Interregional Trade Effects in Static and Dynamic Input-Output Models

M. Jarvin Emerson

Follow this and additional works at: https://researchrepository.wvu.edu/rri_iotheorymethods

Recommended Citation
https://researchrepository.wvu.edu/rri_iotheorymethods/41

This Article is brought to you for free and open access by the RRI Input-Output Archive at The Research Repository @ WVU. It has been accepted for inclusion in Theory and Methods by an authorized administrator of The Research Repository @ WVU. For more information, please contact beau.smith@mail.wvu.edu.
Interregional Trade Effects in Static and Dynamic Input-Output Models

M. Jarvin Emerson
Kansas State University
U.S.A.

prepared for
The Sixth International Input-Output Conference
Vienna, Austria
April 22-26, 1974

*Financial assistance of the National Science Foundation is gratefully acknowledged.
Interregional Trade Effects in Static
and Dynamic Input-Output Models

by M. Jarvin Emerson

Most regional input-output models have been constructed on the basis of
two fundamental and interrelated assumptions of the fixity of technical
coefficients and the stability of trading relationships. The assumption of
trade coefficient stability in regional input-output models seldom has been
challenged despite extensive construction and use of such models. This appears
to be peculiar because as Richardson has pointed out, "The major problem in
the development of interregional I-O models arises from the fact that I-O
analysis itself has no mechanism for explaining trade patterns, yet the
derivation of interregional trade flows is the key distinctive feature of the
interregional model."¹ Conventional regional and interregional input-output
models have assumed that trade coefficients are constant. Isard's² essentially
a priori considerations and the results of Moses³ highly aggregated test model
have been the primary support for this contention. Neither of these approaches
are very conclusive. More recently Riefler and Tiebout have found evidence
of trade coefficient instability.

¹Harry W. Richardson, Input-Output and Regional Economics, New York: John Wiley,
1972, p. 56.
²Walter Isard, "Regional Commodity Balances and Interregional Commodity Flows,"
³L. N. Moses, "The Stability of Interregional Trading Patterns and Input-Output
The Moses test was conducted with a five-commodity, three-region model of the United States over a three year interval using Interstate Commerce Commission 1 percent waybill statistics. Although instability was found Moses concluded "that they have exhibited sufficient stability to warrant their being subjected to further statistical evaluation on various levels of regional and commodity aggregation." As implied the broad levels of industrial and geographic aggregation in the test model and the short time span cast considerable doubt on the conclusiveness of the tests. Nonetheless numerous studies have cited the Moses study as proof of trade coefficient stability.

In a pioneering effort to formulate an interregional input-output system, Isard expected certain trade coefficient stability problems but observed that stability would be present in highly aggregated models.

A more recent test was undertaken by Riefler and Tiebout\(^4\) for an interregional model of California and Washington. Using survey data input-output tables for the two states and an import and export matrix for Washington, the study estimated the remaining coefficients and coefficient changes from secondary data. The test of trade coefficients indicated substantial instability. Of the 27 industries tested only 8 had an error below 10 percent.

**TRADE COEFFICIENTS**

The primary focus of this paper can be stated as follows:

\[ M_{hk}^{jk} \] represents the gross output in region \( h \) of sector \( j \) which is used in region \( k \)

---

\( x^h_j \) represents the gross output of sector \( j \) in region \( h \)

then: \( x^h_j = \sum_{k=1}^{s} M^h_{jk} \quad (h = 1, \ldots, s), \quad (j = 1, \ldots, n) \)

where: \( U^k_j \) represents the amount of \( j \) used in \( k \)

then: \( U^k_j = \sum_{h=1}^{s} M^h_{jk} \quad (k = 1, \ldots, s), \quad (j = 1, \ldots, n) \)

A region's output and use differ by the amount of its net trade. Thus, trade coefficients are defined as:

\[
m^h_{jk} = \frac{M^h_{jk}}{U^k_j} \quad (h, k = 1, \ldots, s), \quad (j = 1, \ldots, n)
\]

This approach collapses the region's interindustry matrix segment thus focusing on the region's trade with other regions.

Since most regional input-output models measure the intraregional interindustry flows, the direct requirements table does not show technical coefficients, but input coefficients. Even if regional technical coefficients were identical to national coefficients, the input coefficients in the regional model would be substantially different by the amount of the corresponding imports. Thus, input coefficients can change not only because of technological change but also because of import coefficient variation.

Further, the usual regional input-output model contains an import row that shows gross imports such that competitive and non-competitive imports are not separated. With few exceptions regional models do not disaggregate the import row. Thus, in that case the problem of import coefficient stability is one of the aggregate import coefficient, \( \sum_j m^h_{ij} \), for each industry. This paper examines both the stability of \( \sum_j m^h_{ij} \) and of the \( m^h_{ij} \)'s in the \( M \) matrix.
SOURCES OF VARIATION IN IMPORT COEFFICIENTS

Explanations for variations in import coefficients in regional input-output models may stem from either economic theory or statistical methodology. As with technical coefficients and input coefficients, trade coefficients also may be affected by technological change. Theories of the firm in economic space suggest that supply (or market) areas are dynamic. Industrial organization may explain certain trading patterns. From a macro-economics viewpoint import substitution is the vehicle of import coefficient change. Statistical aggregation, both industrial and geographic, may influence the degree of import coefficient stability.

Technological Change

A change in the technology in an industry can change import coefficients as well as input coefficients. The relationship between input and import coefficients in most regional input-output formulations can be illustrated as follows:

\[ A = \text{matrix of technical coefficients} \]
\[ R = \text{matrix of regionally produced input coefficients} \]
\[ M = \text{matrix of processing sector imports} \]
\[ A = R + M \]

Thus, a change in either the R or the M matrix changes the other matrix.

Supply Areas

Cost-price relationships, capacity limits, and variations in production (demand) may initiate major shifts in supply locations. A sudden increase in demand may necessitate shifts to different suppliers if usual suppliers cannot fill orders because of capacity limits. Such a phenomena could result in
either increasing or decreasing import coefficients. A rather extreme example of such a situation exists in the construction industry for which demand is markedly unstable. Some manufacturing activity such as aircraft manufacturing exhibits a similar pattern of demand oscillation.

**Industrial Structure**

Large corporations with branch plant operations may exert a different influence on trade coefficients than their non-branch counterparts. Inputs from outside the region may have greater stability because of intra-company linkages.

**Industrial Aggregation**

Economic data are aggregated at numerous levels and influence the apparent behavior of the data. For aggregation into producing sectors, firms are usually grouped according to their products. Since each firm has its own unique structure, such aggregation results in aggregating firms of different product mix of different market and supply characteristics. Thus, while one buyer in a region may purchase its supply of a product from intraregional sources, another buyer in the region may import the same product.

Each firm in an industry may have substantially different import coefficients. If some in the industry expand more rapidly than others, import coefficients will change.

**Regional Delineation**

The spatial distribution of firms within a region may affect the size and behavior of import coefficients. If the friction of distance is an influence, firms located near the center of the region would have lower import coefficients than similar firms located near the border. Similar differences in trade
coefficient stability may occur.

There are no overwhelming theoretical arguments in support of trade
coefficient stability. Relative price stability, industrial structure,
technological change, and simple inertia are among the major theoretical
arguments that have been made to support the assumption of stable trade
coefficients. But these can be made at least equally forcefully for an
instability contention.

The problem of trade coefficient stability is essentially an empirical
one. However, as indicated above, few such empirical tests have been
conducted. A lack of data is the primary reason. We now turn to two empirical
investigations of trade coefficient behavior over time.

**COMPARATIVE STATICS**

On the basis of the Moses study and a lack of conflicting data, the
question of trade coefficient stability has been essentially ignored. However,
the availability of two survey data input-output models for the same region
permit a comparison of trade coefficients over a five-year interval. A survey
data input-output study was constructed for 1965 for the state of Kansas and
was replicated for 1970. The matrix contained 69 processing sectors, 5
payments sectors, and 7 final demand sectors.

The Kansas model also included an import matrix and an export matrix for
each period constructed from survey data. This permitted a comparison of
changes in the import matrix in 1965 with that of 1970 as well as the aggregate
import coefficient for each sector.

---

5M. Jarvin Emerson, *The Interindustry Structure of the Kansas Economy*, Topeka:
manuscript, 1973.
The Kansas vs. the rest-of-the-world model falls short of an Isard type interregional model, but given the dearth of empirical testing of trade coefficients, it does have the capacity to illuminate partially the gray area of trade coefficient behavior over time.

Table 1 summarizes the difference in the coefficients between the two periods. Of the non-zero import coefficients 37 percent changed less than 10 percent. About two-thirds of the coefficients changed less than 20 percent. Nearly one-fifth changed more than 30 percent.

The results of the comparison of aggregate coefficient changes are presented in Table 2 indicating that the aggregate coefficients changed less over the time interval than did the coefficients in the import matrix. Over one-half changed less than 10 percent. However, nearly 30 percent of the aggregate coefficients changed more than 20 percent.

Although the majority of the coefficients exhibited small changes, the results indicated that a significant instability problem existed for about one-third of the sectors.

A comparison of aggregate input coefficients for 1965 and 1970 for selected industries appears in Table 2. The greatest instability occurred in meat packing, aerospace manufacturing, and chemical manufacturing. Meat packing experiences annual instability in supply patterns which reflect sizeable price shifts for livestock and feed grain. Aerospace manufacturing is similar to the construction industry both in the nature of its production process and in the wide amplitude of its demand changes. The changes in the chemical

Table 1

Changes in \( m_{ij} \)'s, Kansas, 1965-70

<table>
<thead>
<tr>
<th>Percent of Changes</th>
<th>37</th>
<th>30</th>
<th>14</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10 percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-19 percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29 percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 percent and over</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2

Changes in \( \Sigma m_{ij} \)'s, Kansas, 1965-70

<table>
<thead>
<tr>
<th>Percent Change</th>
<th>51</th>
<th>21</th>
<th>13</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 to 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 to 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 and over</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
industry were primarily reflective of a technological change involving enzymes.

What do these changes mean for the accuracy of the basic model? A partial answer is attempted in the last section of the paper.

**DYNAMIC SIMULATION**

An alternative approach to the problem of trade coefficient stability is a simulation of anticipated changes in trade coefficients to determine the effect on industry output. Such a simulation was performed with the Kansas model cast in a dynamic framework. The dynamic regional input-output model is similar to Miernyk's regional adaptation of the Leontief dynamic inverse.

**The Model**

Let

\[ X_t = \text{a column vector of } N \text{ sectoral output produced in year } t \]

\[ C_t = \text{a column vector of deliveries to final demand in year } t \]

\[ A_t = \text{an } n \times n \text{ input coefficients matrix} \]

\[ B_t = \text{an } n \times n \text{ matrix of capital coefficients} \]

The direct interdependence within the economy in any two successive years can be described by the following general dynamic equation:

\[ X_t = A_t X_{t-1} + B_{t+1} (X_{t+1} - X_t) = C_t \]

Further, let

\[ U_t = \text{an } n \times n \text{ technical coefficients matrix} \]

---


\[ M_t = \text{an } n \times n \text{ import coefficients matrix} \]

and

\[ U_t = A_t + M_t \]

then

\[ A_t = U_t - M_t \]

Substituting yields

\[ X_t - (U_t - M_t) X_t - B(t+1) (X(t+1) - X_t) = C_t \]

Plausible paths of import coefficient change were introduced and industry growth paths were simulated and compared with growth paths assuming no change in import coefficients. Two different sets of plausible paths were introduced. The first was an extension of the results of the comparative static analysis discussed above. The second set of import coefficient changes were based on the best practice firm technique extended to import coefficients.

The simulations permit a comparison of the effects of plausible changes in import coefficients on industry growth paths. Simulations using import coefficient changes based on the best practice firm technique resulted in wider differences between the two growth poles than the simulations incorporating import coefficient changes stemming from the actual changes between 1965 and 1970.

Two examples of the simulations appear in Figures 1 and 2. For both industries the growth rate after import coefficient changes had been introduced was higher than had there been a constancy assumption. Also in both cases the best practice firm technique resulted in higher simulated growth paths. The two examples were among those with the greatest differences in the simulated growth paths.
Figure 1

DOLLAR OUTPUT × 10^5


SECTOR OTHER FOOD & KINDRED PRODUCTS
O-OUTPUT WITH IMPORT COEF CONSTANT
X-OUTPUT WITH IMPORT SUBSTITUTION
Figure 2

Data points for 1965 to 1975:

- **O-Output with Import Coef Constant**
- **X-Output with Import Substitution**

Graph showing trends over the years.
This paper has examined the empirical stability of trade coefficients in input-output models using two primary data input-output models. The results indicated that although most of the coefficients were stable, a significant portion exhibited instability. A dynamic simulation was suggested to determine the consequences for a regional economy of changes in trade coefficients.
SELECTED REFERENCES


