THE LINK BETWEEN TRADE, MIGRATION, AND REGIONAL CHANGE

by

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ABSTRACT

Although trade and migration have each been shown to be important elements in the process of regional economic change, little is known about the relative impact of trade versus migration in this process. This is due, in great part, to the mutually exclusive assumptions which underpin these two sets of theories: migration theory generally assumes no trade; trade theory assumes no migration. Yet we know that both processes occur simultaneously. Moreover, although these theoretical concerns have been a major constraint to the study of this topic, lack of regional trade data has also presented major difficulties. In this thesis, we develop a model which links measures of both trade and migration to a measure of regional economic change. The structure of this model allows for a common metric whereby we can generate certain measures of the relative strength of trade versus migration on the process of regional economic growth.

We develop a theoretical framework which enables us to incorporate information on aspects of trade, employment, and regional economic change in a common framework. Our model is based on a Cobb-Douglas production function. We have extended this production function framework in two ways: by introducing a regional dimension, and, by incorporating a variety of input measures. We have included input measures for capital, labor, and intermediate inputs both from within the region and from all other regions (our measure of trade). We use information from the 1977 multiregional input-output accounts which provide detail on both intra- and interregional trade for over 120 commodities. A separate equation relating employment to migration is estimated and provides the final link between trade, migration, and regional economic change. We also develop two submodels that place focus on the distribution of traded inputs by a "service" versus "nonservice" categorization.

Our analysis indicates that although both trade and migration are shown to be important to the process of regional economic change, there is no single, simple tradeoff between the two. We interpret our results as indicating that there is wide regional variation in the use of the different input factors. Results from our submodels indicate that although nonservice inputs by origin (either from within the state or as traded inputs) have similar impacts on output, service inputs evidence major differences between those originating from within the state and those that are traded. In terms of regional policy implications, we feel that the wide range of relationships indicated by our results imply that continued study into regional differences should remain a priority.

Thesis Supervisor: Karen R. Polenske

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CHAPTER 1

Link Between Trade, Migration, and Regional Change

The introduction of space into the realm of economics makes explicit the existence of separate places or regions. The existence of regions leads to the possibility of economic changes both within and between these regions. Trade and migration are two critical processes that can affect regional economic change. With its focus on the spatial aspects of economics, much of regional economics is related to the study of these two topics.

The introduction of spatial aspects into economics can lead quickly to a range of complexities. In order to make more tractable the tremendous variety of interactions that can occur in such systems, theorists have tended to focus on specific economic actions, holding constant the other processes. Thus, much of trade theory is premised on the condition that there are complete barriers to migration. Conversely, migration theory assumes complete trade barriers.

There is an enormous amount of information that can be gained through such theoretical constructs. Regional economic theories offer tremendous insights into the way that regions can change internally. Both trade and migration theorists suggest ways that regions may interact and impact upon each other. Moreover, these theorists offer frameworks within which other analysts may measure empirically these different actions.

With the introduction of space, regional economics brings us much closer to the way we view the world. However, both trade and migration theory, while offering us a way to examine important economic actions, are coupled with clearly unrealistic assumptions. Although we can examine issues related to trade or issues related to migration, current theory does not allow for the reality of their coexistence. This is unfortunate for at least two important reasons: (1) both trade and migration occur simultaneously in the real world, and; (2) if trade and migration cannot be examined jointly, if there is no common metric, then there is no way that we can assess the relative impact of each in the process of regional change.

Horiba and Kirkpatrick (1981, 1983) were the first to devise a way to include these two processes in a single framework. They argue that commodities that are traded embody the labor of the worker who produced the commodity. In essence, this is a measure of what they term the "substitutability" of migration for trade. This portion of the traded good is able to be quantified and can be associated with a particular skill level of a potential migrant. They constructed a model in which they used measures of the composition of the labor force (in the south) and migration flows (between the north and south) by age, education, and gender. By using this information in conjunction with information on commodity production (and, therefore, commodity trade) by the same labor force characteristics, they are able to generate a common measurement of trade versus the embodied labor of migrations. They compare changes in coefficients of variation between the underlying characteristics of the labor force reflected in the composition of traded commodities and the changes in southern labor force characteristics brought about by migration. Their results indicate that one year of commodity trade does more than five years of migration to equalize regional wages.

Their ingenious approach to the problem offered us some measure of the relative impact of trade versus migration on regional change. However, the device they designed to capture the effects of migration was not genuinely representative of a true migration flow. The movement of a person from one region to another results in a variety of impacts. The most obvious include the loss of a person (possibly employed) in the origin region, the gain of a person (possibly employable) in the destination region, and the associated impacts on both the origin and destination regions' labor markets and population. Moreover, each migrant is a source of personal consumption expenditure, which also is transferred between regions. Thus, although important, these initial studies only mark a beginning to the process of understanding the link between trade, migration, and regional change.

Even though current theory cannot fully support the mutual inclusion of these two processes, we believe that a major constraint that has hampered this important examination has been the lack of data. To probe the issue of trade versus migration on regional change, we would require a detailed set of regional data that included measurements of variables for regional change, interregional migration, interregional trade, and a variety of other variables necessary to develop a complete model of the regional economy. Moreover, we would need to develop and construct a econometric model that could capture the variety of impacts of this system to describe the economy and all of its linkages.

This thesis documents the development of just such a model. The critical data inputs, previously discussed, have only recently become available with the release of the 1977 multiregional input-output accounts. These data provide information on the Use and Make tables of commodities by industry for over 120 sectors and 51 regions (50 states plus Washington, DC).[1] These data also include information on both inter- and intrastate commodity trade along with the disaggregated margins associated with that trade.

The existence of this data set, in conjunction with several other data sources already available, provided us with the potential for model development. In order to develop such a model properly, we gave careful consideration to

1. providing a firm theoretical basis for the development of a model,
2. making explicit the relationships between each of the variables chosen
3. carefully detailing the source of each of the variables used in the model, and
4. developing a set of a priori expectations associated with each of the variables in the model.

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[1]For a complete description of the data, the collection process and reliability tests refer to The Multiregional Input-Output Accounts, 1977: Final Report, six volumes, produced by Jack Faucett Associates, Inc., Chevy Chase, Maryland. Developed under contract to the U.S. Department of Health and Human Services, Contract Number HHS-100-81-0057.

A Use table is structured on a commodity (rows) by industry (columns) basis. Column sums provide information on the dollar value of each of the commodity inputs required by an industry to produce its output (both primary and secondary products). Row sums provide information on the total use of a particular commodity by all industries. The Make table is structured on an industry (rows) by commodity (columns) basis. Row sums represent the total dollar value of the output of a particular industry (both primary and secondary). Column sums present information on the output of a particular commodity irrespective of the producing industry. More detailed explanations are provided later in this study.

In Chapter 2, we present an overview of the current state of both the theoretical and empirical literature related to the study of trade and migration. We also analyze the work to date and indicate which theoretical assumptions will require modification to encompass our model design. We further provide some working definitions to be used in the development of our model.

In Chapter 3, we present detail on the theoretical development of the model. This requires that we relax certain of the restrictive assumptions associated with both trade and migration theory. Both the rationale and the implications for this are thoroughly detailed. We also use this chapter for a discussion of the choice and implications for using the production function and the relevance of each variable chosen for inclusion in the model. We examine the effects of the interactions and substitutions that exist between the variables as is implied in the use of the production function.

In Chapter 4, we present an overview and description of the state of the regional economy in 1977, including full detail on the different data sources. We provide all aspects of the methodology used to generate each of the variables and information on the relative sizes of each of the variables by the regional detail used.

In Chapter 5, we discuss the results of our model. The major portion of this discussion focusses on our results with respect to the relative impact of trade versus employment on regional development. We present full information on the results of our model with respect to each of the variables. As we discuss throughout the paper, the use of the production function as the basis for our model presents us with a range of values for each of the relevant variables. Thus, we offer the reader a variety of tables that present information on different values that may be obtained.

In Chapter 6, we present a further analysis of our results. We also provide the link between employment and migration and are able to discuss the relative impact of trade versus migration on regional economic change, the core issue of this paper. Our analysis leads to possible applications for regional policy.

In Chapter 7, we offer a synopsis of our results. We raise questions with regard to certain policy issues and offer a variety of ways for researchers to extend and more fully develop the model. In so doing, we raise doubts about the manner in which the service and manufacturing sectors are traditionally regarded. We also offer a major critique of many aspects of our model. We also use this chapter to summarize the total process of model development, our results, and the insight gained from both. We offer a list of future directions that the model might take.

CHAPTER 2

Regional Economic Theory

The earlier discussion of some of the underlying economic processes that affect regional economic growth reveals a fairly complex set of factors. A critical definitional issue immediately arises. The term "regional economic growth" can be defined and measured in a variety of ways. Growth in per capita income is the most common measure generally found in the literature; however, many of the factors involved in per capita income growth may also act as valid measures for capturing the way a region changes (e.g., employment growth, productivity growth, etc.). For our purposes, the term "regional economic growth" will refer to increases in regional per capita output.[2] We will use the term "regional economic change" to allow for the reality of the case of regional economic decline (decreased regional per capita output).

In an attempt to simplify and make more tractable the vast mosaic of individual economic transactions that result in regional economic change, regional economists have posited several different, and sometimes conflicting, theories. Here we summarize these theories and review the literature of some of the major empirical tests. We will present a synthesis of these theories in the next chapter as a first step in our model development.

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[2]We discuss the rationale and implications for the use of per capita output as a valid measure of regional change later in this thesis.

In order to develop the proposed model, we will need to review the theoretical and empirical literature related to both intra- and interregional change. We will include a discussion of each of the major topics involved: regional output, trade, and migration theory. In so doing, we will present the current state of knowledge and begin the development of our proposed model.

Changes in Regional Output

One of the simplest models developed to examine issues related to regional economic change is the one-sector model. In an economy characterized by one region and no technological progress, output is determined solely as a function of the factor inputs. Because of its apparently simple and intuitive approach to describing the production process, the Cobb-Douglas production function is most often used to examine the underlying relationships between output, capital, and labor. The Cobb-Douglas production function is generally presented as:

$$Q_t = F(K_t, L_t)$$

where Q_t is output in period t, K_t is the capital stock in period t, and L_t is the labor force in the same period. Because the level of outputs is a function of the level of the two inputs and under the assumption of constant returns to scale and perfectly competitive factor markets, we can express the growth rate of output in terms of the growth rate of the two inputs.

$$\dot{Q}_t = \alpha\dot{K}_t + (1-\alpha)\dot{L}_t$$

where " $\cdot$ " indicates the growth rate of the variable and α is the contribution of capital to output.

Rearrangement of this equation yields

$$\dot{Q}_t - \dot{L}_t = \alpha(\dot{K}_t - \dot{L}_t)$$

From this equation, we can see that output per worker can only increase if the capital-to-labor ratio increases. Both capital and labor are assumed to exhibit decreasing marginal returns. Thus, there is a limit to the amount of growth implied by this equation. We can develop this model more fully by allowing for the introduction of the role of technology in this process. Changes in technology will act to increase the amount of output/worker that can be obtained at any point along the original curve.[3]

In a test based largely on this model, Borts and Stein (1964) classify the 48 contiguous U.S. states into the categories of either "high-wage" or "low-wage" and hypothesize that capital should tend to flow away from the high-wage states to the low-wage states and that labor migration should tend to flow from the low-wage states to the high-wage states. Using data on the growth of labor, capital, and capital/labor ratios for the period 1919-1957, the authors are forced to reject their hypothesis.

Ghali, Akiyama, and Fujiwara (1981) test regional output growth as a function of capital and labor growth within the region. They assume capital growth is a function of both the rate of return available to

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[3]Disagreement arises as to whether technological change can be defined as applying only to capital or only to labor or to the overall production process.

capital in the region (relative to the average rate of return to capital across all other regions) and the expected growth of output in the region (which effect they measure by including a lagged variable for output) and that labor responds in a manner analogous to capital. Further, they assume that the average earnings in a region (relative to average earnings across all other regions) and the expected growth of earnings (using the same proxy variable as capital) influence the migration decision. They present results that are consistent with the theory.

Hulten and Schwab (1984), using information on the nine U.S. Census regions, decompose regional output growth into the three categories of labor-force growth, capital-stock growth, and what they term "total factor productivity." Their results indicate that interregional growth differentials can be mostly attributed to differential growth rates of the labor force within the regions and partially to differential growth rates of regional capital stock.[4]

The one-sector model appears to be a relatively simple construct. This is a strength in that it allows research into a variety of aspects of regional economic change with a minimal amount of data. By examining the empirical work based on this model, we can see that implementation of even such a simple model can be difficult. Although the preclusion of trade and/or factor movements from this model adds to its simplicity, it is clearly unrealistic. In fact, the major empirical tests reviewed here

[4]"Total factor productivity" can be loosely interpreted as unembodied technological change. Technological change as embodied within either capital stock or human capital is reflected in the measurement of the other categories.

either explicitly or implicitly included aspects of these sources of change.

This is understandable because trade and factor movements are vital to the process of regional economic change. Thus, a model that does not allow for the incorporation of these effects is lacking. If we try to include these effects into the model, if we make explicit the role of trade and factor movements, we have to go beyond this simple framework and move to a model with more than one region.

Trade and Factor Movements

By introducing more than one region into an economic model, analysts increase the level of complexity tremendously. In terms of the supply of factors, multiregional models allow for the possibility of the movement of factors from one region to another. Although certain theorists may preclude such movement by assumption, even so a multiregional model is at least structurally a closer reflection of the reality of regional economic relationships than is the one-sector model. Along with the increased possibilities related to the supply of the factors of production, such models also allow us to examine both the sources and impacts of changes in demand for products between regions.

Commodity Trade

Interregional trade theory is closely linked to international trade theory; however, several important differences exist between the two. In its simplest form, international trade theory assumes fully competitive markets, zero transportation costs, no barriers to trade, and identical production functions across countries. In actuality, the process of international trade generally involves violations of each of these assumptions.

With a "region" rather than a "country" as the unit of analysis, however, many of the barriers to trade inherent in the international framework are less problematic. At the regional level, taxes and tariffs are much less common and, if they exist, of a different order of magnitude. Geographical distances, an indirect measure of transportation costs, are often much smaller between regions than between countries. More important, however, is the existence of common institutions that tend to obviate many of the problems inherent in international trade. The use of a common currency and the availability of capital from an integrated national capital market are two of the most important of these structures (Armstrong and Taylor, 1985).

Other differences between an international and an interregional framework, relevant to the following discussion, also stem from regional commonalities. Thus, assumptions regarding identical interregional production functions are probably somewhat less unrealistic than those assuming identical international production functions. Richardson (1969, p. 289) suggests that demand functions are more alike between regions than they are between countries. Within a regional context, then, many of the assumptions of international trade theory are more closely met than in a country context.

Much of the empirical work related to the spatial aspects of trade at the regional level stems from attempts to explain why certain regions tend to specialize in the production and export of particular goods. Although the concept of comparative advantage is universally accepted as the underlying basis for trade, the actual theory offers very little reason for the existence of the causes for the relative advantage. To overcome this deficiency, several competing theories have arisen.

Alternative Trade Theories

In an attempt to explain the continued existence and consequences of regional output specialization, analysts have developed several theories and models. The export-base models of North (1955) and Perloff and Wingo (1961) are predicated on the assumption that the nexus for regional growth is to be found in the export sector(s) of the regional economy. The demand for goods gives rise to the possibility of specialization in production. Regional endowments, such as natural resources or the existence of bountiful factor inputs, may spur production of the demanded good(s) within a region for export purposes. Although this "basic" industry forms the center of productive activities and acts as the cause of regional growth, the nature of the production process, with both forward and backward linkages between industries, gives rise to even greater regional production. Moreover, other economic activities arise to service the needs of the basic industry and the remainder of regional demand. It is the increased demand for the exports, however, that is theorized to generate the multiplier effect that affects regional economic change.

These sets of theories are subject to major criticism. Their fundamental weakness is that they offer no real theory; in its usual implementation, a model based on this construct offers very little in terms of predictive capabilities. Moreover, Weiss and Gooding (1968) have shown that the level of detail chosen for disaggregating export categories may affect tremendously the results of the model.

Perroux (1955), Myrdal (1957), Hirschman (1958), and Boudeville (1966) developed the growth-pole theory to show the importance of a group of "propulsive" industries as the key to regional growth. They theorize that this set of industries is important due to the specific nature of the myriad forward and backward linkages involved. Changes in external demand are translated, through these linkages, into high multiplier effects in the local economy.

Many of the effects of this set of theories are captured in the definitions of internal and external economies of scale, generally referred to as agglomeration or localization economies. As a propulsive industry begins to grow, for example, the growth process itself may result in increased economies of scale with resultant economic benefits. Moreover, the existence of other production in the same industry in a region may result in economic gains due to the intraindustry linkages that already exist. Thus, localization economies may yield increased output.

Other economies may also serve to increase the propulsive effect of the nodal industry. The existence of interindustry linkages, the existence of social overhead capital, access to a wide and varied pool of different grades of labor all act to increase the productive output of the industry. Thus, agglomeration economies can be shown to impact the growth of a region.

Each of these theories allows insight into the effects of regional growth by focusing on the size of the production process and the resultant impacts on linkages between industries. In terms of prediction, there is no mechanism whereby this growth process leads to convergence. Using models based on these theories, we can envision continued cumulative growth (or decline) for certain regions.

Factor Proportions Theory

The factor proportions theory of trade was proposed and used by Bertil Ohlin (1933) and later developed by both Heckscher and Ohlin to analyze the issue of regional specialization. Unlike Ricardo in his theory of comparative advantage, they allowed for the introduction of qualitative differences in the factor inputs (both labor and capital) and also considered other factors, such as natural resource endowments in the region. They theorize that it is these differences that are the basis or underlying cause for the existence of comparative advantage, assuming that there is no factor mobility, only trade, between regions.

For example, assume two regions, **A** and **B**. Region **A** has an initial endowment of relatively abundant labor, but very little capital, while Region **B** is capital rich but has little available labor. Further assume that both regions produce two goods: cloth and shovels; cloth production is labor intensive and shovel production is capital intensive, both regions operate with the same production function, and both regions produce both commodities for domestic consumption.

The Heckscher-Ohlin theory would predict that Region **A**, which is labor abundant, will produce and also export cloth to Region **B**, while Region **B**, which is capital abundant, will produce and export shovels to Region **A**. This follows because the abundance of labor in Region **A** would cause labor costs to be low relative to capital costs. The converse of this would be true for Region **B**. Region **A**'s comparative advantage in the production of cloth thus arises out of its factor proportion advantage of labor to capital. For Region B the relative relationship is reversed, and goods requiring capital-intensive production are advantageous for Region B to produce for trade.

As trade continues, Region A may find that the export demand for cloth is large enough that economic gains may be realized by shifting resources away from shovel production into more cloth production. Given the fixed nature of the production activities, this will allow for an increase in both capital and labor as input to cloth. Region B may also release some of its input from cloth production to increase shovel production. In both cases, however, the relative mix of inputs will be different from that being used previously in production in the export sector. Region A will gain relatively little labor relative to capital. Region B will gain relatively little capital, but much labor. As these new inputs are introduced into the ongoing production processes, the relative mix of capital and labor will shift in both regions. In Region A, this will tend to increase the relatively low capital/labor ratio, while in Region B it will tend to decrease the relatively high capital/labor ratio. This, in turn, will affect the marginal revenue products of both capital and labor in each region. Thus, even in the absence of factor mobility, the Heckscher-Ohlin theory indicates that there is a tendency towards convergence of factor price differentials.

The Heckscher-Ohlin theory is based on the following set of assumptions:

1. There are only two factors of production.[5]

2. Factors of production are qualitatively identical across regions.

3. Production functions are identical across regions.

4. Production functions always exhibit constant returns to scale.

5. Trade is free from all barriers, including transportation costs.

6. At all possible sets of factor prices, the production processes require the same relative input mix.

7. Individual tastes are identical across regions.

This list of assumptions is highly restrictive, especially when combined with the underlying restriction of no factor movements. In order to develop a model that includes these real-world effects, we must examine what might occur if we relax some of these restrictions.

Factor Movements

If we allow for the movement of the factors of production between regions, the outcome from the earlier example may be fairly different. Workers in the labor abundant Region **A** will become aware of the scarcity of labor in Region **B** (i.e., higher wages being offered), and they may decide to migrate. This movement of labor would tend to ameliorate any residual factor-price differential between the two regions. Thus, we find migration to be an important adjustment mechanism in the process of regional economic growth.

The study of both the determinants and impacts of migration occupies

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[5]As previously mentioned, theorists imposed this condition on the original theory, which did allow for differences to exist in natural-resource endowments.

a prominent position in the field of regional economics. The basic theory is premised on the following set of assumptions:

1. There is perfect competition in all markets.
2. Production functions exhibit constant returns to scale.
3. Migration is costless.
4. There are no barriers to movement.
5. Factor prices are perfectly flexible.
6. The factors of production are homogeneous.
7. Information is complete and free.

Given this set of assumptions, we can follow through what would occur in the previous example. As labor in Region **A** becomes aware of the higher wage rate in Region **B**, migration will occur, with labor moving from Region **A** to Region **B**. The supply of labor in Region **A** will decrease, thus exerting an influence on and increasing the real wage rate in Region **A**. The supply of labor in Region **B** will increase, thus forcing a decrease in the real wage rate in Region **B**. We find the final effect of this movement to result in factor price convergence across both regions. Again, the list of assumptions underpinning this theory is highly restrictive. What is important to note, however, is that both trade and factor movements act as equilibrating mechanisms for factor price convergence.

Implicit in both theories is the fact that this equilibrating function will also act to shift the levels of production of commodities in both regions. For traded goods, the Heckscher-Ohlin theory implies an increase in the production of the good with the more advantageous factor proportions mix. Migration, on the other hand, acts to change the output mix in two very different ways. As with trade, relative factor proportions change, thus inducing a change in the output mix. Each additional migrant also represents a source of possible change in demand (the personal consumption expenditures of the individual migrant), which is being shifted from one region to another. This will also change the outputs produced in each region and, therefore, will affect regional economic change.

Empirical Tests

The pioneering work in testing the Heckscher-Ohlin theory was performed by Leontief (1953, 1956). In these studies, he examined input factor proportions for each of the commodities produced in a region and each of the commodities imported into the region. His hypothesis was that the composition of export commodity inputs should reflect the favorable factor endowments of the region, while the composition of the inputs in the imported goods should reflect the opposite. The particular situation he hypothesized to exist was that U.S. exports should consist of more capital-intensive commodities, while imports should reflect more labor-intensive types of goods. Leontief's findings, however, showed that the United States was exporting goods with lower capital/labor ratios than the goods that it was importing. Many analysts have attempted to explain what has been termed "Leontief's paradox" (Caves, 1973; Baldwin, 1971). Leontief attributed the results to higher productivity on the part of U.S. workers relative to foreign workers. Differential natural resource endowments may have played a role. It is also possible that the required assumption of identical production functions was violated.

Moroney and Walker (1966) in a pioneering study also tested the factor proportions theory of trade. They used a slightly different approach from Leontief's. Instead of comparing the factor content of imports versus exports for a region, they argue that an examination of the relative factor proportions that exist within a region, theoretically, should be a valid indicator of a region's specialization in export goods. For this test, they divide the United States into two regions; South and nonSouth.[6] Their argument for this classification is that basic discernible differences could be noted between these two areas as regards labor with the South evidencing relative labor abundance. This dichotomy arose from an examination of the average wage differential between the two geographical groupings. Theoretically, these factor proportions indicated that the South should specialize in the production and export of labor-intensive goods (low capital-labor ratios), while the nonSouth should specialize in the production of capital-intensive goods.

They calculated location quotients and capital-labor ratios for each of the regions by two-digit Standard Industrial Classification (SIC) codes for the years 1949 and 1957.[7] Their hypothesis of an inverse rank order between these two measures had to be rejected both due to statistical insignificance (at $\alpha = .05$) and the existence of a positive, rather than a negative, sign attached to the correlation coefficient. In a second formulation, they tested the same rank ordering on capital-labor ratios

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[6]For the South, they grouped the East South Central, South Atlantic, and West South Central nine census regions. The nonSouth consisted of the remainder.

[7]Based on information in the <u>Census of Manufactures</u> (1958) and the <u>Annual Survey of Manufactures</u> (1949 and 1957).

against percentage changes in location quotients between 1949 and 1957. This test was statistically significant (at p = .06) and was of the proper sign.

The authors conclude that their results might be explained in reference to a more dynamic framework. One possibility is that a region's endowment of natural resources may predominate in the determination of an initial structure of comparative advantage. As we previously mentioned, the original Heckscher-Ohlin theory included natural resources as separate and distinct factor inputs. The continued pattern of industrial growth, however, may be more influenced by the relative endowments of capital and labor (non-natural resource inputs) as the dynamic of growth is underway. Continued growth and development may not rely as heavily on the initial conditions but may arise to service the demands of the workers and provide inputs into secondary markets that may develop.

Estle (1967) uses the basic framework supplied by Moroney and Walker. Rather than using average wage comparisons to determine the relative factor proportions for an area, Estle developed a set of capital-labor ratios for the two regions using the same sectoral detail. An examination of these data indicate that, contrary to Moroney and Walker's contention, the South is actually capital abundant (relative to the nonSouth) with a capital-labor ratio 19 percent above the national average for that year. The capital-labor ratio for the nonSouth region was only 70 percent of the national average.

Using these data, in conjunction with data provided in the Moroney and Walker article, Estle showed a statistically significant (at p = .03) inverse rank ordering between location quotients and capital-labor ratios.

As regards the test involving percentage change in location quotients, Estle's results are not statistically significant (even at $\alpha = .10$) but are of the correct sign.

In a further test of the factor proportions theory, Klaasen (1973) developed a model along the lines of that used by Moroney and Walker. The major differences between the two studies are Klaasen's increased sectoral detail (171 three-digit SIC categories) and the inclusion of the New England region into the area called "South." (Klaasen argues that this area can be shown to be labor abundant and thus should be included in that category.)

A test of the rank ordering of capital-labor ratios and concentration ratios reveals the same patterns as those presented by Moroney and Walker; namely, the correlation is not significant (at $\alpha = .10$) and is of the wrong sign. Using capital-labor ratios in conjunction with the percentage change in concentration ratios, Klaasen generates results consistent with those of Moroney and Walker; the correlation is significant and of the predicted direction.

Klaasen expanded the factor proportions test to include raw materials (both manufactured and natural resources) as a separately measured input. He constructed a variable to measure the percentage of value of shipments of an industry that can be attributed to value added by the industry in question. In essence, he uses this variable to capture some measure of the level of integration of the industry. Using this variable in a multiple regression analysis, Klaasen presents results on the factor proportions test that are statistically significant in explaining percentage change in industrial concentration, while the measure of resource dependency is statistically significant as regards relative industrial concentration.

U.S. Regional Migration

There is a vast body of literature relating the impact of migration on regional economic growth and of regional economic growth on migration. General reviews of this literature have been presented by Greenwood (1975, 1985), Cebula (1979), and Fields (1979). These authors show that most previous authors have focused on migration as arising out of a response to regional differentials in wages, and to some extent, earnings and employment. Representative studies include those by Sjaastad (1962), Raimon (1962), Galloway (1967; 1969), Gatons and Cebula (1972), Cebula, Kohn, and Vedder (1973), and Ziegler (1976). More recent studies of labor-force migration in response to regional differentials in wages, employment, and earnings include Krumm (1983a; 1983b), Mead (1982), Beaumont (1983), and Rogerson and Mackinnon (1981). Nearly all of these analysts also show that there is strong link between regional differentials in wages and earnings and the migration decision.

Regional wage differentials, however, are clearly not the only impetus to migration. A number of analysts have examined the linkages between migration and several other variables, such as distance, climate, and education (see Greenwood (1975, 1985), Cebula (1979), and Fields (1979)). To capture some of these effects, Graves (1983) proposed a methodology to measure certain aspects of regional "amenities" by developing a "composite amenity" variable, which was shown to be especially significant in explaining the migration decisions of older migrants.

Migration theory occupies a prominent position in regional economics for several reasons, only one of which is its importance as an adjustment mechanism in the process of interregional economic growth (Richardson, 1979). Yet, the exact role played by migration in this process still is not totally clear. One way to view migration is as a sequential process. First, migration is assumed to take place in response to regional differentials in certain economic variables, such as wages and employment conditions; second, this migration is assumed to affect regional economic growth. More theoretically appealing is to view this as a simultaneous process. Although the standard position of most authors has been that regional differentials induce migration, which then causes changes in regional development, certain authors have suggested that migration creates changes in employment levels and wages (Borts and Stein, 1964). To reconcile these opposing views, several analysts have constructed simultaneous models of migration and regional economic growth.

Okun (1968) estimated a simultaneous-equations model of net interstate migration and changes in per capita service income. His model consisted of two primary equations: (1) the absolute change in service income per capita as a function of net migration, service income, a race variable, and an age-sex migration factor, and; (2) the change in net migration as a function of service income, the change in service income, a fertility measure, and the percent of the labor force engaged in agriculture. A third equation is included as a measure of the age-sex factor. Utilizing a two-stage least-squares methodology, he obtained an R^2 of 0.86. Greenwood (1981) notes, however, that Okun's results may have been a function of the use of service income to explain the variance in changes in service income (the simple correlation between the two variables was 0.88).

Muth (1968, 1971) constructed a simultaneous-equations model of net migration and employment change between U.S. cities during the 1950s. Although his results lend support to the hypothesis that there is a reciprocal relationship between migration and regional economic growth, they tend to favor the Borts and Stein conclusion that the effects of migration on employment growth are greater than the converse impacts. Mazek and Chang (1972), Goldstein and Moses (1973), and Greenwood (1975; 1981) all discuss the difficulties present in the Muth studies. Generally, the criticism relates to Muth's use of net, rather than gross, migration.

Olvey (1972), in a study analogous to those conducted by Muth (1968, 1971), constructed a simultaneous-equations model of migration and employment change using data from 56 Standard Metropolitan Statistical Areas (SMSAs). Unlike Muth, Olvey specified separate equations for two types of in-migration, two types of out-migration, and individual equations for both the manufacturing and the nonmanufacturing sector. By using gross (rather than net) migration, Olvey was able to identify a simultaneous relationship between employment growth and in-migration, which was more specific than that found by Muth using net migration.

Cebula and Vedder (1976) constructed a simultaneous-equations model relating net migration between SMSAs to growth in per capita income. They also introduced variables for per capita property taxes and average temperatures. The authors found that net migration and per capita income growth were both significant and positively related. They did not, however, present any statistics regarding the overall explanatory power of their model.

Mead (1982) estimated a four-equation model of migration and economic growth using data for 69 nonmetropolitan state economic areas (SEAs) for 1960-1970. He used these equations to estimate: (1) in-migration as a function of expected income and moving costs, (2) out-migration as a function of expected income, moving costs, and characteristics of the resident population (i.e., education level), (3) changes in earnings as a function of changes in capital, prices, and wages, and (4) changes in wages as a function of excess labor supply, nonagricultural employment growth, in-migration, and out-migration. Utilizing a three-stage, least-squares methodology, Mead found a statistically significant relationship between migration and changes in earnings and employment.

Greenwood (1981) adopted a simultaneous-equations framework for examining intermetropolitan migration as a function of the growth rates of employment, unemployment, income, and the civilian labor force. He developed a second model to examine the relationships between intermetropolitan location of employment, housing, and the labor force. For both models, he used data for the same set of 62 SMSAs and for 1950-1960 and 1960-1970.

Engle (1969) examined the combined impact of product demand, labor migration, and capital movements on regional economic growth. His major results indicate that demand for exports from the area led to growth in the area, but that increases in the supply of either labor or capital led to a decline. These results were termed "paradoxical" by the author. Engle explained that this was probably due to the fact that the only region examined was the Boston metropolitan area and that its particular product market is characterized by specialized and immobile factors of production.

In a later article, Engle (1974) developed a model to examine the linkages between regional investment and the expected rate of return on this investment. More precisely, he argued that the appropriate way to formulate the decision-making process was to examine not only the rate of return available in the region being examined, but also the rates available in all alternative sites. Thus, a measure of the opportunity costs of investment was incorporated into the model.

McHugh and Widdows (1984) examined a somewhat different aspect of the effects of investment on regional development. Their specific focus was on the link between the age of capital and the unemployment rate in a region. Using a pooled cross-section, time-series estimated equation of the effects of capital age on state unemployment rates, they argue that the inclusion of such a variable is critical to the proper specification of this kind of model; that is, the exclusion of this variable in an equation developed to estimate unemployment would bias the results.

Varaiya and Wiseman (1981) utilized time-series data on 80 SMSAs to examine the link between investment and manufacturing employment in the United States between 1960 and 1976. The authors come to several different conclusions. Important to this study is the finding that although the disparity between rates of job creation across metropolitan areas can be partially explained by differentials in investment flows, significant amounts of the difference can be explained both across and within regions by the differences in the age of the capital stock.

Trade and Factor Movements; More Recent Regional and International Evidence

In his latest survey article on migration, Greenwood (1985) discusses some of the more recent trends and studies related to issues of migration. The migration patterns evidenced in the United States between 1970 and 1980 reversed the trends that had been occurring for over three decades. During this later time period, almost 90 percent of the increased population in the country was accounted for by southern and western regions.[8] Greenwood (1985, pp. 522-523) notes three major sources for this shift: (1) historically high levels of international migration to these areas; (2) relatively high natural increases due to the composition of the populations in these areas (relatively high concentrations of persons in their child-bearing years), and; (3) internal migration.

Although most of the earlier studies focussed on the economic aspects of the determinants of migration, with the individual migrant as the unit of study, Greenwood notes that more recent work has moved to place the migration decision in a life-cycle context with the family (or household) as the relevant study unit. (See Graves and Linneman (1979) and Polachek and Horvath (1977)). Moreover, quality-of-life factors have been shown to be of importance to the migration decision (Porell 1982).

When examined at a more disaggregate level, both the propensity to migrate and the choice of destination region has been shown to be radically different across a variety of factors for migrants. The fairly large flows of migrants to regions such as Florida, Texas, and California, for example, reflect not only the movement of labor in response to

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[8]Greenwood, 1985, p. 522.

economic factors, but, to a great degree, they also reflect the movement of retired persons to regions with warmer climates and greater social amenities (Crown and Fournier, 1987).

International trade theorists have begun the initial theoretical work on examining the concurrent impact of both trade and factor movements on the production process (Wong, 1983, 1986; Markusen, 1986), however, little empirical work is available. Moreover, as previously discussed, a survey of the regional economic literature indicates that very little research has been conducted on the joint effects of trade and factor mobility on regional economic development.

Horiba and Kirkpatrick (1981) examined the substitutive role that trade may play for direct factor mobility in regional factor price equalization. The authors developed a methodology for measuring and analyzing the normalized factor proportions (both input and output) for the nine census regions. The actual factors examined were: (1) physical capital stock; (2) human capital stock; (3) renewable resources, and; (4) nonrenewable resources. Their empirical results are consistent with those hypothesized using the concepts of comparative advantage. More important, they also generated evidence that factor trade acts to exchange input flows (in an embodied form) in a pattern that is consistent with what would have occurred had the actual factors of production moved in the theorized direction. Thus, trade can be seen as a substitute for actual movements of factors between regions.

In a later study, Horiba and Kirkpatrick (1983) presented empirical evidence of the magnitudes of each of these adjustment mechanisms in terms of regional-price equalization. The authors used only two regions--South and nonSouth. They focused their analysis on the pattern of migration and trade flows (which they viewed as the embodiment of differential labor inputs). As with their previous study, the authors were able to show that there is evidence on both the direct substitution effect of trade for factor (labor) movements and that this affects regional convergence.

Summary

Both theoretically and empirically, migration and trade can be shown to be of critical importance to the process of regional economic change. Little is known about their relative importance in this process. The few studies related to this topic indicate that interregional trade is a more powerful factor than is migration. However, these studies use very restricted definitions for both trade and migration.

We presented a review of the literature in this chapter for two major reasons: (1) to detail the current state of our knowledge, and; (2) to present the range of theories available to us upon which to structure our model. To study this issue more fully, we will develop a model of the U.S. regional economy that will encompass more inclusive measures for both trade and migration. In order to do so, we have used per capita output as the relevant measure of regional change, rather than the more often used income measure. In the next chapter, we will develop the theoretical basis for our model and the implications for our choice of variables based upon this literature.

CHAPTER 3

The Model—Theoretical Issues

In the previous chapter, we presented detail on several of the competing theories that have been used to examine issues related to regional economics. Here we present the theoretical concerns associated with the development of our model. This model is based on a synthesis of certain of these theories, with the major focus on linking aspects of migration theory with the Heckscher-Ohlin theory of trade. Throughout the chapter, we will discuss the variety of impacts that this synthesis entails. The end result of this process offers a framework within which we can conduct an examination of the relative impacts of both migration and trade on regional economic change. In order to develop this model, however, we first must discuss the basics of production, the factors and processes that lead to the generation of output.

An Accounting Framework

In its most simple form, the dollar value of the output of an industry in a region can be thought of as consisting of the sum of the dollar values of the separate intermediate and primary factor inputs used in the creation of the good. Depending upon the level of detail chosen in this accounting framework, the intermediate inputs can be expressed as coming from a wide number of sources. If we have detail on intermediate inputs from 100 industries, for example, we could examine the composition of a dollar's worth of output as a simple function of the sum of these individual inputs. The remainder of the value of the output comes from the value added component of the process, which comprise inputs from the primary factors of production. In this simple description, these are the dollar amounts paid to individuals, businesses, and landowners for the use of labor, capital, and land involved in the production of this good.[9]

Although this relationship describes an identity, it is a useful formulation for a discussion of the impacts of a variety of factors on the output measure. With this accounting framework, we assume that output is the sum of the inputs. Increases in individual inputs, then, will lead to increased output. At a very aggregate level, we can talk about the impact of an increased dollar's worth of intermediate or primary inputs on output. Because we know that outputs are the simple sum of the value of the components of inputs in this accounting framework, any increase in inputs will increase outputs.[10]

The impact of increased labor inputs into this formulation is also straightforward. In its simplest form, this relationship indicates that increased labor is tantamount to increased value added. Thus, if we add additional labor we should generate additional output. The same relationship holds for returns to business; in effect, a measure of capital. Any increase in inputs should yield increased outputs. If this formulation were reflective of the real world, we might be able to

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[9]Although land is an important primary factor to the production process, severe difficulties with measurement and data availability generally preclude the use of this factor in empirical models. We mention it to complete this theoretical exposition only.

[10]This is clearly simplistic in that the use of an input-output framework implies an assumption of fixed input proportions; an increase in intermediate inputs would necessarily be accompanied by an increase in value added. This oversimplification is for exposition purposes only.

generate well-defined constants that relate marginal increases in each factor input on output.

The mechanism by which these processes occur is relatively straightforward. Demand for goods yields a derived demand for the inputs required to produce these goods. For each of the inputs (intermediate and primary), the source of origin plays a role in the total effect on output. For example, increased use of intermediate goods from the region may have a local multiplier effect on output or employment (or both). Moreover, the region may accrue benefits due to economies of scale. Output may be produced for use within the region or may be exported, thus increasing market size. Certain capacity constraints may be overcome by using intermediate inputs purchased from other regions. The purchases of goods from other regions for use as intermediate inputs in the producing region is our definition of trade. Broadly speaking, the source of employment, whether from within the state or from other states, becomes our link to migration.

Introducing Production As A Process

The accounting identity just presented has value for a variety of studies. For our needs, however, this simplified story is not at all satisfactory for a variety of reasons. This formulation, as stated, has nothing to offer in terms of what occurs in the production process. Generation of goods, the creation of outputs, does not happen only because industry pays money for inputs. These inputs must be combined in the process termed production. In order to talk more realistically about the effects of changes in inputs on output, we must incorporate the effects of this production relationship into our model formulation.

The use of the Cobb-Douglas production function allows us to capture this process along with several other important relationships. We know that the marginal products of each of the inputs should exhibit decreasing returns, ceteris paribus. The addition of inputs from any source initially may yield increased outputs, but the output effect of the continued addition of this input will eventually decline. This is accounted for within this formulation.

With the explicit introduction of a production relationship, we can also recognize the fact that many of the inputs used in this process may act as substitutes for each other. Part of the basis for trade theory rests on the possible existence of differential factor endowments among regions. Trade is made possible by combining the factors available in the region in their most effective use in the production process. The linear relationship implied in our simple example cannot account for these kinds of interactions. We need to find a more realistic and theoretically useful way to define these relationships.

Extending the Production Function

A major prerequisite for developing any model is that it be well grounded in theory. In order to discuss the relative impact of trade versus migration on regional economic development, we must develop a framework that encompasses measures for all three: trade, migration, and regional economic development. To this end, the basic formulation we have chosen for our model is an extension of the production function presented in Chapter 1.

This basic relationship is extended in two different ways. The first is by the inclusion of inputs other than only capital and labor, the primary inputs. Our model will also include measures for all other intermediate inputs. These intermediate inputs, in turn, will be diasaggregated by place of origin: intermediate inputs from within the region and intermediate inputs from all other regions. Thus, the form of the production function we use is extended in terms of input detail. The nature of the increased detail also represents a spatial extension of the production function.

The relationship between inputs and outputs described by the production function is well understood and forms the basis for a large portion of microeconomic theory, especially as it relates to the behavior of firms. To make the model tractable, we assume that the production relationship exhibits both a constant elasticity of substitution and constant returns to scale--the traditional Cobb-Douglas function.[11]

As previously discussed, the general form of the production function is usually presented as:

$$Q = f(K,L,M,\ldots)$$

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[11]Although analysts have presented studies of particular industries which evidence increasing returns to scale, the aggregate nature of our model falls in line with previous studies that indicate that the assumption of constant elasticity of substitution and constant returns to scale is reflective of the behavior of the economy as a whole.

See P.H. Douglas (1934, pp. 132-135) for a discussion of the pioneering work on the value of the coefficients in the Cobb-Douglas production function for the United States. A somewhat dated, but important, review of the literature related to different aspects of this production function is presented in A.A. Walters (1963, pp. 1-66).

where

Q	=	Output of a particular good during a specified time period
K	=	Capital used in the production of a particular good during a specified time period
L	=	Labor used in the production of a particular good during a specified time period
M	=	Other specified inputs used in the production of a particular good during a specified time period

The functional form of the Cobb-Douglas relationship is expressed as:

$$Q = f(K,L,M) = A*K^{\beta_0}*L^{\beta_1}*M^{\beta_2}$$

In essence, this formulation states that output is a multiplicative function of technology and a variety of inputs.

We can examine two sources of change using this formulation. First, we can discuss the way that output changes over time by allowing for changes in two (or more) of the independent variables (technology, capital, labor, other inputs). Second, if we hold output constant and allow only one of the sources of input to vary, we can examine issues related to the rate of substitution between these inputs.

Defining Other Inputs

The intent of our modeling effort is to include measures for both trade and migration within a common framework that offers information about regional economic growth. If we can establish a common numeraire for these two processes, we have a way of measuring their relative impacts. Having an arbitrary commonality is not sufficient for our purposes, however. We are interested in the relative impacts of trade and migration on regional economic development.

The most commonly used measure of regional economic development is regional income; more specifically, regional per capita income. Although this would be an ideal dependent variable with which to work, there is very little theory available that will allow for the development of a model that includes the concurrent impacts of trade and migration on regional per capita income.

Instead, we have chosen to focus on per capita output as the measure of regional economic change.[12] We will focus on the returns to producers in the region rather than total returns to the region. The use of this variable is less inclusive than is the regional income measure but should act to capture a large portion of the impacts of regional economic growth. Using output as the dependent variable, we can develop a framework that includes concurrent measures for aspects of trade, migration, and regional economic development. By using the production function, we can include information on output, intermediate inputs, capital, and employment.

Intermediate inputs in our equation have been partitioned into those arising from within the region and those from all other regions. Intermediate inputs used in the production of goods in a region originating from all other regions is our definition of trade. Thus, we have a variable that allows for the measurement of this effect.

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[12]There is also an indirect argument for the use of output as a appropriate dependent variable. One measure very closely related to regional income is gross regional product. This is the sum of the returns to both industries and individuals in the region: the value added for the region. Using output as the dependent variable and inputs as independent variables, we obtain results that, through transformation, are consistent with a model that uses value added as the dependent variable.

This equation also includes an explicit measure for the impact of employment on regional economic growth. By use of a separate equation linking migration to employment, we have a way of introducing migration to this system. Thus, the production function offers a means whereby our three critical factors, regional economic growth, trade, and migration, can all be examined.

The Model and Some Definitions

The production function is generally specified in terms of a specific time period and a particular industry (or set of industries). For our purposes, we define production as the total dollar amount of all goods and services produced in the region during 1977.[13] We constructed the labor variable using information from the Bureau of Labor Statistics on the number of employed persons in the civilian labor force by region. Jack Faucett Associates staff used the traditional 51-region detail for the collection of the 1977 multiregional input-output (MRIO) data. For our purposes, we initially included only the 48 contiguous states plus an entry for the District of Columbia.[14]

Because of the vast differences in regional sizes that exist under this classification, we divided each of the variables by regional

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[13]Although we have detail on over 120 sectors, the final model we estimated was aggregated across all sectors for each region. This decision was based on preliminary work with a more disaggregate model that used detail on ten aggregated industries. This model evidenced severe problems with multicolinearity. These issues remain even with the two industry formulation presented in Chapter 5. To insure the best possible use of our data sources, all of the variables were generated using the full information available (see Chapter 4 for a full description).

[14]Many of our results will be presented for subsets of these regions. We will inform the reader whenever a limit has been placed on the set of regions, and why.

population. Thus, we express each variable in per capita terms and we thus assume that each regional observation carries an equal weight when used in our model estimation.

Although we have access to limited information on the amount of capital stock used in manufacturing industries by region for selected years, we do not have any information on capital stock for service industries at the regional level for any time period. Because of the importance of the service sector in both the input and output side of our equation, we felt that exclusion of some measure for this variable would not be acceptable. To generate a proxy for the value of total capital stock in a region, we multiplied the value of the manufacturing capital stock by the ratio of total proprietor's income in the region to that of manufacturing industries only. Thus, we assume that capital stock is proportional to the returns to the industries in the region. As with all of the other variables, we have expressed this measure in per capita terms.

We generated two variables to capture the impacts of intermediate inputs on the production process.[15] We calculated the interstate input variable as the total dollar value of all intermediate inputs imported into the region for use in the production of regional output, and the intrastate input variable as the total dollar value of all intermediate inputs produced and consumed in the same region for use in the production of regional output. Again, these are expressed in per capita terms.

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[15] Complete detail on the actual data and methods used are presented in the next chapter.

Our model takes the following form:

$$Output/pop = f(K/pop, L/pop, M_r/pop, M_a/pop)$$

where

Output/pop	=	Dollar value of per capita total output produced in the region in 1977 ($000s)
K/pop	=	Dollar value of per capita capital available for production in the region in 1977 ($000s)
L/pop	=	Total number of per capita employment used in the production in the region in 1977
M_r/pop	=	Dollar value of all intermediate inputs imported into the region for use in production of outputs in the region in 1977 in per capita terms ($000s)
M_a/pop	=	Dollar value of all intermediate inputs produced and consumed in the same region in the production of outputs in the region in 1977 in per capita terms ($000s)

As just discussed, this equation relates total outputs to total intermediate inputs, total labor inputs, and total capital inputs. By partitioning the intermediate inputs into those from other regions versus those from own region, we have a measure of trade. By retaining these two sources of inputs on the right-hand side of the equation, we can generate results that allow us to discuss explicitly the impact of trade on per capita output. We will cover the link between employment and migration later in this chapter.

Full Specification of the Model

The actual model that was estimated for this paper takes the following form:

$$Output/pop = A * K/pop^{\beta_1} * L/pop^{\beta_2} * M_r/pop^{\beta_3} * M_a/pop^{B_4}$$

In order to estimate this equation using ordinary least squares regression techniques, the following logarithmic transformation was performed:

$$\ln(Output/pop) = \beta_0 + \beta_1 * \ln(K/pop) + \beta_2 * \ln(L/pop) + \beta_3 * \ln(M_r/pop) + \beta_4 * \ln(M_a/pop)$$

This logarithmic transformation makes the expression linear in the coefficients. The results of this transformation yield coefficients that we can interpret as elasticities. The interpretation of these coefficients is critical to an understanding of the results of our model. We use the next section of this chapter to explain more fully how best to understand our model results.

Demonstrating that these coefficients represent elasticities is straightforward.[16] Referring to our equation and using per capita interregional trade as an example, we have:

$$Output/pop = A * K/pop^{\beta_1} * L/pop^{\beta_2} * M_r/pop^{\beta_3} * M_a/pop^{\beta_4}$$

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[16]See Kmenta (1971, pp. 458-461) for further information on this multiplicative model form.

let

$$OTHER = A \ {}^{*}K/pop^{\beta_1} \ {}^{*}L/pop^{\beta_2} \ {}^{*}M_a/pop^{\beta_4}$$

then

$$Output/pop = OTHER * M_r/pop^{\beta_3}$$

$$d(Output/pop)/d(M_r/pop) = OTHER * \beta_3 M_r/pop^{\beta_3 - 1}$$

$$\frac{d(Output/pop)/d(M_r/pop)}{Output/pop} = \frac{OTHER * \beta_3 M_r/pop^{\beta_3 - 1}}{OTHER * M_r/pop^{\beta_3}}$$

therefore:

$$d(Output/pop)/d(M_r/pop) * (M_r/pop)/(Output/pop) = \beta_3$$

Thus, we can interpret β_3 (or any of the coefficients) as the impact of a 1% change in per capita interregional trade (or other independent variable) on per capita output. These coefficients, unlike the coefficients attached to a linear model, offer information on the effect of a proportional change in the independent variable.[17]

Although elasticities are a valuable measure of the impact of the independent variable on per capita output, we have difficulties with this

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[17]Because we are using a multiplicative model, the logarithmic transformation is required for the use of an OLS technique. This transformation does not alter the nonlinear nature of the model. Therefore, the reader should be aware that the summary statistics presented are geometric in nature. For example, when we present values for the mean of a variable, it is the arithmetic mean of the log value that is presented.

interaction of factors in generating a simple summary measure of the relationship between trade and regional economic growth. We can present the results using information related to the means of these variables. That is only one measure; it is the slope of the line tangent to the production frontier at the means of the independent variables. Regions, however, vary tremendously with respect to each of these independent variables. The information on the means, although important, does not reflect full information on the true distribution of the differences of the role of trade across regions with varying trade and output values.

The slope of the tangent line at the means is one piece of information. This slope, however, continually changes along the curve. Thus, when we present results, we will note the differences associated with the variance among regions with respect to each of the independent variables. To this end, we will present the mean information for all states and information for both the lowest and highest quartile group of states with respect to the independent variable.

Link to Migration

In order to link migration to these results, we have also estimated a separate migration equation. Information on migration is available for the five-year periods 1965-1970 and 1975-1980.[18] This information is derived from select questions on 1970 and 1980 censuses regarding region of residence five-years prior. Due to the aggregate nature of our model and the use of employment as the link to migration, in the migration

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[18]These data are found in special supplementary reports provided by the Bureau of the Census.

equation we focussed on generating a gross regional measure of the impacts of both in- and outmigration on employment in 1977.

The final equation we wanted to estimate took the following form:

$$Emp_{77} = f(Emp_{70}, \text{Inmig}, \text{Outmig})$$

where

Emp_{77}	=	Total employment in the region in 1977
Emp_{70}	=	Total employment in the region in 1970
Inmig	=	Total migration into the region between 1970 and 1975
Outmig	=	Total migration out of the region between 1970 and 1975

To remain consistent with the rest of our model, we generated this as a multiplicative function and expressed all variables in per capita terms. Because we do not have migration information for this time period, we generated information for the seven-year period 1975-1982. The final equation we generated took the form:

$$\ln(Emp_{82}/pop) = \beta_0 + \beta_1 * \ln(Emp_{75}/pop) + \beta_2 * \ln(Inmig_{75-80}) + \beta_3 * \ln(Outmig_{75-80})$$

This equation is not rooted in migration theory and has nothing to do with the determinants of migration. Rather, it is more a functional description of the data; in fact, it is close to a definition. We would expect that employment in a region for a particular time period is positively related to previous employment. Because inmigration acts to increase the pool of available labor, the coefficient attached to this variable was expected to be positive. Outmigration, having just the opposite effect, was expected to yield a negative coefficient. Although quite simple, for the purposes of this exposition we felt that this model estimate was sufficient.

Full Model

Both of these equations, the basic production function and the migration equation, comprise our full model. By estimating the production function, we will obtain information on the impacts of both employment and trade on regional economic growth. We can substitute the results of the migration equation into the production function to yield estimates of the relative strength of trade versus migration on regional economic development.

As previously discussed, the coefficients resulting from both equations are elasticities and therefore do not generate a simple set of arithmetic changes. These equations do not yield results that allow us to express, for example, dollars of trade into equivalent number of employees in terms of their impact on per capita output. What we have with these results is a set of nonlinear functional relationships that detail how the different inputs may be substituted for each other over a wide range of values for the independent variables.

We can, however, using these results, present interesting information on the tradeoff between trade and migration for selected ranges of the independent trade variable; all states at the mean, the lowest quartile of trade, and the highest quartile of trade.

Summary

In this chapter, we have presented a rationale for our choice of the regional production function rather than regional income as the framework for the development of our model of causes of regional growth. We can use this function indirectly to link trade, migration, and regional growth into a common expression. Due to the multiplicative nature of the relationships involved, the results of the model will not yield a simple summary statistic of the relative strength of trade versus migration on regional economic development; that is, we will not be able to state, for example, that an increase of a certain number of migrants has the same absolute impact on increased per capita output as does a specific dollar amount of trade.

The coefficients generated by the model, however, will provide us with a set of elasticities. These results can be expressed as a range of values that trade and migration may evidence on impacting regional economic change. In the next chapter, we present the actual results from our model along with a description of the rates of substitution between trade and migration on regional economic development.

Chapter 4

The 1977 Regional Economy: A Look at the Data and Data Sources

In order to study issues related to trade, migration, and regional economic development, we had several major sets of tasks to accomplish. The first was to place this study in proper context. The review of the literature presented in Chapter 2 began this process. We have shown the need for further investigation into the link between migration, trade, and regional economic change, and we have offered our analysis of work to date. We will use this chapter to provide information about the state of the U.S. regional economy in 1977. In the previous chapter, we presented detail on the development of this model. The descriptions we offer here are presented so that the reader may understand more fully the results of the process we will be analyzing.

We will begin with a brief description of the data. This will be followed by a presentation of the state of the regional economy as depicted by these data, using a variety of tables and graphics to display the set of processes that we will be capturing in our model. In the final part of this chapter, we present details on the generation of each of the variables used in the model.

The 1977 Regional Economy

Many of the variables used in our final model are derived from the data presented in the 1977 multiregional input-output (MRIO) dataset developed by Jack Faucett Associates, Inc. (JFA). This dataset actually consists of several different, but interrelated, sets of matrices, which contain information on regional outputs, inputs, trade, and consumption for over 120 sectors and 51 regions for the United States for 1977.[19]

We generated information on inputs and outputs for our model from the set of Make and Use matrices. Each row of the Make matrix shows the distribution of the output a particular industry makes of its own and other industries output.[20] Each column of the Use matrix provides information on the various commodities required by an industry to produce its (primary and secondary) output.[21] Another set of data, the Trade matrices, provides detail on the shipment of each of the commodities from origin to destination state.[22]

JFA staff assembled and estimated these data at the same time that a national set of Use and Make matrices was being generated by staff at the Bureau of Economic Analysis. The only benchmark data that were available to JFA staff were a preliminary set of national Make matrix data. As far as we know, there has been no effort to insure that these regional data are consistent with the final set of national data which were subsequently

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[19]Details on individual industries are presented in the appendix. The 51 regions consist of the 50 states plus the District of Columbia.

[20]Although an industry most often produces one primary product, many produce one or more secondary products. Thus, a one-for-one industry-to-commodity concordance does not truly exist.

[21]For the MRIO data, the Use matrix also carries detail on the value added components of this process.

[22]Although there are only 50 U.S. states, the 51-region detail is considered standard for much of the data collection in the United States and, thus, we will use the terms region and state interchangeably.

published.[23] These data, however, still represent the best source available for information on the requisite variables for our model.

Although we are not sure that these data are consistent with the national set of data which was subsequently published, we are completely sure that they are internally consistent. As members of the Multiregional Policy Impact Simulation Model (MRPIS) staff at Boston College, we were intimately involved with the complete process of data definition, collection, and final data generation performed by JFA. We worked with these data for several years to insure consistency; each individual matrix was checked for internal consistency and, because all of these data combine in an accounting identity, all of the different sets of matrices were examined in light of their joint consistency. More detail on this work is presented in the appendix.

Our extensive work with these data over this time period afforded us valuable knowledge about the reliability of each of the individual sets of matrices which comprise this dataset. This has implications for this study; although we feel that the information contained in this dataset is fairly reliable, we are uncertain about the accuracy of the trade data, most especially with respect to service industries. The results from our model based on these data, therefore, should be examined in this light.

The fairly fine level of sectoral detail offered by these data can provide a rich source of information for a variety of studies. Preliminary work on our model, however, indicated that maintaining

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[23]During the writing of this thesis, we located a set of Bureau of Economic Analysis (BEA) estimates for Total Gross State Products published for the relevant time period. We present a comparison between these data and comparable information provided by the MRIO data in the Appendices. (See **Survey of Current Business**, May 1988, pp. 30-46.)

sectoral detail would lead to statistical problems; the major difficulty having to do with multicolinearity. Although we maintain the full 124 sector detail in the process of generating each of our variables, we aggregated the final variables that we use to reflect total values at the regional level. When we speak of regional output, for example, we mean the total dollar value of all goods produced by all industries within a region.

Regional Output in the United States for 1977

Table 1 presents information on the total dollar value of all outputs generated by all industries for each of the 51 regions, ranked according to output size. Figure 1 offers a graphic presentation of output by region by four output levels. The information provided by Table 1 indicates, not surprisingly, that in 1977 California led the nation in terms of total dollar value of regional output. This region alone accounts for over 10% of all national output. The top three regions, California, New York, and Texas, account for over 25% of all national output. The top ten regions generate about 56% of total national output. An examination of Table 1 also reveals a very strong relationship between outputs and population within the regions.

An examination of Figure 1 indicates that much of the dollar value of total production in the United States occurs in the Northeast, especially in the heavy manufacturing states. The regions that comprise the central portion of the United States produce much smaller levels of output. Not surprisingly, these relatively high-output regions are also the largest regions with respect to both population and employment.

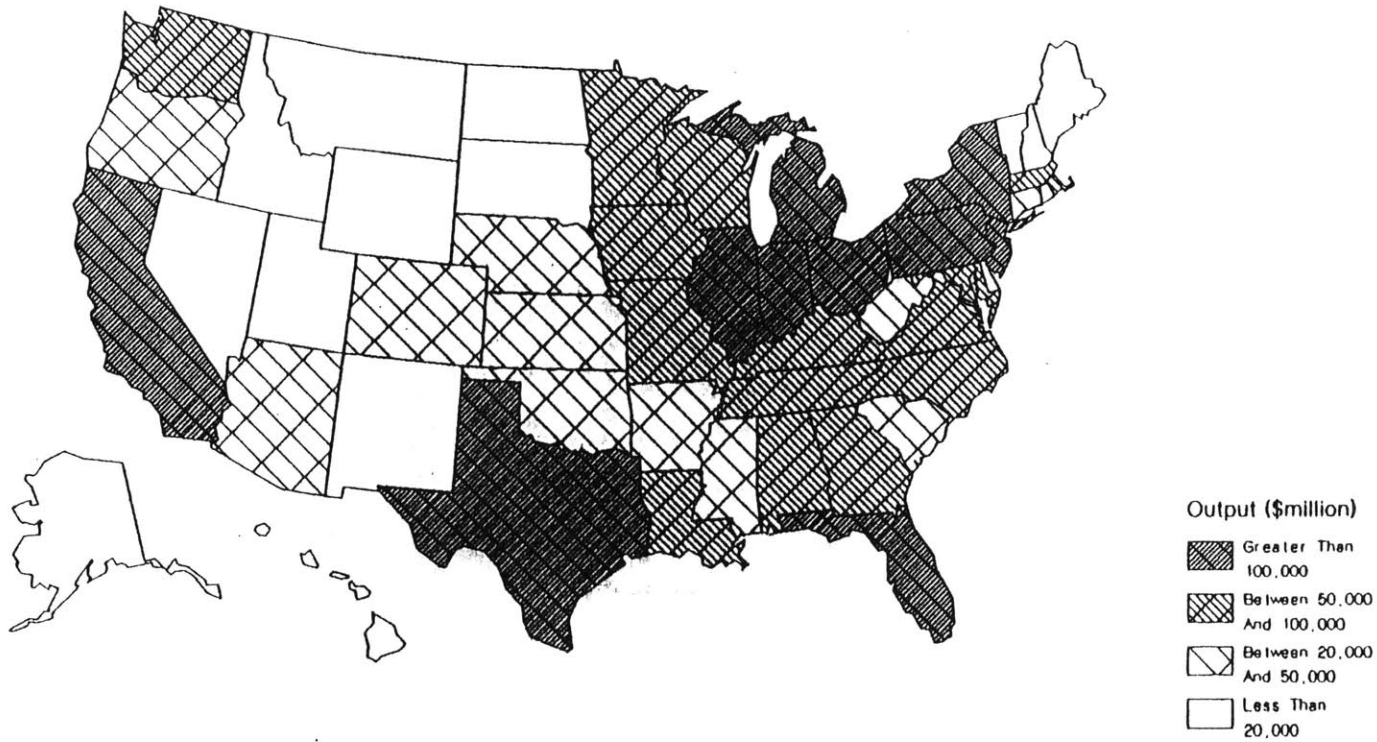
Table 1

Regions by Total Output and National Percent
($million 1977)

Region	Output Amount	% of Nation	Region	Output Amount	% of Nation
California	382,757.6	10.6	Colorado	42,679.3	1.2
New York	289,740.0	8.0	Oklahoma	42,504.0	1.2
Texas	250,935.4	7.0	Kansas	42,219.0	1.2
Illinois	221,375.7	6.1	Oregon	39,950.8	1.1
Ohio	190,893.8	5.3	South Carolina	39,518.6	1.1
Pennsylvania	185,606.6	5.2	Arkansas	31,004.3	0.9
Michigan	173,990.3	4.8	Arizona	30,512.5	0.8
New Jersey	120,283.2	3.3	Mississippi	30,026.6	0.8
Florida	106,117.5	2.9	Nebraska	28,535.6	0.8
Indiana	100,867.6	2.8	West Virginia	28,043.2	0.8
Massachusetts	83,515.5	2.3	Washington DC	19,118.7	0.5
North Carolina	82,942.2	2.3	Utah	18,356.9	0.5
Wisconsin	82,215.9	2.3	New Mexico	16,841.4	0.5
Missouri	82,186.9	2.3	Delaware	16,289.3	0.5
Louisiana	81,518.0	2.3	Maine	13,395.5	0.4
Georgia	77,480.4	2.2	Rhode Island	12,929.2	0.4
Virginia	70,595.5	2.0	Hawaii	12,832.2	0.4
Minnesota	66,662.2	1.9	Idaho	12,335.0	0.3
Tennessee	66,133.5	1.8	Montana	12,281.4	0.3
Washington	62,203.4	1.7	Nevada	11,892.3	0.3
Iowa	56,737.8	1.6	New Hampshire	11,303.2	0.3
Maryland	55,926.4	1.6	Alaska	11,249.3	0.3
Kentucky	51,987.6	1.4	Wyoming	10,302.6	0.3
Alabama	50,853.0	1.4	North Dakota	9,300.5	0.3
Connecticut	48,971.5	1.4	South Dakota	9,179.7	0.3
			Vermont	6,032.8	0.2

SOURCE: Generated from the 1977 MRIO Data.

Figure 1: Total Outputs by Region By Four Output Categories



SOURCE Generated from the 1977 MRIO data

Table 2 presents detail on employment and population by region for the 51 regions (sorted by size of population). Figures 2 and 3 present information on both in- and outmigration by region by four migration levels. Again, not surprisingly, the most populous states are also the states with both the highest in- and outmigration flows. The fact that states are so very disparate in size presents certain difficulties with using states as the unit of regional analysis.

Regions: The Problem With Size

The very open nature of the term "region," the possibilities of being able to abstract from the real world along a variety of dimensions, provides regional economists with a powerful tool, at least theoretically. The difficulty with the power of being able to define regions, however, is the fact that "real-world" data along these same definitions are not as readily available. The MRIO data are the only regional data available for the United States that contain information on interregional trade. Although these data were collected from a variety of sources, most of these sources used individual states as the units of collection. For certain analytic purposes, this regional definition is fairly appropriate. For the purposes of the model we are about to propose, however, the state data, in the form just presented, present certain difficulties.

As we have just demonstrated, states vary tremendously with respect to output, population, and employment (along with a variety of other measures). Were we to use these data as they are with states as the unit of observation, more populous states would carry greater "weight" than would states with smaller populations. In order to insure that each of

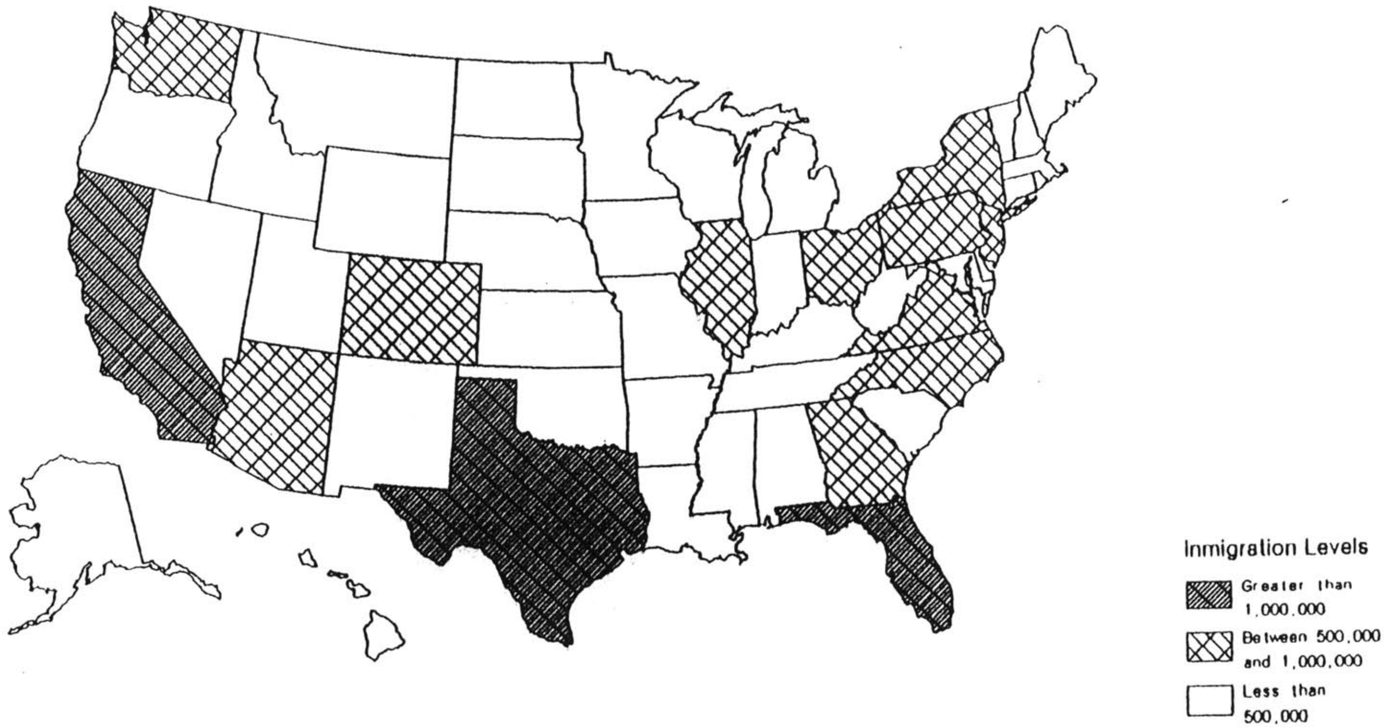
Table 2
Population and Employment by Region by Employment Size

Region	Population*		Employment**		Region	Population		Employment	
	(1000s)	% of Nation	(1000s)	% of Nation		(1000s)	% of Nation	(1000s)	% of Nation
California	22,350	10.2	9,305	10.2	Iowa	2,914	1.3	1,329	1.5
New York	17,852	8.1	7,054	7.8	Oklahoma	2,866	1.3	1,162	1.3
Texas	13,192	6.0	5,476	6.0	Colorado	2,696	1.2	1,172	1.3
Pennsylvania	11,882	5.4	4,770	5.3	Mississippi	2,460	1.1	893	1.0
Illinois	11,406	5.2	4,894	5.4	Oregon	2,439	1.1	1,043	1.1
Ohio	10,771	4.9	4,500	5.0	Arizona	2,427	1.1	896	1.0
Michigan	9,157	4.2	3,781	4.2	Kansas	2,318	1.1	1,073	1.2
Florida	8,889	4.0	3,230	3.6	Arkansas	2,207	1.0	855	0.9
New Jersey	7,342	3.3	3,051	3.4	West Virginia	1,906	0.9	644	0.7
Massachusetts	5,744	2.6	2,555	2.8	Nebraska	1,554	0.7	725	0.8
North Carolina	5,668	2.6	2,465	2.7	Utah	1,316	0.6	500	0.6
Indiana	5,405	2.5	2,317	2.6	New Mexico	1,225	0.6	464	0.5
Georgia	5,212	2.4	2,103	2.3	Maine	1,105	0.5	430	0.5
Virginia	5,206	2.4	2,256	2.5	Rhode Island	955	0.4	402	0.4
Missouri	4,845	2.2	2,089	2.3	Hawaii	916	0.4	375	0.4
Wisconsin	4,613	2.1	2,107	2.3	Idaho	883	0.4	367	0.4
Tennessee	4,402	2.0	1,786	2.0	New Hampshire	872	0.4	385	0.4
Maryland	4,195	1.9	1,829	2.0	Montana	771	0.4	321	0.4
Louisiana	4,016	1.8	1,459	1.6	South Dakota	689	0.3	307	0.3
Minnesota	3,980	1.8	1,820	2.0	Washington, DC	682	0.3	296	0.3
Alabama	3,783	1.7	1,420	1.6	Nevada	678	0.3	298	0.3
Washington	3,772	1.7	1,497	1.6	North Dakota	649	0.3	277	0.3
Kentucky	3,575	1.6	1,438	1.6	Delaware	595	0.3	247	0.3
Connecticut	3,089	1.4	1,396	1.5	Vermont	492	0.2	211	0.2
South Carolina	2,989	1.4	1,188	1.3	Wyoming	412	0.2	186	0.2
					Alaska	396	0.2	158	0.2

* SOURCE: Statistical Abstract of the United States: 1981, p. 9, Table No. 8 Resident Population-States: 1970 to 1980.

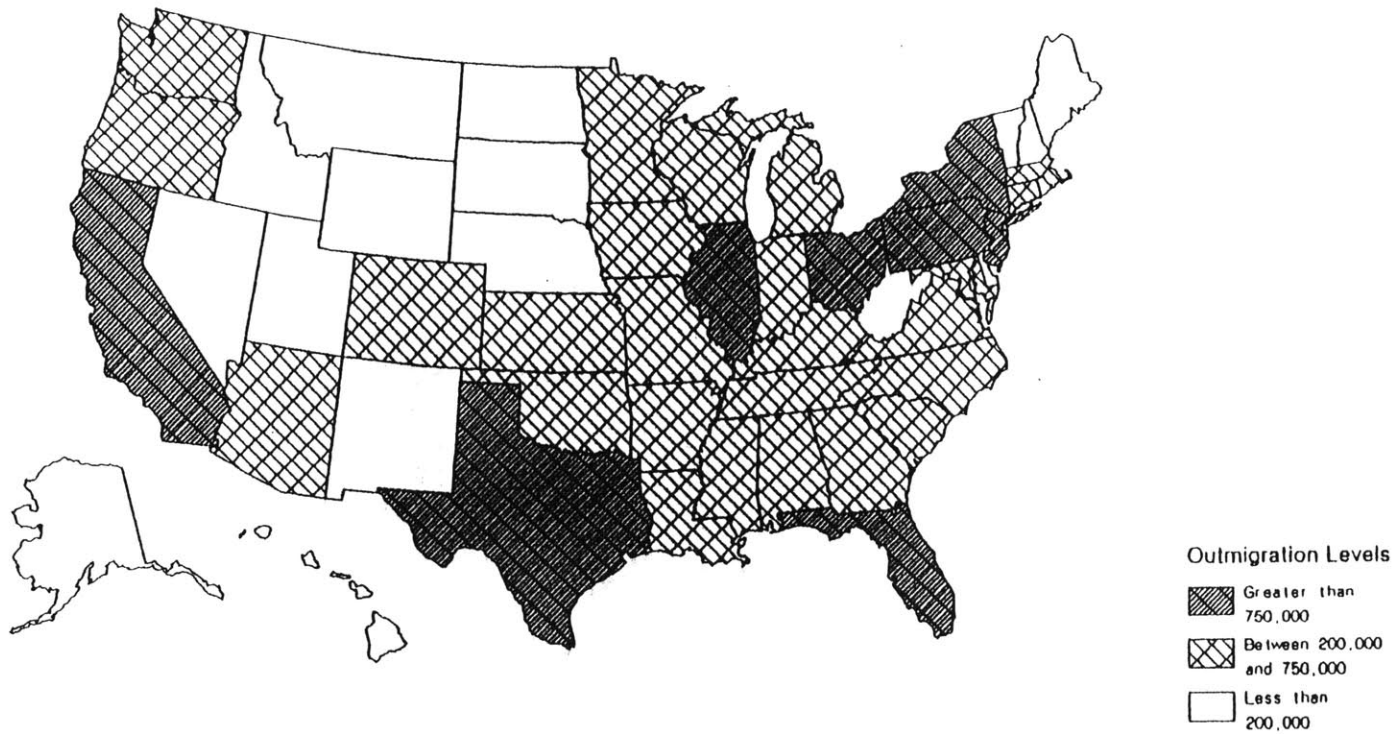
**SOURCE: State and Metropolitan Area Data Book: 1979, p. 34, Table A, Civilian Labor Force employed in 1977 by state.

Figure 2: In-Migration by State
By Three In-Migration Levels 1975-1980



SOURCE Generated from the 1980 Census of Population supplemental report "State of Residence in 1975 by State of Residence in 1980."

Figure 3: Out-Migration by State
By Three Out-Migration Levels 1975-1980



SOURCE: Generated from the 1980 Census of Population supplemental report "State of Residence in 1975 by State of Residence in 1980."

the observations in our model carry similar weights, we have chosen to generate each of our variables on a per capita basis.

Table 3 presents information on per capita state output, interregional trade, intraregional trade, employment, and capital. Figure 4 presents graphic information on states by four per capita output categories. An examination of Tables 1 and 3 indicates that when output is measured on a per capita basis, the ranking of states by per capita output size is very different from that of states by total output levels. An examination of Figure 4 provides a better sense of the spatial distribution of states by per capita output. When the effects of population are included in the output measure, the distribution across states becomes more even. California, Texas, and the states that comprise the manufacturing belt remain important in terms of relatively higher per capita output. Many of the midwestern states, however, which do not generate relatively high dollar values of output, do generate fair amounts of output on a per capita basis. Certain states which generate high output levels actually produce relatively low output on a per capita basis Florida, with its large population of retired persons is a good example. Thus, to insure that observations for each region were not given extra weight due to population alone, we deflated every variable used in the model, as noted above, by the size of the population in the region.

Defining The Variables

The production function described for our model uses five variables: per capita output, per capita employment, per capita capital, per capita traded inputs, and per capita own-state inputs. Table 3 already presented information on each of these variables and their associated ranks. We

Table 3

Regional Detail on Per Capita Measures for Output, Interregional Trade, Intraregional Trade, Employment, and Capital and Ranks

	Per Capita Output	Rank	Per Capita Trade	Rank	Per Capita Own*	Rank	Per Capita Emp**	Rank	Per Capita Cap***	Rank
Maine	12.12	50	2.62	46	3.26	42	0.39	43	5.57	21
New Hampshire	12.96	46	2.85	37	2.96	48	0.44	11	3.38	49
Vermont	12.26	48	2.71	40	2.79	50	0.43	14	4.63	34
Massachusetts	14.54	32	2.71	42	3.63	32	0.44	10	3.79	47
Rhode Island	13.54	41	2.71	41	3.45	36	0.42	24	3.19	51
Connecticut	15.85	24	3.15	29	3.88	29	0.45	6	5.23	25
New York	16.23	22	2.91	35	4.04	24	0.40	35	4.57	37
New Jersey	16.38	20	4.34	11	3.54	35	0.42	26	6.06	13
Pennsylvania	15.62	26	3.27	25	4.33	19	0.40	39	5.65	18
Ohio	17.72	14	4.79	5	4.05	23	0.42	28	6.03	14
Indiana	18.66	10	5.31	4	4.71	16	0.43	17	7.55	6
Illinois	19.41	7	4.37	10	5.15	10	0.43	13	6.12	12
Michigan	19.00	9	4.56	7	5.46	9	0.41	34	5.15	26
Wisconsin	17.82	13	4.39	9	4.77	15	0.46	4	4.36	41
Minnesota	16.75	18	3.48	21	4.88	12	0.46	2	4.74	31
Iowa	19.47	6	4.25	13	6.23	5	0.46	5	5.87	15
Missouri	16.96	17	4.52	8	4.03	25	0.43	16	3.50	48
North Dakota	14.33	34	3.38	22	3.05	43	0.43	20	5.69	17
South Dakota	13.32	44	2.66	43	3.87	30	0.45	7	3.88	44
Nebraska	18.36	11	4.08	14	5.59	6	0.47	1	4.70	32
Kansas	18.21	12	4.73	6	5.10	11	0.46	3	4.90	30
Delaware	27.38	3	11.82	1	6.65	3	0.42	25	4.56	38
Maryland	13.33	43	3.00	32	2.74	51	0.44	12	5.56	22
Wash., D.C.	28.03	2	4.30	12	4.07	22	0.43	22	10.47	3
Virginia	13.56	40	3.02	31	2.96	47	0.43	21	4.54	39
West Virginia	14.71	30	3.54	19	3.77	31	0.34	51	6.53	10
North Carolina	14.63	31	3.30	23	3.97	27	0.43	18	4.57	35
South Carolina	13.22	45	3.29	24	3.36	39	0.40	36	5.44	23
Georgia	14.87	28	3.55	18	3.91	28	0.40	37	4.49	40
Florida	11.94	51	2.10	51	3.03	44	0.36	49	4.30	42

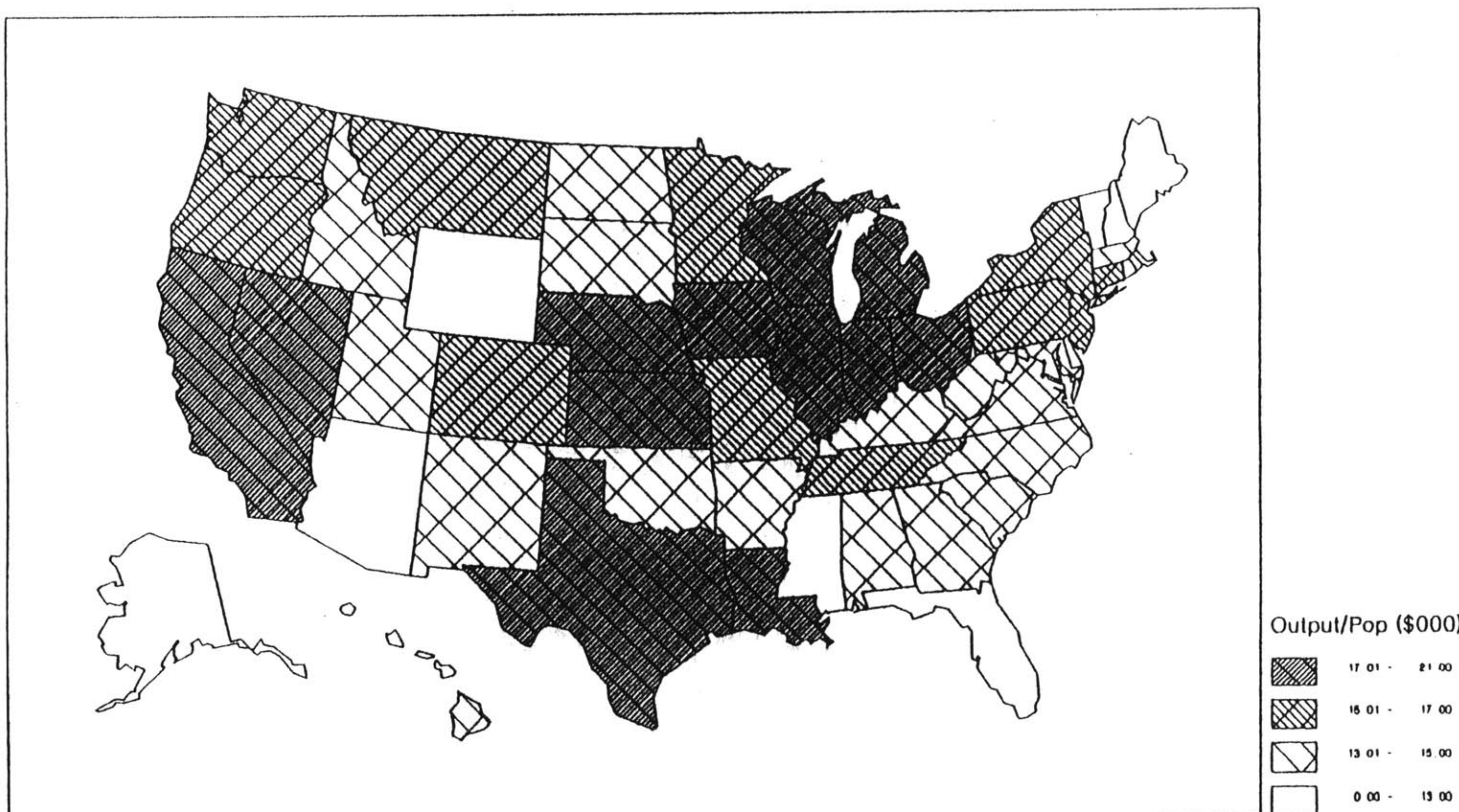
Table 3 (cont.)

Regional Detail on Per Capita Measures for Output, Interregional Trade, Intraregional Trade, Employment, and Capital and Ranks

	Per Capita Output	Rank	Per Capita Trade	Rank	Per Capita Own	Rank	Per Capita Emp	Rank	Per Capita Cap	Rank
Kentucky	14.54	33	3.93	16	3.27	41	0.40	41	4.14	43
Tennessee	15.02	27	3.91	17	3.59	34	0.41	31	4.57	36
Alabama	13.44	42	3.52	20	3.38	38	0.38	44	5.86	16
Mississippi	12.21	49	3.18	28	3.02	46	0.36	48	3.79	46
Arkansas	14.05	35	3.07	30	4.27	20	0.39	42	3.86	45
Louisiana	20.30	5	3.21	27	6.77	2	0.36	50	10.82	2
Oklahoma	14.83	29	2.89	36	4.19	21	0.41	32	4.70	33
Texas	19.02	8	2.78	39	6.79	1	0.42	27	8.17	4
Montana	15.93	23	2.22	48	5.58	7	0.42	29	6.53	11
Idaho	13.97	37	2.83	38	4.01	26	0.42	23	6.84	9
Wyoming	25.01	4	8.73	2	6.55	4	0.45	8	7.79	5
Colorado	15.83	25	2.61	47	4.38	18	0.43	19	5.44	24
New Mexico	13.75	39	2.13	50	3.60	33	0.38	46	7.04	8
Arizona	12.57	47	2.64	44	3.02	45	0.37	47	5.06	28
Utah	13.95	38	2.99	33	3.34	40	0.38	45	3.28	50
Nevada	17.54	15	3.96	15	3.40	37	0.44	9	5.03	29
Washington	16.49	19	3.25	26	4.46	17	0.40	40	7.24	7
Oregon	16.38	21	2.96	34	4.79	14	0.43	15	5.63	19
California	17.13	16	2.17	49	5.49	8	0.42	30	5.07	27
Alaska	28.41	1	6.14	3	4.86	13	0.40	38	21.14	1
Hawaii	14.01	36	2.62	45	2.87	49	0.41	33	5.60	20
Mean	16.38		3.68		4.21		0.42		5.74	
Standard deviation	3.87		1.62		1.11		0.03		2.70	

* Per capita intrastate inputs
** Per capita employment
*** Per capita capital

Figure 4: Per Capita Outputs by Region
By Four Per Capita Output Categories



SOURCE: Generated from the 1977 MRIO Make matrices and population figures from The Statistical Abstract of the United States, 1981.

will discuss the method of construction of each of these variables, along with data sources, in turn.

Per Capita Output

We generated information on per capita output from the Make matrices of the MRIO data. For each region, we calculated the sum of the dollar value of all commodity outputs from all industries (sectors 1 to 124). This value represents total output for all industries in the region and includes both primary and secondary output from each of the sectors.[24] For each regional observation, this figure was then divided by the population of the particular region.

Per Capita Employment

We obtained values for per capita employment from information contained in State and Metropolitan Area Data Book: 1979, (p. 4, Item 538, Civilian Labor Force 1977, Employed, by Region, Division, and State). Again, this variable was divided by the population value for the region.

Per Capita Capital

Although there is surprisingly good information on capita stock at the national level, regional level capital stock information is almost completely lacking. Some limited regional (state) data are available for total manufacturing and selected manufacturing industries for certain years; however, no regional capita stock data are available for any of the

[24] The actual operation we performed was to sum the values contained in rows 1 to 124 (commodity output) across each of the 124 sectors (columns).

service sectors.[25] Given the importance of the service sectors in terms of dollar contribution to total output, and the theoretical importance of capital in our production equation, we needed to include a capital stock measure that accounted for all of the industries involved.

We developed a proxy for total capital stock using the manufacturing capital stock information available in conjunction with information on proprietor's income. Although proprietor's income was only one of our options, given that we originally began with the accounting identity of the MRIO framework, this measure was appealing theoretically as a relevant measure of the returns to industry. Because these data are available within the MRIO dataset and are consistent with our values for outputs and intermediate inputs, we feel that this proxy is empirically a good choice.

The final capital variable developed for our model was generated by using the estimated regional value of manufacturing capital stock as a basis. We first multiplied this value by the ratio of total regional proprietor's income to manufacturing proprietor's income for the region, and then divided the result by the regional population level.

Per Capita Traded Inputs

In an accounting sense, outputs are equal to the dollar values of intermediate inputs and value added. In terms of a production function approach, outputs are a function of labor, capital, and other inputs, all interacting in a multiplicative fashion with the current technology. For the formulation of the variables for our production function, we have

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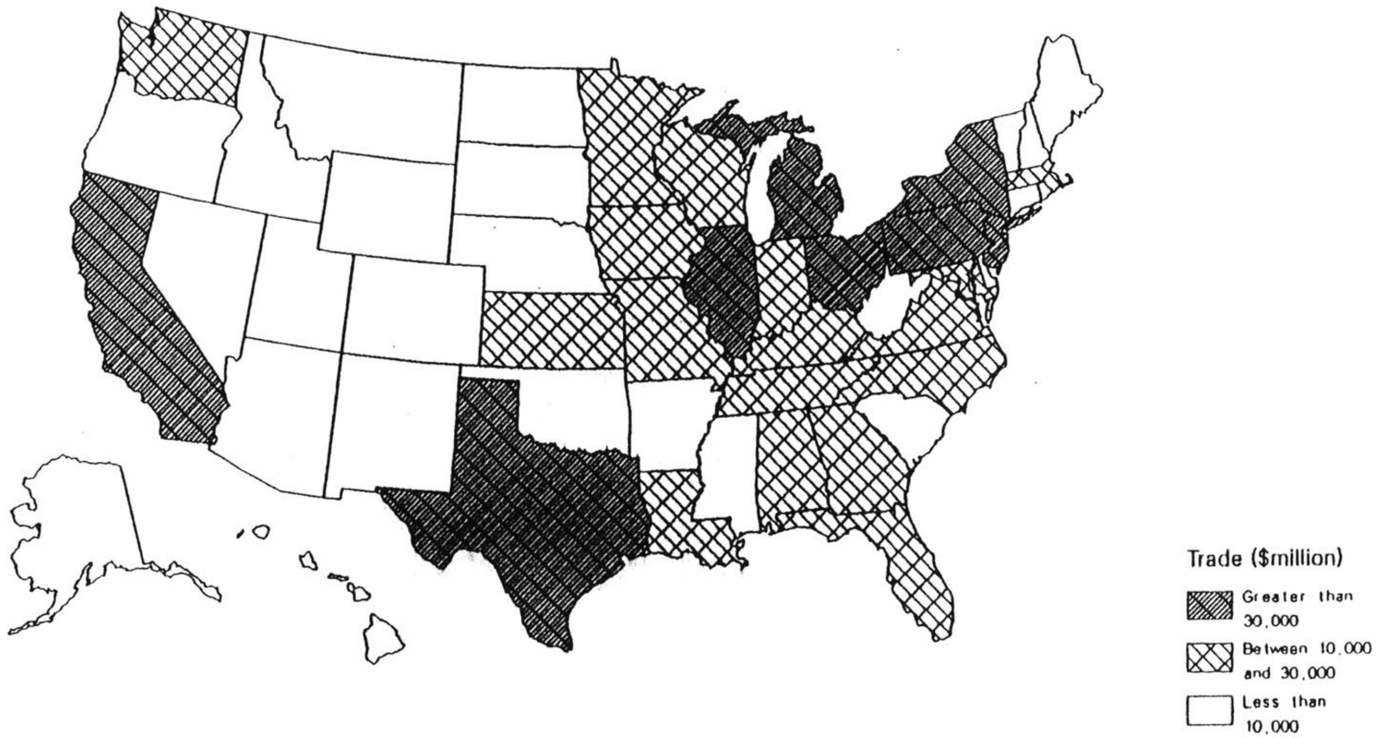
[25]These manufacturing capital data were generated by Lynne Browne at the Federal Reserve Bank of Boston (Browne, 1980). We are thankful to her for making these data readily available to us.

already generated the value-added components of the relationship through the variables for employment (labor) and capital. All of the other commodity inputs must come either from within the region or from trade with areas outside of the region.

The MRIO data provide information on commodity trade by each commodity for every region by both origin and destination region. Figure 5 shows the level of trade by destination region for three trade levels. An examination of this figure indicates that the distribution of trade is similar to that of output; larger states (output, employment, population, etc.), in general, have larger trade amounts. We have estimates of the total amount of a commodity that is available within a region. We also have information on the amount of both inter- and intraregional trade by commodity. Furthermore, for each region, we also have estimates of the total amount of each commodity that is used in the production of each of the 124 sectors. We do not know, however, what amount of commodity trade goes to satisfy intermediate demand for inputs and what part goes directly to final demand.

In order to generate a variable for traded inputs to the production process, we assumed that all commodities were used for both intermediate and final demand in direct proportion to their production within the region and the amount traded. Thus, for example, if a region produces \$40 worth of commodity n and receives \$60 worth of commodity n through trade, we assume that 40% of the dollar amount of the use of that commodity in the production process comes from within the region and 60% is accounted for by trade.

Figure 5: Total Trade by State
By Three Trade Levels



SOURCE: Generated from information in the 1977 Multiregional
Input-Output Dataset

Using the full detail available in the Use matrices (124 sectors), along with the full detail on commodity trade by region, we aggregated that part of the total dollar value of intermediate inputs to the production process that is accounted for by trade. We then divided this value by the population of the region to generate a value for interregional trade. Figure 6 presents information on per capita trade by state by three per capita trade levels. An examination of Figure 6 indicates that, similar to output, when regional trade is expressed in per capita terms, the spatial distribution becomes much more even.

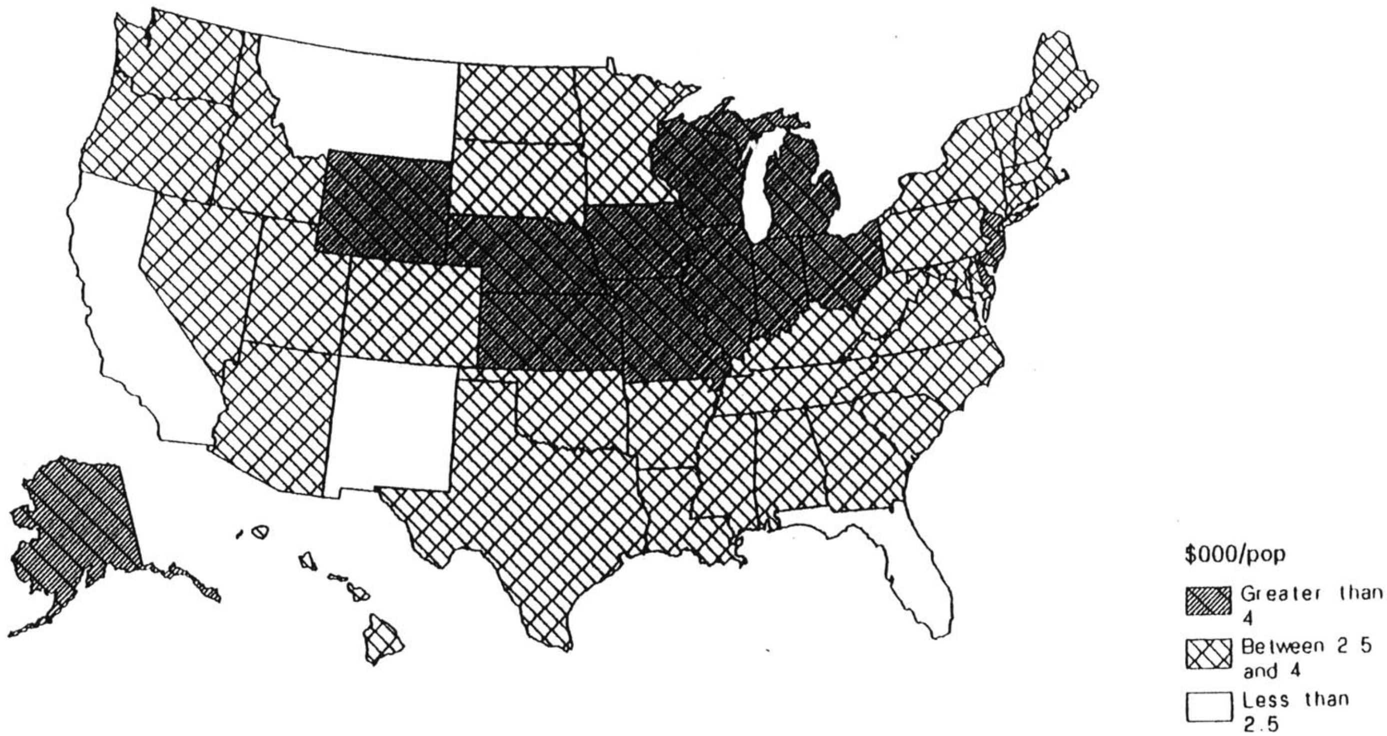
Per Capita Own-State Inputs

We generated values for intrastate trade as discussed above. We aggregated the total dollar amount of inputs used in the production process in a region estimated as arising from within the region and then divided by the population figure to generate a measure of intraregional trade.

Regional Size Revisited

We have already presented an argument for the importance of using per capita measures to control for the effect of differential relative sizes on the regional measures generated. The population variable can also serve as a proxy for a variety of other effects (such as agglomeration economies). With the production function as the chosen functional form of our model, we need to pay attention to the underlying assumptions of this function. In a regional framework, the use of this function implies a common set of technologies and identical production processes. Although we know that there are differences in both of these items among the

Figure 6: Per Capita Trade by State
By Three Per Capital Levels



SOURCE. Generated from information in the 1977 Multiregional Input-Output Dataset and State Population Figures regions, the differences become most acute with respect to the smallest regions. Given that population can act as a proxy for a variety of other measures, we used a minimum population value of one million inhabitants as a final condition for inclusion in our model. There are only 13 regions whose population was less than one million in 1977, with Alaska and Hawaii accounting for two of these regions. These two regions are not contiguous with the other regions in the sample; because distance plays a major role in the determination of trade, and given the spatial characteristics of these two regions relative to the rest of the sample, they would be excluded from this study in any event. The remaining states that were excluded, in decreasing order of population, consist of Rhode Island, Idaho, New Hampshire, Montana, South Dakota, Washington D.C., Nevada, North Dakota, Delaware, Wyoming, and Vermont.

Summary

In this chapter we have presented a description of the regional economy of the United States for 1977 to provide the reader a sense of the spatial distribution of output, employment, and population. The choice of states as the unit of analysis arises out of the availability of data. The vast differences among these regions, in terms of the variables we are interested in measuring, leads to a variety of both theoretical and statistical problems.

To overcome these issues, we have used regional population in two different, but interrelated, ways. First, we have chosen to deflate each of the variables by the size of the regional population to make the observations of more equal weight. This ameliorates much of the difficulty associated with the high correlation between output, input, and population. Second, we have limited our set of observations to those states with populations greater than one million. This acts to insure that the assumption of identical technologies and production processes, although obviously violated, is not so greatly violated as to cause perverse results.

Chapter 5

Model Results

We estimated our final model using the following:

$$\ln(\text{Output/pop}) = A + \beta_1 * \ln(K/\text{pop}) + \beta_2 * \ln(\text{Emp/pop}) + \beta_3 * \ln(M_r/\text{pop}) + \beta_4 * \ln(M_a/\text{pop})$$

where

ln(Output/pop)	=	natural log of per capita total output of the region
ln(K/pop)	=	natural log of per capita estimated capital stock used in the production of regional outputs in the region
ln(Emp/pop)	=	natural log of per capita employment involved in the production of total output in the region
$\ln(M_r/\text{pop})$	=	natural log of the per capita dollar value of all other inputs used in the production of total output originating from outside of the region
$\ln(M_a/\text{pop})$	=	natural log of the per capita dollar value of all other inputs used in the production of total output originating from within the region

Before we present the numerical results of our estimation, we first look at the various ways that each of these inputs can interact with one another. We must carefully describe the complex relationships both within and between each of these sets of factor inputs, so that we can present and interpret the results of the model correctly and so that we can make clear exactly what we can and cannot say about the importance of both trade and migration in this relationship.

Substitution Within and Between Factors

Although this relationship indicates that each of the inputs is necessary to the production process, the exact amount of each input is not at all fixed. A variety of tradeoffs exist between the different input sources. At the simplest level, this may be a difference in the matter of input source. For example, we have partitioned intermediate inputs so that they may come from within the state or from other states, because many factors influence the fundamental trade decisions. Most have to do with price differentials and initial factor endowments within the region.

Certain states may be able to produce particular goods at a price low enough that, even when transportation and other charges are accounted for, make it efficient for another state to utilize this traded good rather than from those own-state sources. Some of these differences in the level of traded inputs may arise from the spatial location of particular regions. Certain regions may be able to receive traded inputs from states with close proximity and, thus, lower transportation and/or handling charges. Still, other differences in the amount of traded goods required for production may arise out of the states' own industrial output, therefore, within-state input mix. Certain states may not be producers of particular required inputs. Even if the regional data indicate that a state produces a certain output, the level of detail available is only 124 industries. It could be the case that certain very specific inputs are required that the region may apparently be producing but, in reality, are only available from one or several other states through trade.

At a slightly more complex level, each of these inputs may act as a substitute for one another. Certain regions may have an abundance of capital, relative to labor, and even if they have the same production function, they may substitute the more abundant (and presumable less expensive) capital for labor. So too, certain intermediate goods may be either capital or labor substitutes. The specification of our model, both in terms of functional form and choice of variables, allows for the possibility of each of these effects.

Overall Results of the Model

The results of the model are presented in Table 4. As previously discussed, we used information on the 38 regions whose population was greater than one million. The associated set of correlations between all of the variables is presented in Table 5. Table 6 contains summary information on the distribution of each variable.

In terms of the overall fit of the model, the adjusted R^2 of 0.912 indicates that the model does well in explaining most of the variance in the natural log of per capita output between states. Every one of the coefficients is statistically significant at $\alpha = 0.05$, thus we accept the hypothesis that these coefficients are greater than zero. The associated F ratio, the test of the joint hypothesis that the slopes of the explanatory variables are all equal to zero, is 139.39, which is significant at greater than the $p = 0.0001$ level.

Table 4

Ordinary Least Squares Regression Results

Dependent Variable--ln(Output/pop)
(n of cases = 38)

Independent Variable	β	Standard Error of β	Beta Coefficient	T	Sig T
ln(K/pop)	0.074911	0.0357	0.1240	2.10	0.044
ln(Emp/pop)	0.276708	0.1107	0.1487	2.50	0.018
ln(M_r/pop)	0.193382	0.0338	0.3072	5.72	0.000
ln(M_a/pop)	0.435718	0.0400	0.6948	11.00	0.000
α (constant)	2.019806	0.1290		15.65	0.000
Adjusted R^2	0.912				
Standard Error	0.043				

Table 5

Correlation Coefficients
(n of Cases = 38)

	ln(Output/pop)	ln(M_r/pop)	ln(M_a/pop)	ln(Emp/pop)	ln(K/pop)
ln(Output/pop)	1.000	0.567	0.892	0.503	0.427
ln(M_r/pop)	0.567	1.000	0.284	0.392	0.039
ln(M_a/pop)	0.892	0.284	1.000	0.363	0.451
ln(Emp/pop)	0.503	0.392	0.363	1.000	-0.153
ln(K/pop)	0.427	0.039	0.451	-0.153	1.000

Table 6

Summary Information on Variables Used in the Equation
(n of Cases = 38)

Variable	Mean	Standard Deviation
ln(Output/pop)	2.747	0.146
$\ln(M_r/\text{pop})$	1.208	0.232
$\ln(M_a/\text{pop})$	1.415	0.233
ln(Emp/pop)	-0.890	0.079
ln(K/pop)	1.650	0.242

Interpreting the Results

Each of the coefficients represents the elasticity of per capita output with respect to the particular independent variable. Thus, for example, a 10% change in the dollar value of capital per capita, ceteris paribus, would yield approximately a 0.7% change in per capita output on average.

Table 4 also includes the beta coefficients associated with each of the independent variables. This statistic provides information on the set of coefficients that have been standardized. Thus, each beta represents the effect of the impact of a one standard deviation change of the independent variable on the dependent variable. Because this standardization procedure removes the units of measurement from the expression, this set of coefficients allows us to make direct comparisons between the relative impacts of each of the independent variables on per capita regional output.

If we rank the impact of the four independent variables by order of their beta coefficients, we find that the two measures for per capita intermediate inputs are the most significant coefficients with respect to per capita output. Of these, intraregional per capita inputs are significantly larger than interregional per capita inputs with respect to per capita output (beta coefficients of 0.69 and 0.31 respectively). Thus, a change of one standard deviation in per capita intraregional inputs generates more than twice the impact of a one standard deviation change in per capita interregional inputs on per capita output.

Per capita employment is the next most important factor with respect to per capita output with a coefficient of 0.28 (beta of 0.15) followed by per capita capital with a coefficient of 0.07 (beta of 0.12). Again, these coefficients represent the elasticities of the independent variables with respect to the dependent variable at the mean.

Questioning the Size of the Coefficients

That intermediate inputs, capital, and employment are all significant factors with respect to regional per capita output is not at all a surprising finding. That intermediate inputs provide such a large portion of this explanation is also not surprising. What is surprising is the very large difference between the coefficients attached to intra- versus interregional per capita inputs.

If we take these results at face value, we can say that a 10% change in intermediate inputs originating from within the state will result in a 4.4% change in per capita output. If the 10% change in intermediate inputs has its source in traded commodities, this yields only a 1.9% increase in per capita output. Given that these intermediate inputs are measured in terms of dollars of intermediate goods supplied to the production process, we must provide an explanation for the very large differential between the relative impacts. One way to approach this issue is to ask the question "why should it matter where the inputs come from?"

Do Goods From Other States Really "Count" Less?

There are a variety of sources from which the differences in the sizes of the coefficients attached to inter- versus intraregional inputs might arise. Given that the coefficients represent elasticities, one possibility is that the total amount of traded inputs is so much smaller than those originating from within the state that a 10% change in per capita intraregional inputs swamps the effects of a 10% change in per capita interregional inputs. An examination of Table 6, however, indicates that the distribution of inputs between inter- and intrastate sources is much too close for this to be the answer. There is a large total dollar amount of intermediate inputs that has its origins rooted somewhat more heavily from within a particular state than from other states; however, very large amounts of per capita intraregional inputs also exist. In order to explain the relatively small impact of trade (interregional inputs of intermediate products) on regional per capita output, we have to examine the actual composition of both traded goods used for intermediate inputs and in-region intermediate inputs.

What Gets Traded?

We can imagine providing an extra dollar of intermediate inputs to the production process. If we think of this as a dollar, we should not care that the input originated from within the state or elsewhere. This is true, however, only under the assumption that a dollar's worth of inputs from within the region is identical in composition to a dollar's worth of inputs from other regions.

There is no reason to believe this should be the case. In fact, we would expect that the composition of goods traded between regions is very different from what may be available within the region. The determinants of trade (regional endowments, price differentials, etc.) would lead us to imagine that trade patterns would vary widely between regions as diverse in both resource endowments and size as individual states.

Composition of Intermediate Inputs

In order to get a better sense of the distribution of inputs by source, we decomposed the aggregate measure of per capita inputs (for both inter- and intrastate sources) into two categories: those related to manufactured goods (termed "nonservice" inputs, variable "Nons") and those related to services (termed "service" inputs, variable "Serv").[26]

We ran the model using this extra detail and present the results in Table 7. We present the associated correlation coefficients in Table 8 and summary measures for each of the variables in Table 9.

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[26]This is true in a broad sense only. The actual categories used were generated by MRIO classification codes. All inputs from industries 1-96 were combined to form a "nonservice" category. This includes agriculture, mining, construction, primary and secondary manufacturing, and transportation. Industries 97-124 were combined to form a "service" category. This includes wholesale trade, retail trade, finance, insurance, and real estate (FIRE), all other services, and government enterprises.

Table 7
Ordinary Least Squares Regression Results
Dependent Variable--ln(Output/pop)
(n of cases = 38)

Independent Variable	β	Standard Error of β	Beta Coefficient	T	Sig T
ln(K/pop)	0.052926	0.0202	0.0876	2.62	0.013
ln(Emp/pop)	0.063278	0.0686	0.0340	0.92	0.364
$\ln(Serv_r/pop)$	0.084052	0.0339	0.0857	2.48	0.019
$\ln(Serv_a/pop)$	0.301049	0.0203	0.4898	14.82	0.000
$\ln(Nons_r/pop)$	0.185597	0.0184	0.3297	10.09	0.000
$\ln(Nons_a/pop)$	0.241418	0.0180	0.4908	13.40	0.000
α (constant)	2.277628	0.0860		26.49	0.000
Adjusted R^2	0.972				
Standard Error	0.024				

Disaggregated Results

An examination of Table 7 indicates that the disaggregated model yields overall results similar to the aggregate form. Each of the coefficients (except for employment, which will be discussed below) is significant at p = 0.04 or greater. The overall fit of the model remains high with an adjusted R^2 of 0.972. The sum of the coefficients remains close to one.

The coefficient attached to employment, in this formulation, is no longer significant (even at $\alpha = 0.10$). A major reason for developing the model in the aggregate form was the issue of multicolinearity. The high

Table 8

Correlation Coefficients
(n of Cases = 38)

	ln(Output/pop)	ln(K/pop)	ln(Emp/pop)	ln($Serv_r$/pop)	ln($Serv_a$/pop)	ln($Nons_r$/pop)	ln($Nons_a$/pop)
ln(Output/pop)	1.000	0.427	0.503	0.484	0.657	0.540	0.777
ln(K/pop)	0.427	1.000	-.153	0.258	0.213	0.016	0.432
ln(Emp/pop)	0.503	-.153	1.000	0.059	0.455	0.399	0.250
ln($Serv_r$/pop)	0.484	0.258	0.059	1.000	-.016	0.384	0.519
ln($Serv_a$/pop)	0.657	0.213	0.455	-.016	1.000	0.072	0.225
ln($Nons_r$/pop)	0.540	0.016	0.399	0.384	0.072	1.000	0.259
ln($Nons_a$/pop)	0.777	0.432	0.250	0.519	0.225	0.259	1.000

Table 9

Summary Information on Variables Used in the Equation
(n of Cases = 38)

Variable	Mean	Standard Deviation
ln(Output/pop)	2.747	0.146
ln(Emp/pop)	-.890	0.079
ln(K/pop)	1.650	0.242
$\ln(Serv_r/pop)$	-.810	0.149
$\ln(Serv_a/pop)$	0.184	0.238
$\ln(Nons_r/pop)$	1.061	0.260
$\ln(Nons_a/pop)$	1.053	0.297

correlation between per capita intrastate service inputs and employment is probably the source of this difficulty.

However, even with this problem, the results of the disaggregated model provide strong evidence that it is the composition of the traded inputs that is responsible for the varied effects of inter- versus intrastate inputs on per capita outputs. Given the vast numbers of people employed in the service sector, as compared to the nonservice sector, this high correlation between employment and intrastate service inputs is not at all surprising.

In the disaggregated model, the coefficients attached to per capita intra- and per capita interstate inputs for the nonservice industries become more similar to each other. A 10% change in intrastate nonservice inputs yields about a 1.9% change in per capita output, while a 10% change in interstate nonservice inputs yields about a 2.4% change in per capita output. The coefficients attached to the service inputs, however, exhibit vast differences. A 10% change in per capita intrastate service inputs yields, on average, a 3.0% increase in per capita output. A 10% change in per capita intrastate service inputs, however, only yields a 0.8% increase in per capita outputs.

Difference in Service Sector Inputs

When we discussed the results of the aggregate model, we examined the relative sizes of the input flows from intra- and interstate sources and found them to be quite similar. An examination of Table 6, however, indicates that the distribution between service and nonservice inputs is fairly dissimilar. Although all of the inputs are important to the process, service inputs represent a much smaller share of the set of total inputs than do nonservice inputs.

Service inputs not only represent a smaller total amount of intermediate inputs than do nonservice inputs, but the distribution of the service inputs across source (traded versus in-state) is very dissimilar. Our results indicate that, although states, on the average, use nonservice inputs almost equally from within state and from other states, service inputs are used predominantly from the same state. Given this distribution, it is not at all surprising that the coefficient attached to per capita intrastate service inputs is so low relative to all of the other inputs.

Further Sources of Difference

The vast differences in the average total dollar volume of trade in services versus nonservices, coupled with the vast differences between intra- and interstate service inputs, provides a clear explanation for the differences in the coefficients. We would expect that, were we to further disaggregate this model to provide even greater detail on inputs by industry, the coefficients associated with the same commodity from intrastate sources would be almost the same as those from interstate sources. Given the problem with multicolinearity that occurs with the simple disaggregation between service and nonservice inputs, we can see that further disaggregation would evidence even greater statistical difficulties.

Were we able to perform this aggregation, we can speculate on a variety of reasons why these coefficients may not be identical. As previously discussed, although the industrial classification available provides information on 124 industries, these are, in themselves, aggregate data. Thus, inputs from industry n in region r from within region r may actually be different from inputs from industry n from all other regions.

The distribution between intermediate inputs and value added is different between industries. This has implications for per capita output. Imagine a region that produces two goods, one that requires little in terms of intermediate inputs with respect to value added, and one that consists almost entirely of intermediate inputs with a small amount of value added. One dollar's worth of intermediate inputs to the first industry would be associated with more output than would one dollar's worth of intermediate inputs to the latter. For example, assume that the production of $1 of commodity A consists of $0.33 worth of total intermediate inputs and $0.67 in value added. Further, assume that the production of $1 of commodity B consists of $0.50 worth of total intermediate inputs and $0.50 in value added. $1 in intermediate inputs for commodity A would be associated with $3 worth of commodity A's output while $1 in intermediate inputs for commodity B would be associated with only $2 worth of commodity B's output. Thus, the industrial output mix of the region plays a role. Still another set of factors that may influence the level of outputs has to do with both multipliers and industrial linkages and economies of scale.

Further Insight into Service Inputs

As the results of our model indicate, traded inputs to the production process have a smaller impact on per capita output than do locally supplied (own state) inputs. We showed earlier that the major source of this difference is that service sector inputs, although statistically significant, are traded very differently from nonservice sector inputs. Statistical issues make it difficult for us to delineate more precisely the nature of this problem.

We can gain more insight into the problem of service inputs, however, using a different approach. We ran the model once more with a different set of industrial detail. Instead of using the full set of industries for our measure of per capita regional output, we examined a major subset of output. We adopted the previously used set of "service" versus "nonservice" industry groupings. The "nonservice" grouping, as defined earlier, comprises all of the manufacturing sectors, agriculture, construction, and mining. We used this as our output measure for the next model. Our variables for employment and capital were reformulated to be consistent with this new measure for output. Given that the dependent variable for this model is per capita "nonservice" output, we needed measures for both employment and capital that were consistent with this variable. We used capital stock data that reflect the measure of manufacturing capital stock, by state, in 1977. We replaced the BLS employment data with state measures of nonservice employment.[27] These data are more consistent with our dependent variable; however, they are not consistent with the BLS data in that they do not include measures for certain employment categories, most importantly agricultural employment (estimated at approximately 3.2% of national employment in 1977) and self-employment figures. Although these data constraints do not allow direct comparisons between this sub-model and our full model, we feel that, for these purposes, this model remains useful. The intermediate input variables were maintained at the full-industry level but the distinction between "service" versus "nonservice" input type was maintained.

The results of this model are presented in Table 10. Table 11 contains information on the correlation coefficients, and Table 12 provides summary information on each of the variables used.

As was the case with the full model, as soon as we disaggregate the input information, we have problems with multicolinearity; however, we can still use these results to get a sense of what the underlying relationships may be. When we limit our examination to only the

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[27]We included employment for the manufacturing, transportation, construction and mining sectors.

Table 10

Ordinary Least Squares Regression Results

Dependent Variable—ln(Nonservice Output/pop)
(n of cases = 38)

Independent Variable	β	Standard Error of β	Beta Coefficient	T	Sig T
ln(K/pop)	0.093917	0.0344	0.1600	2.73	0.010
ln(Emp/pop)	-.129831	0.0627	-.1221	2.07	0.047
ln($Serv_r$/pop)	0.011970	0.0597	0.0153	0.38	0.703
ln($Serv_a$/pop)	0.147293	0.0304	0.1567	4.84	0.000
ln($Nons_r$/pop)	0.340227	0.0324	0.4672	10.50	0.000
ln($Nons_a$/pop)	0.400855	0.0256	0.6356	15.64	0.000
α (constant)	1.279866	0.1652		7.749	0.000
Adjusted R^2	0.962				
Standard Error	0.044				

nonservice industries, we generate results that are consistent with those of the full model. Per capita inputs remain as the major source of change to per capita output; however, for the case of nonservice outputs, both sources of nonservice inputs are the two most critical factors. Intrastate nonservice inputs are the most influential with an elasticity greater than 0.4 (beta of 0.64), but interstate nonservice inputs also have a relatively high elasticity (0.34 with beta of 0.47). Service inputs from within the state remain statistically significant, but are much less important to the production of nonservice output (elasticity of

Table 11

Correlation Coefficients
(n of Cases = 38)

	ln(Nonservice Output/pop)	ln(K/pop)	ln(Emp/pop)	$\ln(Serv_r/pop)$	$\ln(Serv_a/pop)$	$\ln(Nons_r/pop)$	$\ln(Nons_a/pop)$
ln(Nonservice Output/pop)	1.000	0.597	0.416	0.566	0.215	0.713	0.862
ln(K/pop)	0.597	1.000	0.786	0.401	0.008	0.579	0.402
ln(Emp/pop)	0.416	0.786	1.000	0.241	0.020	0.241	0.176
$\ln(Serv_r/pop)$	0.566	0.401	0.020	1.000	-.016	0.397	0.523
$\ln(Serv_a/pop)$	0.215	0.008	0.020	-.016	1.000	0.019	0.079
$\ln(Nons_r/pop)$	0.713	0.579	0.630	0.397	0.019	1.000	0.348
$\ln(Nons_a/pop)$	0.862	0.402	0.176	0.523	0.079	0.348	1.000

Table 12

Summary Information on Variables Used in the Equation
(n of Cases = 38)

Variable	Mean	Standard Deviation
ln(Nonservice Output/pop)	2.226	0.224
ln(Emp/pop)	-2.100	0.210
ln(K/pop)	0.318	0.381
ln($Serv_r$/pop)	-.810	0.149
ln($Serv_a$/pop)	0.184	0.238
ln($Nons_r$/pop)	0.874	0.307
ln($Nons_a$/pop)	0.842	0.354

0.02). For the full model, the beta coefficient attached to intrastate service inputs was 0.49. For the model using nonservice per capita outputs the beta coefficient attached to within-state service inputs is only 0.02.

Of even greater importance to this story, however, is the coefficient attached to the interstate use of service inputs. The coefficient attached to this variable is no longer statistically significant. Although we were not able to run the model using only service outputs as the dependent variable, by implication we can say that the statistically significant results attached to the use of interstate service inputs to the production process for the full model must arise out of the use of these inputs by the service industry itself.

We must emphasize that the results of both submodels (those containing measures for "service" versus "nonservice" inputs) should not be accepted without major qualification. The problems associated with multicolinearity must be kept firmly in mind. Moreover, the quality of the data, especially as regards the trade of service industries, is uncertain. This, coupled with the assumptions used in generating the traded values of the inputs, may account for the findings.

In summary, our findings support the conclusion that trade is a significant factor with respect to per capita output. Not all goods are traded equally, however, and it appears that the service sector, both on the demand and the supply side, is the source of many of the differences between the coefficients attached to inter- versus intrastate inputs to the production process.

Summary

The results of our model indicate that, as expected, changes in capital, labor, or other inputs may all serve to increase per capita output. The use of the production function, a log-linear formulation, allows us to capture the various interactions between each of these variables. Intermediate inputs, when partitioned by source (within state versus from other states), evidence differences with respect to per capita output.

On average, for our sample as a whole, traded inputs yield lower proportional increases in per capita output than do inputs originating from within the region. Much of the difference between these impacts can be explained by the existence of large variations in the composition of the inputs by source. When we examine the composition of trade by service versus nonservice inputs, our data indicate that the bulk of trade that occurs relates to nonservice goods; total nonservice inputs, in turn, derive more equally from inter- and intrastate sources.

Service inputs, on the other hand, are both much smaller in terms of total dollar amounts, and are distributed fairly unequally between those used from within the state and those obtained from other states. In essence, not unexpectedly, services are provided predominantly on a local basis with very little trade occurring.

CHAPTER 6

Further Examination of the Results and the Link to Migration

In the previous chapter, we presented the overall results of the model with respect to the effects of traded inputs, own-region inputs, capital, and labor on per capita output. When we examine the data, we find that regions vary tremendously with respect to each of these variables. The nature of the production function allows for both substitutions and interactions between many of these variables. Thus, in order to interpret the results of the model fully, we must examine these results at a variety of input levels.

Interpreting Elasticities

The solution to this production function model yields a set of elasticities. These values represent the percentage change in the dependent variable that is brought about by a percentage change in the independent variable. Were this a simple linear, rather than a log-linear model, the results would yield changes in the level of the dependent variable as a function of a change in the level of the independent variables. These relationships would be constant across the range of the values for the variables.

By their nature, however, elasticities represent percentages and percentages are a function of the level of the variable. For example, according to the results of the model, a 10% change in per capita employment, on average, results in a 2.8% change in per capita output.

We can perform a transformation on these data and generate the number of people this represents versus the dollar value of the resulting output. This "number-of-people-to-output" relationship, however, will be different for every observation. Some regions have relatively little employment compared to others. In certain cases, this may be due to the fact that some regions have fewer inputs across all input categories. In certain cases, however, the lower value for employment may exist because the region is more highly endowed with capital (or one or more of the other inputs) which is used as a substitute for the labor input.

This tradeoff between the various inputs exists not only for labor and capital but for each of the different inputs. Thus, to understand the full measure of our results, we must present information on the differential impacts associated with these results.

A Variety of Results

We are interested in the relative size of migration versus trade on regional economic development. Our model provides measures for the effects of per capita trade on per capita output and the effects of per capita employment on per capita output. We can decompose the results of the model into the relative size of the contributions of each of the variables.

Our results, from Chapter 5 (Table 4), indicate that:

$$\begin{aligned} \ln(\text{Output/pop}) = 2.02 &+ 0.193*\ln(\text{Traded Inputs/pop}) \\ &+ 0.436*\ln(\text{Own State Inputs/pop}) \\ &+ 0.277*\ln(\text{Employment/pop}) \\ &+ 0.075*\ln(\text{Capital/pop}) \end{aligned}$$

We performed the implied multiplications and generated the relative share of each of the independent variable effects on total output. The results of this operation are presented in Table 13.

Table 13

Composition of Total Per Capita Output by Source
(n of cases = 38)

ln(Output/pop)	2.747
Constant	2.020
Traded Inputs Contribution	0.234
Own State Inputs Contribution	0.617
Employment Contribution	-0.246[28]
Capital Contribution	0.124
Total all sources	2.749*

* Different from ln(Output/pop) due to rounding errors.

From our prior discussion, we know that these regions vary with respect to the composition of the sources of inputs. In order to understand the differences among the regions, we examined a variety of different regional groupings. We generated groups of regions that were comprised of both the lowest one/third and highest one/third of our sample

[28]Because per capita employment is less than one, the natural log of the value is negative. This does not mean that employment detracts from output. The overall coefficient is 0.277. When multiplied by the natural log of the employment values, however, the contribution remains negative. Large employment values will yield smaller negative amounts.

of 38 regions using values for the dependent and independent variables. Thus, we have approximately 12 observations each for regions with the: highest (lowest) per capita output, per capita trade, and per capita employment. Table 14 presents detail on these regional groupings by the relative share of composition to output that was used in Table 13. As is clear from an examination of Table 14, overall model results are considerably different among the selected groupings of states. The predicted value of the natural log of per capita output, on average, is approximately 2.7. For states with low output, low trade, or low employment, the predicted value is also lower. For states with high output, high trade, or high employment, the predicted value of the natural log of per capita outputs is consistently higher.

The difference in the predicted values of per capita outputs between the various high and low state groupings arises from differences in the shares for all four of the independent variables. The bulk of the difference, however, arises from the fact that higher output states are also states that use much larger amounts of own-state inputs. Both increased per capita trade and higher per capita employment effects also account for part of the difference. The capital share of high-output states is also higher than the average for the sample. These results indicate that higher output regions draw from the variety of inputs to generate their output.

High-trade states generate a predicted value for per capita output that is larger than the average of the sample as a whole. When we look at the differences between high-trade versus low-trade states, we find that the predicted values of the natural log of per capita output are different

Table 14

Composition of Total Per Capita Output by Source
Across Different State Endowments

	Overall Model (n=38)	High Output (n=13)	Low Output (n=12)	High Trade (n=12)	Low Trade (n=12)	High Employment (n=12)	Low Employment (n=12)
ln(Output/pop)	2.747	2.904	2.595	2.856	2.679	2.786	2.652
Constant	2.020	2.020	2.020	2.020	2.020	2.020	2.020
Own-State Inputs Contribution	0.617	0.722	0.518	0.659	0.605	0.629	0.573
Traded Inputs Contribution	0.234	0.265	0.201	0.287	0.185	0.244	0.205
Employment Contribution	-.246	-.233	-.259	-.233	-.253	-.233	-.272
Capital Contribution	0.124	0.130	0.116	0.123	0.122	0.116	0.216

between the two and that, as expected, most of this difference is accounted for by the difference in the relative shares of trade in the two groupings. Differences in own-state inputs account for some portion of the output difference, as do differences in the employment contribution.

High-employment states generate only marginally greater estimates for per capita output than the sample as a whole. The differences between the predicted values for per capita output between high-employment versus low-employment categories stems mostly from the higher use of own-state inputs by the high-employment states. Some of the difference is accounted for by differences in the contribution of trade to per capita output. Although there are major differences between the high-employment and low-employment regions with respect to per capita employment contributions, the contributions of per capita capital are also fairly different; high-employment states evidence much lower per capita capital than does either the sample as a whole or lower-employment regions. Conversely, low-employment regions evidence greatly increased contributions of per capita capital than either the sample as a whole or high-employment regions. This would indicate that employment and capital are strong substitutes for each other.

In summary, we see that the higher output associated with high-output states is derived from increased shares across all of the different input sources. High-trade states also evidence higher output than does the average of the full sample. The capital contribution to high-trade states, however, is almost identical to the sample as a whole. Higher trade, increased own-state input, and higher per capita employment each contribute, in that order, to the increased output. High-employment states evidence only marginally higher per capita output than does the sample as a whole. Unlike the higher (lower) grouping of states by trade, however, the contributions to capital are very different from the sample as a whole. It appears that the increase (decrease) in per capita employment is traded off against the decreased (increased) use of capital; high-employment states are also low-capital states and low-employment states are also high-capital states.

Looking at Multipliers

We have already examined the results of our model and a selected set of regional groupings by discussing the values of the coefficients (the elasticities of the independent variables with respect to per capita output) and the contributions to predicted output by each of the different inputs. We also generated a different set of measures for the impact of a change in the independent variables on the dependent variable--the multipliers. This value represents the unit change in the dependent variable associated with a unit change in the independent variable. Because we are dealing with a multiplicative function, the multipliers we generate are not simple constants. The multiplier assumes different values for each of the observations.

The multiplier for each of the independent variables is the partial derivative of the production function with respect to that variable; the marginal change in output with respect to a marginal change in input.[29]

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[29]The elasticities, essentially, are comprised of the multiplier weighted by the average value for the inputs divided by the average value of the output.

Referring to our equation and using per capita interregional trade as an example, we have:

$$\text{Output/pop} = A * K/\text{pop}^{\beta_1} * L/\text{pop}^{\beta_2} * M_r/\text{pop}^{\beta_3} * M_a/\text{pop}^{\beta_4}$$

then

$$d(\text{Output/pop})/d(M_r/\text{pop}) = A * K/\text{pop}^{\beta_1} * L/\text{pop}^{\beta_2} * \beta_3 * M_r/\text{pop}^{(\beta_3 - 1)} * M_a/\text{pop}^{\beta_4}$$

We generated multipliers for each of the four input variables. The results for the total sample are presented in Table 15. These results reflect the multiplier effects at the mean values for the total sample.

An examination of Table 15 indicates that a one unit change in employment is associated with about a 10.6 unit change in output, for the 38 observations that comprise our full model. A one unit change in trade is associated with about a 0.9 unit change in output. Alternatively, a one unit change in output is associated with a 0.09 unit change in employment or a 1.09 unit change in trade.[30]

Unlike the measures for elasticities, the multipliers do not incorporate any information on the relative size of the level change. Moreover, the multipliers present relationships at a single point and differ over every point on the curve. We can use these multipliers, however, in conjunction with average values for the variables, to generate

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[30]Certain of our multipliers have values that are less than one. This indicates that sole reliance upon that input for production most likely results in an infeasible solution. In essence, the ceteris paribus assumption is highly restrictive for these inputs.

proximate values for the "number-of-persons" and "dollars-of-trade" to output previously mentioned.

Table 15

Multipliers for the Independent Variables
(average for sample n = 38)

Marginal Change in Output With Respect to Marginal Change in	Value
Interstate Trade	0.92
Employment	10.59
Capital	0.23
Intrastate Inputs	1.66

Because all of our variables are expressed in per capita terms, we can multiply both sides of the equation by population to generate proximate values for these multipliers on the level of the particular variable, rather than the per capita value. The results of this process for the sample as a whole indicate that increased employment of 1,000 people is associated with an increased output of about $10,400,000. An increase of $1 million in trade is associated with about $0.82 million in output. Alternatively, an additional 90 persons employed or $1.09 million in trade are each associated with an additional $1 million in output. We must bear in mind that this association applies at the mean values for the sample with average output of $90,686 million, average employment of 2,289,000, and average trade of $18,797 million.

This relationship is different, however, when we look at the subsets of high (low) output, trade, and employment regions, as previously defined. Table 16 presents multipliers and average values of each of the variables for the overall model and each of these regional subsets. For the high-output regions, both the employment multiplier (11.775) and the trade multiplier (0.923) are higher than for the sample as a whole, with an additional 84 employed persons or an additional $1.08 million in trade associated with an additional $1 million in output. These higher multipliers indicate that each marginal change in the independent variable generates more output than does the sample as a whole; moreover, a marginal change of 84 persons for this subsample with average employment of 3,144,000, is a relatively smaller change than is the 94 person change for the full model with average employment of 2,289,000. For the high-trade regions, the employment multiplier is much higher than the sample as a whole (11.187 compared to 10.590) but the trade multiplier is greatly reduced (0.766 compared to 0.917); in this case, increased employment of 89 people or increased trade of $1.3 million is associated with increased output of $1 million.

We presented information on the composition of total per capita output by source in Table 14. An examination of that table indicates that for high-trade regions, the contribution of the trade effect to per capita output is greater than for the sample as a whole; yet the trade multiplier for high-trade regions is significantly lower than that for the sample as a whole. These results are easily reconciled, however. The lower multiplier indicates that although each marginal change in trade generates less output than the sample as a whole, the notably higher level of trade,

Table 16

Multipliers and Average Values Across Different State Categories

	Overall Model (n=38)	High Output (n=13)	Low Output (n=12)	High Trade (n=12)	Low Trade (n=12)	High Employment (n=12)	Low Employment (n=12)
(Average Output)	(90,686)	(135,454)	(45,555)	(101,452)	(109,776)	(61,932)	(63,218)
Own-State Inputs Multiplier	1.661	1.527	1.786	1.678	1.593	1.678	1.667
(average $m)	(24,796)	(39,757)	(11,180)	(25,956)	(32,280)	(16,140)	(16,634)
Traded Inputs Multiplier	0.917	0.923	0.926	0.766	1.093	0.895	0.959
(average $m)	(18,797)	(27,356)	(9,679)	(25,580)	(17,474)	(13,756)	(12,195)
Employment Multiplier	10.590	11.775	9.482	11.187	10.104	10.106	10.579
(average 000s)	(2,289)	(3,144)	(1,376)	(2,424)	(2,774)	(1,734)	(1,612)
Capital Multiplier	0.230	0.248	0.218	0.258	0.219	0.262	0.205
(average $m)	(30,228)	(44,529)	(16,215)	(31,240)	(36,324)	(18,090)	(22,863)

in conjunction with this multiplier, generates a total trade effect that is higher than the sample, on average.

It is clear to us from these results that we cannot speak about a single employment to trade equivalence: there is none. When we examine the process of our model development, the final design and structure of the model, and, finally, the results of the model, this does not come as a surprise. There are clearly large differences among the regions in terms of a considerable variety of factors: the composition and use of the different inputs, the tradeoffs that exist between each in terms of substitution, initial regional endowments, various population levels--all of these factors interact in a variety of ways to produce a wide range of differing effects for each of the input sources. Our model does, however, offer some insight into the varied interactions that do occur. Through the use of this model we are able to identify and measure some of the tradeoffs that do occur; the range of results that we generate offer a rough measure of these tradeoffs. Moreover, this model offers a way for us to begin to measure the range of values that trade and employment assume in the process of regional output.

Link Between Migration and Employment

The model that we estimated used employment, not migration, as the independent variable measure for the labor impacts on per capita output. In order to make the link between trade and migration, we must make a link between employment and migration. To this end, we estimated a separate equation to generate a measure of the effects of migration on employment.

The model and, more importantly, the employment information in the model, are based on data from 1977. Migration information for the relevant time period, however, is only available for the period 1975-1980.[31] The migration model we developed took the following form:

$$\ln(\text{Employment}_t/\text{pop}_t) = A + \beta_1 * \ln(\text{Employment}_{t-1}/\text{pop}_t) + \beta_2 \ln(\text{Inmigration}_{t-1}/\text{pop}_t) + \beta_3 \ln(\text{Outmigration}_{t-1}/\text{pop}_t)$$

where

$\ln(\text{Employment}_t/\text{pop}_t)$	=	Natural log of per capita employment in time t
$\ln(\text{Employment}_{t-1}/\text{pop}_t)$	=	Natural log of per capita employment in time t-1
$\ln(\text{Inmigration}_{t-1}/\text{pop}_t)$	=	Natural log of inmigration per 100 persons for the five-year period beginning in time t-1
$\ln(\text{Outmigration}_{t-1}/\text{pop}_t)$	=	Natural log of outmigration per 1000 persons for the five-year period beginning in time t-1

Because we do not have information on migration flows between 1970 and 1975, we decided to run the regression for the time period for which we do have data. Thus, we estimated this equation for employment in 1982 as a function of employment in 1975 and migration flows between 1975 and 1980. To remain consistent with the production model, this equation was

[31]Information on migration is taken from a question on the census that inquires as to region of residency five-years previous. Thus, these data are only available once every decade.

expressed in per capita terms and solved as a log-linear function for the same 38 regions chosen for the sample. The results of the regression are presented in Table 17.[32] Table 18 presents the associated correlation coefficients and Table 19 offers information on the means and standard deviations for each variable.

Table 17

Dependent Variable--$\ln(\text{Employment}_{82}/\text{pop}_{77})$
(n = 38)

	β	Standard Error β	Beta Coefficient	T	Sig T
$\ln(\text{Emp}_{75}/\text{pop}_{77})$	0.8307	0.1261	0.7454	6.585	0.000
ln(Outmigration)	-.0364	0.0567	-.0831	-0.652	0.525
ln(Inmigration)	0.1701	0.0297	0.7942	5.717	0.000
Constant	-.6143	0.2460		-2.497	0.018

Adjusted R^2 = .645
Standard Error = .055

[32] The choice of generating the model in per capita terms was made in order to remain consistent with the production model. It can be argued that this equation should be estimated without the population deflator. The results of this estimation yield results quite similar to the per capita model results.

Table 18

Correlation Coefficients
(n of Cases = 38)

	$\ln(Emp_{82}/pop)$	$\ln(Emp_{75}/pop)$	ln(Inmig/pop)	ln(Outmig/pop)
$\ln(Emp_{82}/pop)$	1.000	0.448	0.472	0.426
$\ln(Emp_{75}/pop)$	0.448	1.000	-.368	0.063
ln(Inmig/pop)	0.472	-.368	1.000	0.582
ln(Outmig/pop)	0.426	0.063	0.582	1.000

Table 19

Summary Information on Variables Used in the Equation
(n of Cases = 38)

Variable	Mean	Standard Deviation
$\ln(Emp_{82}/pop)$	-.804	0.093
$\ln(Emp_{75}/pop)$	-.963	0.083
ln(Inmig/pop)	4.558	0.434
ln(Outmig/pop)	4.538	0.212

From these tables we can see that this formulation provides an reasonably good fit. Both the prior employment level and inmigration are significant ($\alpha = 0.05$) and both provide strong sources for the explanation of the results (beta coefficients of 0.74 and 0.79). Our a priori expectations were that outmigration should act to decrease employment whereas inmigration should act to increase it. Outmigration has a negative sign indicating that movement out of the region acts, as expected, to decrease employment. The coefficient attached to this variable, however, is not statistically significant. The inmigration coefficient is positive, as expected, indicating that increased inmigration acts to increase employment. Given this formulation and these results, we see that the bulk of employment in 1982 can be explained by the prior 1975 employment level. The coefficient attached to inmigration indicates that a 10% change in the natural log per capita inmigration yields, approximately, a 2% change in the natural log of per capita employment.

We generated multipliers for both inmigration and prior employment from this equation. The change in 1982 employment with respect to employment in 1975 is approximately 0.98 which indicates that for an additional 1,000 persons employed in 1975, about 980 persons would be employed in 1982. For inmigration, the value is 0.75 indicating that for an increase of 1,000 inmigrants, 750 would become employed.

In order to make the full link between migration and employment, we could generate a reduced form equation by substituting this employment equation for our employment variable in the production function. Thus, as a coarse (and somewhat overstated) measure, inmigration accounts for approximately 17% of the employment values previously discussed for the impacts of trade versus employment.

Summary

An analysis of the results of our model provides valuable insight into the link between trade, migration, and regional economic change.

This relationship is complex in that regions differ with respect to their natural endowments of each of the factors of production. Within a region, therefore, substitution among and between certain of these factors allows for increased output. Moreover, both trade and migration also act to ameliorate these initial imbalances. These effects are captured in our use of the production function.

There is no single simple role we can ascribe to trade or migration. The production relationship requires inputs from a variety of sources: capital, labor, intermediate inputs, etc. We have, however, demonstrated that the composition of what gets traded has a substantial impact on per capita output. We have also been able to generate measures for both the amount of trade and employment used across varied groupings of states by selected characteristics; those with high (low) employment and those with high (low) traded inputs.

Thus, we have provided information regarding the various combinations of trade and employment (and, by implication, migration) that these diverse regions require for production.

Chapter 7

Implications and Extensions of the Model

There were several factors that influenced our decision to develop this model. Although the topics of migration and trade have extensive theoretical and empirical bases, the fact remains that the assumptions that underpin these theories are mutually exclusive: simple trade theory is predicated on the assumption of no migration; migration theory begins with the assumption of no trade. Trade studies have given evidence of the importance of trade to regional development. Migration studies also have shown the importance of the movement of people on regional development. The reality is very clear: both exist, both are important, but both occur simultaneously.

Yet, regional economists have had little to say about the joint effects of these two important processes. Because of the exclusionary natures of the assumptions between these two bodies of knowledge, little research has been conducted on these simultaneous processes. In order to investigate this topic, we developed a framework that would allow for the effects of both, which could be supported in theory, and which could be empirically tested.

We view the development of our model as a major step in realizing these goals. By using the production function and partitioning aspects of intermediate inputs into their inter- and intraregional portions, we are able to offer a formulation that allows for the common metric required to generate a measure of the relative strength of trade versus migration on regional economic development. We feel that our model results can be interpreted as offering evidence of the importance of both trade and migration to regional economic change.

In terms of the relative importance of trade versus migration on this process, however, we cannot report one unique outcome. There is a complex set of factors that comprise the production process, and each factor contributes in a crucial way in determining the level of output. The distribution of input factors is fairly different among regions; part of this has to do with regional endowments, part of this has to do with the composition of regional outputs. These different inputs combine in a variety of ways with a wide range of substitution possibilities among them; therefore, the measure of the relative strength of trade versus migration on regional development is, by the nature of this process, a varied one and depends upon the structure and composition of the region. We have presented some rough estimates of the range that this measure assumes for our sample as a whole and selected regional groupings. Although these measures offer some insight into the workings of the regional economy, we feel that our results can be best interpreted as indicating the need for even more detailed studies on this topic.

Policy Implications

There is an ongoing major debate in the regional development field about the appropriate role of policy with respect to migration. Certain theorists have argued that migration occurs due to regional wage inequalities with lower wage regions losing workers to regions with higher wages. Eventually, it is theorized, these movements act as a means of spatially redistributing labor that will lead to regional wage equalization. The costs and benefits associated with these changes may result in regional growth and decline, but the net effect is greater national efficiency.

Others have argued that the process of migration is a costly one both to individuals and communities. Unlike many of the other inputs used in the construction of economic models, labor has always had a unique character. The nonpecuniary costs associated with migration, such as loss of community, family, and friends, may not allow for the smooth transition implied by a model which treats migrants as simply another factor to the production process. Instead of increasing the speed of the migration flow, the argument is that given these factors, in order to insure regional economic health, investment in the region could act to keep the people in place by providing jobs, thus ameliorating some of the costs associated with a region in decline. The debate about the choice between these simple policy solutions, the possibilities either of aid to migration as a means to increase the speed of this transition, or incentives to business investment in declining regions to insure employment, continues.

Evidence from migration studies as to the factor-price equalization effect of migration is mixed at best. This may be due to a variety of reasons. Not all migrants move for economic reasons alone. Many of the studies involving the determinants of migration have indicated that economic reasons are only one of a vast array of reasons given for the decision to relocate. Our model, although not framed as a wage-equalization study, can be used to offer insight into this debate. Our results indicate that the effect of employment on regional economic growth varies widely among the regions, both in its direct effects and in the substitution effects with other factors. The employment impacts of migration, therefore, will differ along these lines. Thus, in terms of the policy debate, without more information about the particular region(s) involved, it is unclear as to whether or not unconditional aid to migration would accomplish the stated goal of speeding up the process of regional wage equalization. Given that our model does not distinguish between migrants on the basis of job-status categories, we cannot say whether selective aid to migration would be able to accomplish this goal.

That trade is an important aspect of regional development has been well documented both theoretically and empirically. Our model indicates that interregional and intraregional trade are important factors in the process of regional per capita output growth. Although a policy of selected aid to migration could conceivably increase regional output, so too could, for example, investment in the region. Such investment could act to increase capital and either or both inter- and intraregional trade, depending in part on the region and the specific interregional and interindustry linkages of the region in question. Again, there could also be substitution effects that must be taken into account.

Although the interaction and substitution effects that exist between the input factors in our model make the generation and exposition of our results somewhat more complicated and tentative than might a different formulation, we view the inclusion of these effects as a major strength of the model. We feel that in order to examine issues related to regional economic policies we must be much better informed about the actual working of the regional economy.

Refinements and Extensions of the Model

The model developed for this paper is an elaboration of the basic Cobb-Douglas production function in which output is expressed as a function of inputs (both capital and labor). Estimates of the parameters of the Cobb-Douglas function are generally used to determine the relative significance of capital versus labor in the production process. Clearly, the focus in this formulation is mainly on the inputs to the equation. Our model, however, was devised in an attempt to measure more than just the capital and labor shares associated with output.

We use this production function concept, but we place it in a regional context. By its nature, a regional economic framework forces us to consider the dynamics of this relationship. Although the original focus on this equation may have been on the inputs, increased outputs are a major source of regional economic growth. Regional economists are always cognizant of the existence of other regions and the issues of linkages and growth both within and between these regions. Our model evolved out of our awareness that not only do inputs matter, but, in a regional model, the source(s) of the inputs may also play an important role in the dynamics of the production process. In this light both capital and labor can be viewed as coming either from within the region or from a number of other regions. For commodity inputs, this movement of goods is a measure of trade. For labor, the movement of people is subsumed under the title of migration. Given the nature of the Cobb-Douglas production function, its use as a means of measuring the relative strength of factor inputs, and the possibility of partitioning the sources of the inputs into inter- and intraregional origins, it was clear to us that this production function offered a firm theoretical basis for examining issues related to the relative strength of trade versus migration on regional development (output).

The level of aggregation and detail of each of the variables used in this model were chosen to insure that, given the available data, this model would be of sufficient detail to yield results if the overall formulation chosen was appropriate. The results of the model are consistent with a priori expectations, at least with respect to the major focus on the trade and migration relationship. We feel that this model could be extended and revised in a number of ways that might yield even more information. Some of this work may be done to insure that these results are truly reflective of the underlying relationships.

In order to generate a measure of the relative importance of trade versus migration, we needed some common metric that could incorporate measures for both. We feel this is the greatest strength of this model. As previously stated, because of their underlying assumptions, neither migration nor trade theory alone can offer this kind of a framework. That is not to say that this should be viewed as the definitive model. Although we consider this formulation a firm beginning, several aspects of its construction could yield even greater insight and more reliability in future studies.

Data Issues

As with most studies, both money and time constraints played a large role in determining the course of the research and, to some extent, model development. The measures used for the estimates of the link between employment and migration were generated at a very rough level. As noted earlier, it would be useful to include more detail on these flows in terms of their composition by a variety of variables; working status, age, gender, etc. Given the nature of this initial model, however, we felt that enough information could be gleaned from the inclusion of these more aggregate measures.

Using what little information on capital stock that was available, we were able to generate a proxy for the value of capital stock by region. Although from the theoretical standpoint, this variable is critical to the implementation of many economic models, finding actual measures for regional capital stock continues to be problematic.

Information on regional trade flows is also quite sparse. Although the 1977 MRIO dataset does contain information on trade flows for each of its 124 commodities by origin and destination state, the quality of these data, especially with respect to the service industries, remains in question. Moreover, although these are the most current data available, they were collected over twelve years ago.

Modeling Issues

One of the major areas of extension we would like to see with this model is the move from a cross-sectional to a time-series framework. Although this cross-sectional approach can be interpreted as offering information about the results of a long-run adjustment process, a time-series approach could allow insight into both the end results and the process that generates these results. A major difficulty with this, again, is the lack of data. As previously stated, we feel that one of the strengths of this study is that the regional data used were collected and assembled at the regional level rather than being imputed to the region from the national level through some allocation scheme. These data are more clearly reflective of the true nature of the regional processes. Were such data available for time studies of this issue, we could undertake a more rigorous examination of regional economic growth defined as changes in per capita output.

A major part of the Cobb-Douglas production relationship is the possibility of the inclusion of the effects of technology change on the production process. Given the cross-sectional nature of this initial study, we did not feel it critical to account explicitly for the effects of these kinds of changes. In the formulation chosen for this paper, we capture these effects, along with all other non-measured effects, in the coefficient associated with the constant. An examination of the constant indicates that it was positive, statistically significant, and large. Were the model to be extended over time, however, much greater emphasis would need to be placed on the interpretation and impact of the effects captured by this constant on the system of equations.

As previously discussed, the level of aggregation chosen for this model was, to some extent, a function of the availability of data, with the major constraint related to capital stock information. Given the definitions and sources of our variables, we had unexpected problems with multicolinearity even when we attempted to develop gross categories for only two sectors: services and nonservices. Again, this was complicated by the complete lack of regional capital stock information for service industries.

As with many studies, we assumed that the service industries could be modeled in a fashion identical to those for the manufacturing industries. Although this task was somewhat complicated by the lack of information on service industry capital stock data, this did not appear to be an insurmountable problem. There were alternatives available to us, such as the procedure we used to generate our capital stock variable, which enabled us to generate a proxy for this missing information. However, unlike the manufacturing model that yielded some results (although somewhat problematic in terms of the issue of multicolinearity), when we attempted to model the service industries in a manner analogous to manufacturing, the problems with multicolinearity were so severe that we felt we could not trust the results. Better trade and or capital stock data might be the solution to this problem. However, given the dramatically large shift from manufacturing to service based output that has been underway in this country for so long, we feel it important to study carefully what can be done to allow us to model the service sector; to more exactly determine what distinguishes service output from other (manufactured) output.

Summary

Our true economic world is comprised of innumerable transactions among people, firms, governments, markets, etc. By formulating theories about certain aspects of this dynamic process, by simplifying this tremendous complex of interrelated activities, economists can gain insight into some of these fundamental relationships.

Implementing empirical tests of these theories often involves yet another level of abstraction and/or simplification. Not all theories lend themselves well to empirical testing. Even those that do require the formulation and development of a model. Yet, developing models is neither a simple nor an exact science. Modelers are constrained by a wide range of factors such as the theory, data availability, time, and money. Overcoming these constraints often requires making difficult decisions regarding every one of these issues, with each decision having implications for both model development and results.

Thus, the true outcome from the modeling effort cannot be measured only by the final results that the model generates. Clearly, these results are important. The analysis of these results may (or may not) yield evidence of the veracity of the subject under examination. This is generally the primary goal of the modeling effort. However, modeling is also a process. The dynamics of model construction and evolution oftentimes can have its own outcomes and implications.

Model Outcomes

We developed a model of the United States in an attempt to measure the relative impact of trade versus migration on regional economic development. In this dissertation, we document the major part of that process from the review of the literature through model development, model results, and our analysis of those results. The results of our model are consistent with the two different bodies of theory used for model development, namely trade and migration. Both are theorized to be and have been shown to be important processes to the dynamic of regional economic change. Our model provides further empirical evidence of this fact.

The design of our model also allowed for an examination of the relative impacts of these two sources of change. As discussed throughout this document, conflicting theoretical assumptions between trade and migration theory have been a major impediment to the study of this topic. Our model, by including both trade and migration in a common framework, provides a metric by which we can evaluate certain aspects of this relationship. Our results indicate that trade and migration have a somewhat complicated relationship with respect to per capita output. We can, however, generate a range of values which offer insight into the relative strength of trade and migration on per capita output.

Model Development Outcomes

We encountered several major difficulties throughout our work on the model. Many of the problems are inherent in the task that is modeling. As discussed above, a major part of the work involved with modeling consists of working within constraints. Part of what constitutes a good model is the way these constraints are handled. Even though we were aware of all of this, we were still struck at the severe limitations we encountered in two different areas: theory and data.

Although our model does allow for a common metric between the process of trade and migration (through employment), we have not integrated trade and migration theory. International trade theorists have begun this crucial process, but more work is required. Regional theorists should also take part in this work.

The reality of having to work with limited data is not new. Lack of appropriate data for empirical testing is almost always problematic. In many cases, this difficulty can be surmounted by using a variety of different methods or sources for generating information that will serve the purpose at hand. Although researchers must pay very close attention to the implications for using these alternative measures, research can continue.

In order to study the dynamic of regional economic change, time series data at the regional level are required. These data are not available. The model developed for this undertaking was based on the most recent set of regional input-output data available for this country; yet, they present regional information for the country only as it was in 1977. We feel that the use of actual regional data is one of the strengths of this model. Although these data offer rich detail, there are obvious tradeoffs to the use of data that reflect the economic composition of our regional economy over a decade ago. Although as regional analysts we have been faced continuously with the limitations imposed by the lack of data, we were still very surprised at the paucity of information available on capital stock in the United States at the regional level. Empirical research, at the regional level, will continue to suffer until this situation is improved.

In order to continue the process of understanding the dynamics involved with regional growth, we feel that much more work needs to be done with respect to integrating trade and migration theory to enable models to reflect the reality of their simultaneous nature.

The development of our model offers one solution to creating the requisite common metric for measuring the relative impacts of trade versus migration on regional economic development. We have extended substantially the body of knowledge we have regarding the link between these processes, and we have detailed a variety of possible extensions to our model which, when effected, may yield even greater insight.

APPENDIX A

The 1977 Multiregional Input-Output (MRIO) Data

APPENDIX A

The 1977 Multiregional Input-Output (MRIO) Data

The Social Welfare Research Institute (SWRI) modified set of the multiregional input-uutput accounts for 1977 were used as the primary data source in the construction of our model.[1] The original data were developed for the Department of Health and Human Services by Jack Faucett Associates (JFA) of Chevy Chase, MD. These accounts are composed of four interrelated data sets: (1) outputs, employment, and payrolls; (2) final demands; (3) interindustry flows; and, (4) interregional trade flows. These data were assembled for each of the 50 states plus Washington, DC, and contain detail for over 120 intermediate industries. Supplementary documentation consists of a six volume Final Report: The Multiregional Input-Output Accounts, 1977, also produced by Jack Faucett Associates.[2]

The final data assembly resulted in a regional set of Use, Make, Trade, Margin, and Consumption Matrices. There were several inconsistencies noted between the actual data and documentation that was received from Jack Faucett Associates at the Social Welfare Research Institute. These inconsistencies applied both within individual matrices and between different sets of matrices. In order to insure complete

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[1]The 1977 multiregional input-output accounts were assembled as one part of the development of a Multi-Regional Policy Impact Simulation Model (MRPIS) that was developed at The Social Welfare Research Institute, Boston College, Chestnut Hill MA 02167.

[2]Jack Faucett Associates, 1982, The Multiregional Input-Output Accounts, 1977, Six Volumes, Submitted to the U.S. Department of Health and Human Services, Contract Number HHS-100-81-0057, Jack Faucett Associates, Chevy Chase Maryland.

consistency both within and between all elements of these data, a necessary step to the creation of a 1977 input-output model which was used to implement the industrial sector of the Multi-Regional Policy Impact Simulation Model (MRPIS) under development at SWRI, several adjustments were performed on these data.

At the time that these data were collected, the creation of a new national set of Use and Make matrices was also underway. Jack Faucett Associates was given some preliminary information for the national Make matrix and much of the consistency work done by them focussed on insuring concordance between the sums of the regional Make matrices and the national information.

This also meant, however, that benchmark comparisons between the regional and the national data were not able to be made at that time. To the best of our knowledge, that comparison has yet to be made. What we do have with this data set, however, is an internally consistent set of information, which provides regional detail on inputs, production, trade, and consumption for the United States for 1977.[3]

As a first step to our model development, we performed consistency checks on these data for the Social Welfare Research Institute. In this Appendix we will present descriptive detail on each of the matrices used in our model, the adjustments that were performed on the original data at the Social Welfare Research Institute, and the consistency checks that

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[3]The author worked on the MRPIS project at the Social Welfare Research Institute at Boston College during this part of the model development. He was intimately involved with screening and correcting the data over a period of three years and is thoroughly familiar with the difficulties involved.

were performed both within and between these different matrices.[4]

We also offer the full set of industry titles used for these accounts along with the Standard Industrial Classification (SIC) categories subsumed under that title. This is followed by a description of the aggregation scheme used in the model developed for this dissertation.

Make Matrices

Because JFA had access to the preliminary information on the national Make matrix, the regional Make matrices were assumed to be the most reliable of all of the data provided. The Make matrices contain output data for each sector, both as primary and secondary to the production process. Column totals represent total sector output. Row totals represent total commodity output. Each matrix was dimensioned 128x128; the actual data is contained in rows (columns) 1-125. (Row and Column titles can be found later in this Appendix.) Row (column) 126 contains the value of primary output. Row (column) 127 contains the value of secondary output. Row (column) 128 contains total industry (commodity) output.

An examination of the original data indicated that there were certain very noticeable data entry errors (e.g., entries misplaced in columns, values larger than others by an order of magnitude, etc.). For several of these types of errors, JFA was consulted before the values were changed.

Internal sums for these matrices were generated and placed in the appropriate locations to reflect row and column sums for both primary and

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[4]Two other sets of matrices, Trade Margins and Excise taxes, were used to insure inter-matrix consistencies. For full information on the composition of these data, please refer to the six volumes.

secondary output. Some of the rows and columns for certain Make matrices contained some very small values that were inconsistent with the associated Use matrices. These values were set to zero. There was also a major issue as to how to treat imports in the model. The final decision made was to place the value for imports outside of the model proper and keep the detail only as a balancing entry. Thus, all values in the Make and Use matrices reflect domestic quantities produced and consumed. These row and column sums were then used as input to a set of bi-proportional matrix adjustment procedures, developed at SWRI, to generate complete consistency between the Use and Make matrices.

Internal consistency checks were performed on each of the Make matrices in the dataset. For each row (column), the sum of elements 1-125 should be equal to the entry in row (column) 128. Row (column) 126 should be equal to the value of the diagonal element (primary output) while row (column) 127 should be equal to secondary output (total minus primary). Each of these relationships was found to be consistent.

Use Matrices

Each of the Use matrices contains consumption data for each intermediate sector and the final demand sectors. Entries represent products consumed. Row totals represent total consumption of the product, plus exports, minus imports, plus or minus inventory change.

Each of the Use matrices is dimensioned 132x135. Row and column titles for sectors 1-124 are the same as the Make matrices. Rows 125-132 contain information on statistical discrepancy, value added, and the components of value added. Columns 125-135 contain detail on statistical discrepancies, personal consumption expenditures, gross private investment, exports, imports, federal government expenditures (both defense and nondefense), state government expenditures (both capital and current account), total final demand, and total commodity consumption.

Some adjustments needed to be made to certain components for value added in several industries and regions. Large discrepancies between the Use and Make matrices for sector 105 (Real Estate) were corrected by utilizing outside data sources. Many of the other value added differences were corrected by hand to insure that the sum of the individual components for value added were equal to the total amount

As previously mentioned, to insure the concordance between the Make and the Use matrices, a bi-proportional adjustment procedure was used to modify the Use matrices to insure consistency with the Make matrices. As previously indicated, for certain sectors where there was no output in the Make matrix, selected elements in the Use matrix also had to be changed. The sum of rows (columns) 1-126 were found to be equal to row (column) 126. The components of value added (rows 129-131) were found to be equal to the total value for value added (row 128) in each sector. Total intermediate input (row 127) and total value added (row 128) were checked and found to be consistent with total output (row 132) for each sector and region. Similar checks were performed for the differing components of final demand, and all of the data were found to be internally consistent.

Trade Matrices

The Trade matrices represent the amount of each commodity shipped from region to region. There is one matrix for each commodity. For each matrix (origin region), each column presents the flows of a commodity (row entry) to a destination region (column entry).

To insure consistency with the rest of the model, several adjustments were performed upon the trade data. Selected consumption values were too large (small) for certain commodities and regions. In these cases, adjustments were made to maintain the balance. As previously mentioned, imports were remapped from the point of consumption to the point of entry, thus making this a domestic model. Changes in inventory were also remapped to final demand at the point of consumption.[5] For each of the trade matrices, the sum of rows 1-53 was checked to insure that it was equal to the sums which were maintained in row 54.

Between Matrix Consistency Checks

Besides the internal consistency required for each of these matrices, there are also a variety of accounting relationships that must be satisfied between the different matrices. We can generate a new Trade matrix using diagonalized columns of the original trade matrix with the associated margins included. We can also generate a Consumption matrix consisting of a diagonalized consumption vector from the Use matrix. Final Demands are also kept in a separate array. For each of the regions, assume that those matrices are arranged as in Diagram 1.

Make and Trade Consistency

There is a logical relationship between the row sums of the Make and the Trade matrices. Everything that is produced in a region must be shipped either within or between regions. Thus, the row sum of the make matrices should be equal to the row sums of the Trade matrices. This

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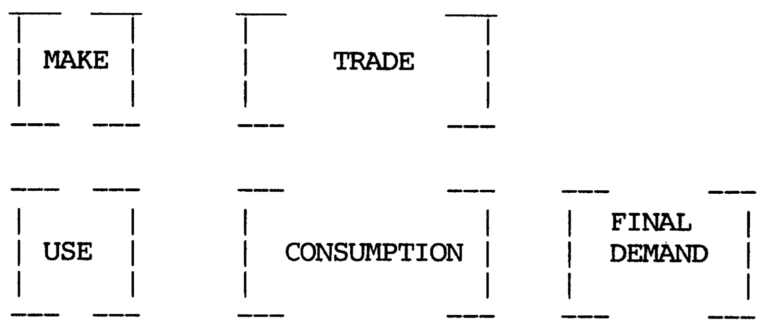
[5]Because trade is the balancing element in several key identities associated with the MRIO model, a variety of other small changes were made to insure that these relationships held.

relationship was tested and was consistent for each of the regions.

Diagram 1



Use, Consumption, and Final Demand

Total consumption should be equal to total demand plus total intermediate use. All output must be consumed, either as industrial input or by final consumers. This relationship was tested and is consistent for each of the regions.

Make and Use Consistency

The column sum of the Make matrix should be equal to the column sum of the Use matrix. That is because the Use matrix as defined includes data in the final rows for value added, statistical discrepancy, and inventory valuation adjustment. This relationship was tested and is consistent for each of the matrices.

Trade and Consumption

The column sum of the diagonalized Trade matrix (including margin information and excise taxes) should equal the value for Consumption. This relationship was tested and is consistent for each of the matrices.

National Totals

One final check was performed to insure that the grand sum values for the matrices were consistent. For all regions, the grand sum total of final demand was found to be identical to the grand sum total of value added plus the grand sum total of excise taxes.

Summary

The data used for the development of our model was based on those collected for the multi-regional input-output Accounts for 1977. Those data contained internal inconsistencies which were modified by the staff at the Social Welfare Research Institute at Boston College. Those corrected data were the actual source we used.

We presented detail on the major changes that were made along with a rationale for those changes. As an important part of our model creation, we conducted several consistency checks both within and between the several sets of matrices that comprise these data. We are certain that the data we used was the most consistent set of regional data available.

APPENDIX B

Industry Titles and Associated SIC Codes
For the 1977 Multiregional Input-Output Accounts

APPENDIX B

Industry Titles and Associated SIC Codes For the 1977 Multi-Regional Input-Output Accounts

MRIO Code	Sector Name	1977 SIC Code(s)
Agriculture, Forestry and Fisheries		
001	Dairy Farm Products	0241, pt. 0191, pt. 0259 pt. 0291
002	Livestock and Poultry	021, 025 (excl. pt. 0259), 027, pt. 0191, pt. 0219, pt. 0291
003	Cotton, Grain & Tobacco	0131, 0132, pt. 0191, pt. 0219, pt. 0259, pt. 0191, pt. 011, pt. 0139
004	Fruits, Nuts, Vegetables, and Miscellaneous Crops and Services	0116, 0133, 0134, 0161 pt. 017, pt. 018, pt. 0119, pt. 0191, pt. 0219, pt. 0259, pt. 0291
005	Forestry Products	08
006	Commercial Fishing and Trapping	09
Mining		
007	Iron and Feroalloy Ores	101, 106
008	Nonferrous Ores	102–105, pt. 108, pt. 109
009	Coal	1111, pt. 1112, 1211, pt. 1213
010	Crude Petroleum	pt. 131, pt. 132, pt. 138
011	Natural Gas and Liquids	pt. 131, pt. 132, pt. 138
012	Stone, Clay, Sand, & Gravel	141–142, 144–145, pt. 148, 149
013	Chemical and Fertilizer Minerals	147

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
Construction		
014	Residential Building Construction	pt. 15-17
015	Nonresidential Building Construction	pt. 15-17
016	Public Utility Construction	pt. 16-17
017	Highways and Streets	pt. 16-17
018	Other Construction	pt. 15-17, pt. 138 pt. 108, pt. 1112, pt. 148, pt. 1213
019	Maintenance Construction	pt. 15-17, pt. 138
Manufacturing		
020	Ordinance	3482-3484, 3489, 3795
021	Meat Products	2011, 2013, 2016-2017
022	Dairy Products	2021-2024, 2026
023	Canned and Frozen Foods	2032-2035, 2037, 2091-2092
024	Grain Mill Products	2041, 2043-2048
025	Bakery Products	2051-2052
026	Sugar and Confectionery Products	2061-2063, 2065-2067
027	Beverages, Extracts, and Syrups	2082-2087
028	Other Food Products	2074-2077, 2079, 2095, 2097-2099
029	Tobacco Products	211-214

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
030	Fabric, Yarn, and Thread Mills	221-224, 2261, 2269, 2281-2284
031	Floor Coverings & Miscellaneous Textile Products	227, 2291-2299
032	Hosiery and Knit Goods	2251-2252, 2257-2258
033	Apparel	231-238, 2253-2254
034	Other Fabricated Textile Products	2259, 2391-2399
035	Logging and Lumber	2411, 2421, 2426, 2429
036	Wood Products	2431, 2434-2436, 2439, 2441, 2448-2449, 2491-2492, 2499
037	Pre-Fàbricated Buildings and Mobile Homes	2451-2452
038	Household Furniture	2511-2512, 2514-2515, 2517, 2519
039	Other Furniture and Fixtures	2521-2522, 2531, 2541-2542, 2599
040	Paper and Allied Products	261-264
041	Paperboard Containers and Boxes	265
042	Newspapers, Periodicals, and	271-279
043	Industrial Chemicals	281, 2865, 2869
044	Agricultural Chemicals	2873-2874, 2875, 2879
045	Other Chemical Products	2861, 2891-2893, 2895, 2899
046	Plastics and Synthetics	2821-2824
047	Drugs	283

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
048	Cosmetics & Cleaning Products	2841-2844
049	Paint and Allied Products	285
050	Petroleum Refining and Allied Products	291, 2951-2952, 2992, 2999
051	Rubber & Miscellaneous Plastics	301-304, 306, 307
052	Leather and Leather Products	311, 313-317, 319
053	Glass and Glass Products	321-323
054	Stone and Clay Products	324-329
055	Iron & Steel Mills & Forging	331, 339, 346
056	Iron & Steel Foundries	332
057	Primary Nonferrous Metals and Products	333-336, 3463
058	Metal Containers & Miscellaneous Metal Products	3315, 341-342, 347, 349
059	Structural Metal Products	3431-3433, 3441-3444, 3446, 3448, 3449
060	Screw Machine Products and Metal Stampings	345, 3465, 3466, 3469
061	Engines and Turbines	3511, 3519
062	Farm and Lawn Equipment	3523, 3524
063	Construction and Mining Equipment	3531-3533
064	Materials Handling Equipment	3534-3537
065	Metalworking Equipment	3541, 3542, 3544-3547

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
066	Special Industry Machinery and Equipment	3551-3555, 3559
067	General Industrial and Other Nonelectrical Machinery and Equipment	3561-3569, 3552, 3599
068	Office and Computing Equipment	3572, 3573, 3576, 3579
069	Service Industry Machinery and Equipment	3581, 3582, 3585, 3586, 3589
070	Electrical Transmission and Electrical Industrial Equipment	3582, 3612, 3613, 3621-3624, 3629
071	Household Appliances	3631-3636, 3639
072	Electric Lighting and Wiring Equipment	3641, 3643-3648
073	Receiving Sets, Records, and Tapes	3651-3652
074	Communications Equipment	3661-3662
075	Electronic Components	3671-3679
076	Other Electrical Equipment	3691-3694, 3699
077	Motor Vehicles and Parts	3711, 3713-3715
078	Aircraft and Parts	3721, 3728
079	Missiles, Spacecraft, and Parts	3761, 3769
080	Aircraft, Missile, and Spacecraft Propulsion Units	3724, 3764
081	Other Transportation Equipment	3716, 3731, 3732, 374, 375, 3792, 3799

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
082	Scientific and Photographic Equipment, Watches, and Clocks	3811, 3822-3824, 3829, 386, 387
083	Medical, Dental, and Optical Equipment	383, 3841-3843, 385
084	Other Manufactured Products	3911, 3915, 393, 3942, 3944, 3951-3953, 3955, 3961-3964, 3991, 3993, 3995, 3996, 3999 (excl. 39996)
Transportation		
085	Railroads	40, 474, pt. 4789
086	Local Passenger Transportation and Inter-City Bus	41
087	Motor Freight	42, pt. 4789
088	Water Transportation	44
089	Air Transportation	45
090	Pipelines, Except Natural Gas	46
091	Transportation Services	471, 4722-4723, pt. 478
092	Communications, Except Radio and Television	48 (excl. 483)
093	Radio and Television Broadcasting	483
Electric, Gas, and Sanitary Services		
094	Electric Utilities (Private and Public)	491, pt. 493
095	Gas Transmission and Distribution (Private and Public)	492, pt. 493

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
096	Water and Sanitary Services (Private and Public)	pt. 493, 494-497
Trade and Services		
097	Wholesale Trade	50, 51 (excl. manufactures' sales offices)
098	Eating and Drinking Places	58
099	General Merchandise and Apparel Stores	53, 56
100	Food, Drug, and Liquor Stores (includes state and local government liquor stores)	54, 591, 592
101	Automotive Dealers and Gasoline Service Stations	55
102	Other Retail STores	52, 57, 593, 599, 7396
103	Banking, Credit Agencies, and Investment Brokers	60-62 (excl. pt. 613), 67
104	Insurance	63
105	Real Estate and Rental	65-68, pt. 1531
106	Hotels and Lodging Places	70 (excl. dining)
107	Personal and Repair Services, Except Auto	721-726, 734, 762-764
108	Miscellaneous Services and Advertising	731-733, 735-737, 739, 769
109	Miscellaneous Professional Services	811, 8911, 893, 899
110	Auto Rental, Repair and Maintenance	751-754

Industry Titles and Associated SIC Codes
For the 1977 Multi-Regional Input-Output Accounts (cont.)

MRIO Code	Sector Name	1977 SIC Code(s)
111	Amusements	78, 791-794, 799
112	Doctors and Dentists, including Outpatient Care Facilities	801-803, 8041
113	Hospitals and Nursing	805-806
114	Other Medical and Health Services	074, 804 (excl. 8041), 807, 809
115	Educational Services	821-829
116	Nonprofit Organizations	84, 86, 89
117	Other Social Services	83
Government Enterprises		
118	Federal Government Enterprises, Except Utilities and Local Transit	4311, pt. 613
119	State and Local Government Enterprises Except Utilities and Local Transit	Several
Special Industries		
120	Directly Allocated Imports	
121	Scrap	
122	Government Industry	
123	Household Industry	
124	Rest of World	

Source: Jack Faucett Associates, The Multiregional Input-Output Accounts, 1977. Volume 1, Preliminary Report, pp. A-1 to A-32.

Final Row and Column Numbers and Titles For The 1977 MRIO Data

The Make Matrices
Row and Column Numbers

Row and Column Number	Title
125	Inventory Valuation Adjustment
126	Primary Output
127	Secondary Output
128	Total Industry Output (Row)
	Total Commodity Output (Column)

The Use Matrices
Row Codes

Row	Title
125	Inventory Valuation Adjustment
126	Statistical Discrepancy
127	Total Intermediate Input
128	Value Added
129	Employee Compensation
130	Indirect Business Taxes
131	Property-Type Income
132	Output

The Use Matrices
Column Codes

Column	Title
125	Inventory Valuation Adjustment
126	Statistical Discrepancy
127	Total Intermediate Input
128	Personal Consumption Expenditures (PCE)
129	PCE Sales Tax
130	PCE Retail Margin
131	PCE Purchaser's Value
132	Gross Private Investment
133	Investment Sales Tax
134	Investment Retail Margin
135	Investment Purchaser's Value
136	Net Inventory Change
137	Exports
138	Imports Landed Value
139	Imports Transportation Margin
140	Imports Insurance
141	Imports Duties
142	Imports Foreign Port Value
143	Federal Government Defense
144	Federal Government Defense Retail Margin
145	Federal Government Defense Purchaser's Value
146	Federal Government Nondefense
147	Federal Government Nondefense Retail Margin
148	Federal Government Nondefense Purchaser's Value
149	State and Local Government Capital Account
150	State and Local Government Retail Margin
151	State and Local Government Capital Purchaser's Value
152	State and Local Government Current Account
153	State and Local Government Retail Margin
154	State and Local Government Current Purchaser's Value
155	Total Final Demand
156	Total Commodity Consumption

Source: Jack Faucett Associates, MRIO Data Files, 1977: Tape Documention; Tape 1, Provided by the National Archives and Records Administration, pp. 6-10.

APPENDIX C

Comparison of BLS and MRIO Value Added Totals By Region For 1977

APPENDIX C

Comparison of BLS and MRIO Value Added Totals
By Region For 1977
($millions)

Region	Data Source: MRIO*	Data Source: BLS**	Difference	Per Cent Difference
Maine	6,933.0	7,515.0	-582.0	-8.4
New Hampshire	6,553.3	6,291.0	-137.7	-2.2
Vermont	3,199.1	3,399.0	-199.9	-6.3
Massachusetts	47,319.2	49,020.0	-1,700.8	-3.6
Rhode Island	7,175.0	7,057.0	118.0	1.6
Connecticut	27,079.4	29,547.0	-2,467.6	-9.1
New York	160,707.9	170,357.0	-9,649.1	-6.0
New Jersey	63,998.7	66,915.0	-2,916.3	-4.6
Pennsylvania	95,197.1	98,668.0	-3,470.9	-3.7
Ohio	96,243.7	96,613.0	-369.3	-0.4
Indiana	46,808.0	47,726.0	-918.0	-2.0
Illinois	112,000.4	115,465.0	-3,464.6	-3.1
Michigan	78,906.3	88,484.0	-9,577.7	-12.1
Wisconsin	39,758.0	39,818.0	-60.0	-0.2
Minnesota	34,427.3	35,595.0	-1,167.7	-3.4
Iowa	24,898.9	26,233.0	-1,334.1	-5.4
Missouri	40,784.3	41,328.0	-543.7	-1.3
North Dakota	4,906.4	5,342.0	-435.6	-8.9
South Dakota	4,558.9	5,125.0	-566.1	-12.4
Nebraska	12,965.7	13,619.0	-653.3	-5.0
Kansas	19,185.7	20,341.0	-1,155.3	-6.0
Delaware	6,066.1	5,609.0	457.1	7.5
Maryland	32,112.3	34,361.0	-2,248.7	-7.0
Wash., D.C.	13,630.2	14,975.0	-1,344.8	-9.9
Virginia	39,304.3	42,880.0	-3,575.7	-9.1
West Virginia	14,381.4	14,477.0	-95.6	-0.7
North Carolina	41,924.0	43,754.0	-1,830.0	-4.4
South Carolina	19,767.8	19,709.0	58.8	0.3
Georgia	38,520.6	40,354.0	-1,833.4	-4.8
Florida	60,210.0	64,830.0	-4,620.0	-7.7
Kentucky	26,201.8	28,434.0	-2,232.2	-8.5
Tennessee	33,212.2	33,196.0	16.2	0.1
Alabama	25,596.3	25,768.0	-171.7	-0.7
Mississippi	15,082.4	15,787.0	-704.6	-4.7
Arkansas	14,629.8	14,665.0	-35.2	-0.2
Louisiana	40,868.2	38,003.0	2,865.2	7.0

Comparison of BLS and MRIO Value Added Totals
By Region for 1977 (cont.)
($millions)

Region	Data Source MRIO*	BLS**	Difference	Per Cent Difference
Oklahoma	22,044.1	23,587.0	-1,542.9	-7.0
Texas	124,840.2	132,091.0	-7,250.8	-5.8
Montana	6,173.2	6,317.0	-143.8	-2.3
Idaho	6,439.3	6,914.0	-474.7	-7.4
Wyoming	5,406.0	5,417.0	-11.0	-0.2
Colorado	23,526.9	24,772.0	-1,245.1	-5.3
New Mexico	9,788.4	9,982.0	-193.6	-2.0
Arizona	17,493.9	18,996.0	-1,502.1	-8.6
Utah	9,915.5	10,122.0	-206.5	-2.1
Nevada	6,742.6	7,118.0	-375.4	-5.6
Washington	32,999.0	35,172.0	-2,173.0	-6.6
Oregon	21,058.3	21,842.0	-783.7	-3.7
California	212,304.5	227,590.0	-15,285.5	-7.2
Alaska	7,101.0	7,370.0	-269.0	-3.8
Hawaii	7,909.7	9,037.0	-1,127.3	-14.3
Totals	1,868,456.3	1,957,587.0	-89,130.6	-4.8

* Generated from information contained in the 1977 MRIO data.
** Taken from "Gross State Product by Industry, 1963-86," Table 1, Survey of Current Business, May 1988, pp. 30-46.

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