0172	0.0371	0.0125	0.0256	0.0181	0.0075	0.0087	0.0188	0.0356
1994	0.0523	0.0177	0.0383	0.0129	0.0264	0.0181	0.0075	0.0087	0.0189	0.0357

1972	0.0898	0.0375	0.0206	0.0605	0.0205	0.0220	0.0532	0.0249	0.0602	0.0602
1973	0.0896	0.0374	0.0206	0.0606	0.0205	0.0221	0.0532	0.0249	0.0603	0.0603
1974	0.0895	0.0374	0.0206	0.0606	0.0205	0.0221	0.0532	0.0249	0.0602	0.0602
1975	0.0895	0.0374	0.0206	0.0606	0.0205	0.0221	0.0532	0.0249	0.0603	0.0603
1976	0.0898	0.0375	0.0206	0.0606	0.0206	0.0221	0.0533	0.0249	0.0603	0.0603
1977	0.0889	0.0371	0.0206	0.0606	0.0205	0.0221	0.0532	0.0249	0.0602	0.0602
1978	0.0890	0.0372	0.0206	0.0606	0.0206	0.0221	0.0533	0.0250	0.0603	0.0603
1979	0.0886	0.0370	0.0206	0.0606	0.0206	0.0221	0.0533	0.0250	0.0603	0.0603
1980	0.0881	0.0368	0.0206	0.0607	0.0206	0.0221	0.0533	0.0250	0.0604	0.0604
1981	0.0876	0.0366	0.0206	0.0607	0.0206	0.0221	0.0534	0.0250	0.0604	0.0604
1982	0.0877	0.0366	0.0206	0.0608	0.0206	0.0221	0.0534	0.0250	0.0604	0.0604
1983	0.0886	0.0370	0.0206	0.0607	0.0206	0.0221	0.0534	0.0250	0.0604	0.0604
1984	0.0884	0.0369	0.0206	0.0607	0.0206	0.0221	0.0534	0.0250	0.0604	0.0604
1985	0.0883	0.0369	0.0206	0.0607	0.0206	0.0221	0.0533	0.0250	0.0604	0.0604
1986	0.0888	0.0371	0.0206	0.0607	0.0206	0.0221	0.0533	0.0250	0.0603	0.0603
1987	0.0881	0.0368	0.0206	0.0607	0.0206	0.0221	0.0533	0.0250	0.0603	0.0603
1988	0.0875	0.0365	0.0206	0.0607	0.0206	0.0221	0.0533	0.0250	0.0604	0.0604
1989	0.0876	0.0366	0.0206	0.0607	0.0206	0.0221	0.0534	0.0250	0.0604	0.0604
1990	0.0876	0.0366	0.0206	0.0607	0.0206	0.0221	0.0534	0.0250	0.0604	0.0604
1991	0.0909	0.0380	0.0207	0.0608	0.0206	0.0221	0.0534	0.0250	0.0605	0.0605
1992	0.0922	0.0385	0.0214	0.0630	0.0214	0.0230	0.0554	0.0259	0.0627	0.0627
1993	0.0925	0.0386	0.0214	0.0631	0.0214	0.0230	0.0554	0.0260	0.0628	0.0628
1994	0.0928	0.0388	0.0214	0.0631	0.0214	0.0230	0.0555	0.0260	0.0628	0.0628

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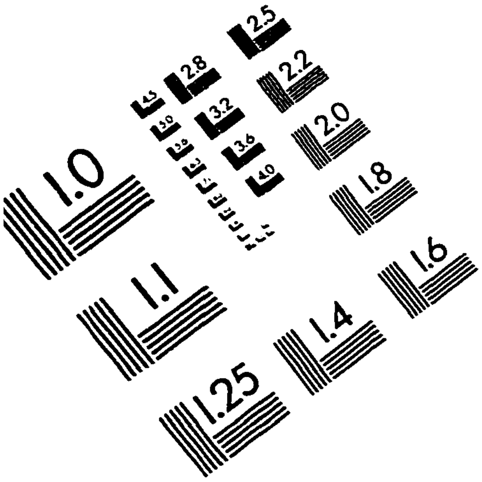
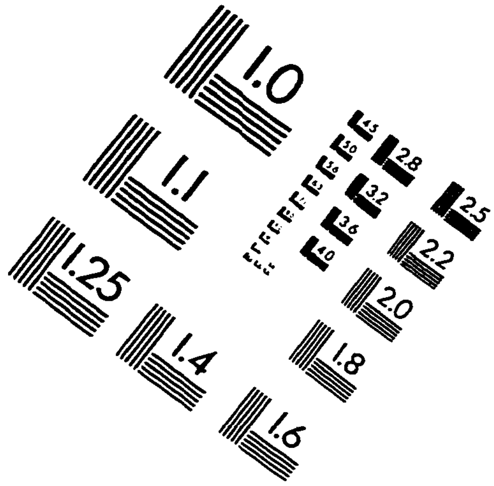
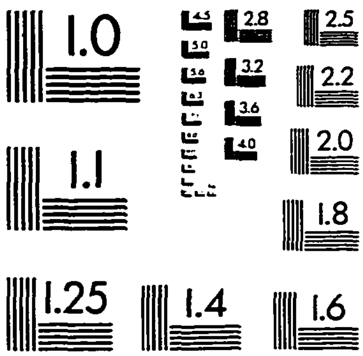
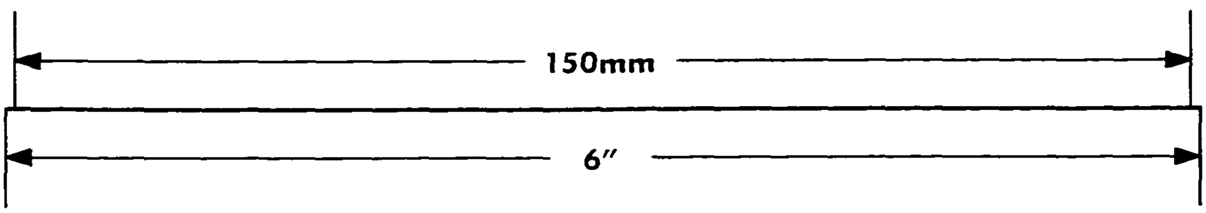
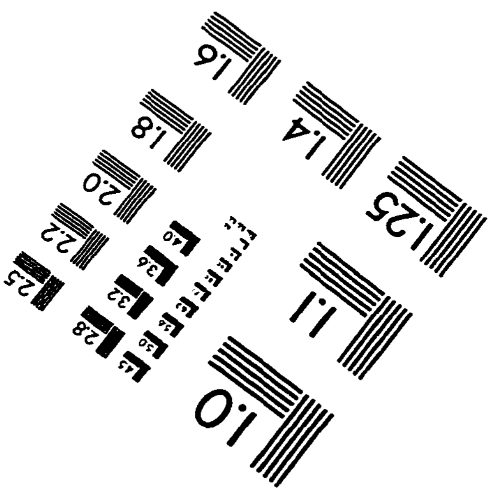
IMAGE EVALUATION TEST TARGET (QA-3)

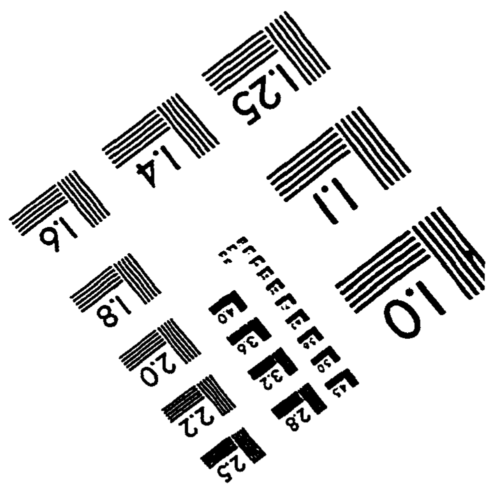












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