ALTERNATIVE MODELS OF REGIONAL COMPARATIVE ADVANTAGE IN THE UNITED STATES

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ABSTRACT

ALTERNATIVE MODELS OF REGIONAL COMPARATIVE ADVANTAGE IN THE UNITED STATES

By

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The goal of the research undertaken in this dissertation has been to test empirically the Heckscher-Ohlin and Classical trade models. The uniqueness of these tests is that United States regional data were employed rather than international data. Two sets of comparative regions were used: South-non-South and New England-non-New England.

Incorporating the regional approach into the two models, they could be stated in a form leading directly to empirically testable hypotheses. The Heckscher-Ohlin model brings together a combination of relative factor endowments and relative factor intensity in production as determinants of comparative advantage. Specifically, the model predicts that a region tends to specialize in producing those goods requiring intensively the use of the relatively abundant factor of that region. Stated as an empirically testable hypothesis: industry rankings of concentration in the South will be negatively correlated with industry capital-labor ratios.

For actual testing, capital-labor ratios were found by dividing year-end book value of capital assets by total employees for 71 Standard Industrial Classification three-digit industries for 1957-1958, while concentration in the South was found by dividing value added in the South for each industry by value added in the nation for each corresponding industry. Data were available in the Annual Survey of Manufactures, 1957, and the Census of Manufactures, 1958. Different measures of the basic variables were used in the tests. They were: gross capital, net capital, unweighted labor, and labor weighted by a wage index.

The Classical model, using the labor theory of value, bases comparative advantage on relative labor productivity advantage. With the inclusion of wages, the determinant of comparative advantage becomes relative average labor cost. Both labor variables were considered in the study, the empirically testable hypotheses being that ratios of labor productivity in the South to that in the non-South will be positively correlated with concentration in the South; while South-non-South average labor cost ratios will be negatively correlated with concentration in the South.

Average labor productivity is found by dividing value added by total employees, while average labor costs are found by dividing the average annual wage (total payroll divided by total employees) by average productivity.

Two broad conclusions can be drawn from these tests. First, an already industrially developed region can be expected to display patterns of specialization in those industries which have a comparative advantage with respect to labor productivity as well as those industries whose production functions require relatively more of the relatively abundant factor of that region.

Second, for a newly developing region, initial attraction of industries is likely to be based directly on sources of raw materials and in the endowment of natural resources of that region. As development proceeds, however, there will be a relatively higher growth in those industries which can achieve a comparative advantage based on labor productivity, or on intensive utilization of the relatively abundant and therefore relatively cheap factor of production.

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To my father, Dr. Adrian J. Klaasen,

whose love of teaching inspired me

to pursue graduate study

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CHAPTER I

THEORETICAL MODELS OF TRADE AND COMPARATIVE ADVANTAGE

Introduction

Man has traded goods and services since means of communication and transportation emerged between societies, and the consequent writings by early economists dealt with the gains and/or losses of trade and its effects on the domestic economy.

Adam Smith, presenting a free trade argument in his Wealth of Nations, suggests a reason for trade which involves a comparative cost theory. Smith writes, "It is the maxim of every prudent master of a family, never to attempt to make at home what it will cost him more to make than to buy. . . . What is prudence in the conduct of every private family, can scarce be folly in that of a great kingdom."[1]

Also primarily concerned with the gains or losses from trade, David Ricardo set forth the first exposition of the comparative cost doctrine in his Principles of

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[1]Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations, ed. Edwin Cannan (New York: Random House (The Modern Library), 1937), p. 424.

Political Economy and Taxation.[2] The basis of Ricardo's analysis was the labor theory of value. In his "two good, two country" example, labor input was used as the measure of absolute costs, making commodity prices proportional to labor costs.

Let us consider Ricardo's example. The countries involved are Portugal and England; the goods are wine and cloth. England's cost in producing one unit of wine is the labor of 120 men for one year; for one unit of cloth, it is 90 men for one year. Portugal's cost in wine production is 80 men for one year; for cloth, it is 90 men for one year.[3] Although Portugal has an absolute advantage in producing both goods, she will purchase her cloth from England in exchange for wine. As Ricardo states, "Though she [Portugal] could make the cloth with the labour of 90 men, she would import it from a country where it required the labour of 100 men to produce it, because it would be advantageous to her rather to employ her capital in the production of wine, for which she would obtain more cloth from England, than she could produce by diverting a portion of her capital from

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[2] David Ricardo, Principles of Political Economy and Taxation (London: J. M. Dent and Sons, Limited, 1911).

[3] In this particular example, Ricardo does not specify any physical quantity of wine or cloth. Later, he refers to a "pipe" of wine and a "certain quantity" of cloth. Ibid., p. 84.

the cultivation of vines to the manufacture of cloth."[4]

The concept in the above passage has become known as the classical theory of comparative advantage. It is based on relative labor cost differences which in turn lead to relative commodity price differences. The key is the relative price concept, for if all money prices in each country, although different absolutely, differed in the same proportion, no trade would occur.

The Classical Model

To prepare the way for empirical testing of the classical comparative cost theory, an updated restatement of the theory is desirable.[5] The assumptions are: (1) perfect competition in factor and product markets, (2) no artificial barriers to trade, (3) no transportation costs, (4) perfect factor mobility within countries but complete immobility between countries, (5) linearly homogeneous production functions for all goods, and (6) production functions for a given commodity vary between countries.

The last assumption provides the basis for comparative

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[4] *Ibid.*, p. 82.

[5] Jagdish Bhagwati, "The Pure Theory of International Trade," *Economic Journal*, LXXIV (March, 1964), pp. 1-64.
Richard E. Caves, *Trade and Economic Structure* (Cambridge: Harvard University Press, 1960).
M. O. Clement *et al.*, *Theoretical Issues in International Economics* (Boston: Houghton-Mifflin Company, 1967).

cost differences as it is derived from the idea that equal combinations of the factors used in the production of a given commodity would yield different quantities of that commodity in different countries.[6] Labor costs were assumed to contain all influences of an economy on the production of goods. Factors not convertible to labor costs were assumed to be used in constant proportions with labor in all uses.[7] For simplicity, one can restate the assumption as: goods in any one country are produced with the same capital-labor ratio, and capital-labor ratios differ between countries.

For trade to occur, relative prices must differ between countries. The reason for price differences is the real unit cost differences between countries. In the classical theory, these costs are expressed as labor costs per unit of output, or its reciprocal, thus making the average product of labor the key to cost differences.

Using an example, we can show how labor productivity determines trade specialization.[8] Assume two countries, A and B, each producing two goods, x and y. Under classical

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[6]Clement et al., p. 4.

[7]Caves, p. 12.

[8]J. L. Ford, "On the Equivalence of the Classical and the Factor-proportions Models in Explaining International Trade Patterns," The Manchester School of Economic and Social Studies, XXXV (May, 1967), p. 185.

conditions, $\left(\frac{K}{L}\right)_x = \left(\frac{K}{L}\right)_y$ in, say country A, where K and L represent the amount of capital and labor respectively required to produce one unit of output of either x or y. Then, $\frac{1}{K}$ and $\frac{1}{L}$ represent the average products of the two factors. Under competition, product prices equal production costs such that $P_x = rK_x + wL_x$ and $P_y = rK_y + wL_y$, where r and w are the prices of capital and labor inputs respectively.

In either country, say A, the money cost ratio between x and y can be expressed as $\frac{K_x r + L_x w}{K_y r + L_y w}$. Because $\left(\frac{K}{L}\right)_x = \left(\frac{K}{L}\right)_y$, we can let $k_y = \alpha K_x$ and $L_y = \alpha L_x$. Dividing the cost ratio by $K_x r$, we get $\frac{1 + \frac{L_x w}{K_x r}}{\alpha\left(1 + \frac{L_x w}{K_x r}\right)} = \frac{1}{\alpha}$. Because $\alpha = \frac{L_y}{L_x}$, the cost ratio equals $\frac{L_x}{L_y}$, and is completely independent of the factor price ratio $\frac{w}{r}$. It is then, a function solely of the average product of labor in the production of the two goods. If trade conditions exist, that is $\left(\frac{P_x}{P_y}\right)_A \neq \left(\frac{P_x}{P_y}\right)_B$, they are a result of $\left(\frac{L_x}{L_y}\right)_A \neq \left(\frac{L_x}{L_y}\right)_B$, which represents unequal labor productivity ratios between countries A and B. Say cost ratios are such that $\left(\frac{1}{\alpha}\right)_A < \left(\frac{1}{\alpha}\right)_B$, or $\left(\frac{L_x}{L_y}\right)_A < \left(\frac{L_x}{L_y}\right)_B$. The reciprocals of L_x and L_y are the average products of labor in producing x and y. The cost ratios can then be written as $\left(\frac{\frac{1}{L_y}}{\frac{1}{L_x}}\right)_A < \left(\frac{\frac{1}{L_y}}{\frac{1}{L_x}}\right)_B$, which yields $\left(\frac{APL_y}{APL_x}\right)_A < \left(\frac{APL_y}{APL_x}\right)_B$, or $\left(\frac{APL_x}{APL_y}\right)_A > \left(\frac{APL_x}{APL_y}\right)_B$. This last relation results in different relative price ratios between countries which gives a basis for trade between those countries. Specifically, if $\left(\frac{P_x}{P_y}\right)_A < \left(\frac{P_x}{P_y}\right)_B$, country A will export good x to country B and import good y from B. Both countries will tend to specialize in the production of their respective export goods.

We have established that the pre-trade commodity price ratio within a country is a function only of the average productivity of labor in the two industries. A country will have a comparative cost advantage in manufacturing that good in whose production its labor productivity is relatively higher. This is the essence of the classical theory of comparative advantage.

The Factor-Proportions Model

An alternative theory of comparative advantage and trade was provided by two Swedish economists, Eli Heckscher and Bertil Ohlin.[9] Like Ricardo, Heckscher did not undertake

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[9]Eli Heckscher, "The Effect of Foreign Trade on the Distribution of Income," Readings in the Theory of International Trade, eds. H. S. Ellis and L. A. Metzler (Homewood,

his paper to explain trade flows, but rather to find the influence of foreign trade upon the prices of factors of production. At the outset it was necessary for him to establish reasons for differences in comparative costs among countries.[10] These reasons, in Heckscher's model, are substantially different from those in the classical model. Heckscher assumes constant and immobile factor supplies within each country; that each commodity is produced according to the same linearly homogeneous production function in all countries; that the production functions differ among all commodities in the specific sense that, given the same factor price ratios, the capital-labor ratios differ between any commodities x and y; and perfect competition in factor and commodity markets. Heckscher then suggests two reasons for comparative advantage: first, factor endowments differ between countries; these differences giving rise to intercountry differences in relative costs of labor and capital; and second, given the presumed differences in factor intensities in the production of different goods, the money costs of production of any specific commodity differ between countries.

Illinois: Richard D. Irwin, Inc., 1949), pp. 272-300.

Bertil Ohlin, Inter-regional and International Trade (Cambridge: Harvard University Press, Harvard Economic Studies, 1967).

[10] Heckscher, p. 277.

As a student of Heckscher, Ohlin expanded upon the work of his teacher with the stated purpose of constructing a theory of international trade.[11] The basic framework of Ohlin's book was designed to answer the problem of how commodity price ratios were determined and how they differ between countries.

Ohlin suggests four determinants of commodity price ratio differentials: consumer tastes, distribution of factor ownership, supply of factors, and production functions. The last determinant can be eliminated by assuming that production functions are the same in all countries for each good. This is not to say that Ohlin ignored possible differences in production functions between countries, but rather that he relegated any differences to a subordinate role in determining patterns of commodity prices.

The first two determinants can be combined under the heading of consumer demand. Interregional or international differences in factor supplies are crucial determinants of differences in costs of production. Yet as long as the demand element remains, it could offset the factor supply influence on prices. After discussing demand, Ohlin warns, "But one must be careful to remember the qualification implicit in the possible influence of differences in demand conditions. . . ."[12] This effect was considered

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[11]Ohlin, Preface.

[12]Ibid., p. 10.

remote, however, and the demand element has been essentially dropped.[13]

Thus, the essence of the Heckscher-Ohlin trade model lies in factor supply conditions. The crucial assumption is that different relative factor supplies or "endowments" exist between countries. Although there are differences of opinion as to how to measure "relative abundance" of factors, the ultimate effects on costs are the same as long as all other assumptions hold. If factors are measured in terms of physical units, the opportunity costs of producing a unit of the good that uses relatively intensively the abundant factor are lower in that country than elsewhere. If relative factor supplies are measured as factor price differences, then by definition, the relatively cheap factor is the "abundant" factor. Any good which requires the relatively cheaper resource more intensively in production will have relatively a lower cost of production and price. A country involved in trade will tend to export that good and specialize in its production.

A better understanding of the Heckscher-Ohlin model may be gained by examination of a "two good, two factor, two country" example. Assume competition prevails in both factor and commodity markets, free trade exists between countries, and there are no transportation costs. In addition, production functions are assumed linearly homogeneous

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[13]Caves, p. 11.

and are the same for each good across countries, but differ between goods within each country. Factor supplies are fixed within countries and are immobile internationally.

Assume country A to be relatively capital abundant and good x to be relatively capital intensive. The condition for trade between countries A and B is the inequality of commodity price ratios, that is, $\left(\frac{P_x}{P_y}\right)_A \neq \left(\frac{P_x}{P_y}\right)_B$. This relation can exist only when the cost ratios in the two countries are unequal. Given the assumptions of the model, these ratios are a direct function of factor price ratios. Under the given factor supply conditions, capital is cheaper relative to labor in country A compared to country B; that is, $\left(\frac{r}{w}\right)_A < \left(\frac{r}{w}\right)_B$. Capital intensive good x can then be produced at a lower unit cost in country A, and competition ensures that $\left(\frac{P_x}{P_y}\right)_A < \left(\frac{P_x}{P_y}\right)_B$.

The model can be analyzed further by use of the following example. Different factor price ratios between countries A and B indicate different relative factor endowments; say $\left(\frac{K}{L}\right)_A > \left(\frac{K}{L}\right)_B$ resulting in $\left(\frac{r}{w}\right)_A < \left(\frac{r}{w}\right)_B$.

In Figure I, we have isoquants for goods x and y in both countries. Because of the assumption of linearly homogeneous production functions, these isoquants are representative of all isoquants for each of the two goods in both countries. In addition, goods x and y are capital and labor intensive respectively, irrespective of factor price ratios. The factor price ratio in country A is shown by the slope of line PSRQ (with sign changed). Under the given different factor endowments, the factor price ratio for country B has a lesser slope and is represented by lines MNU and DET.

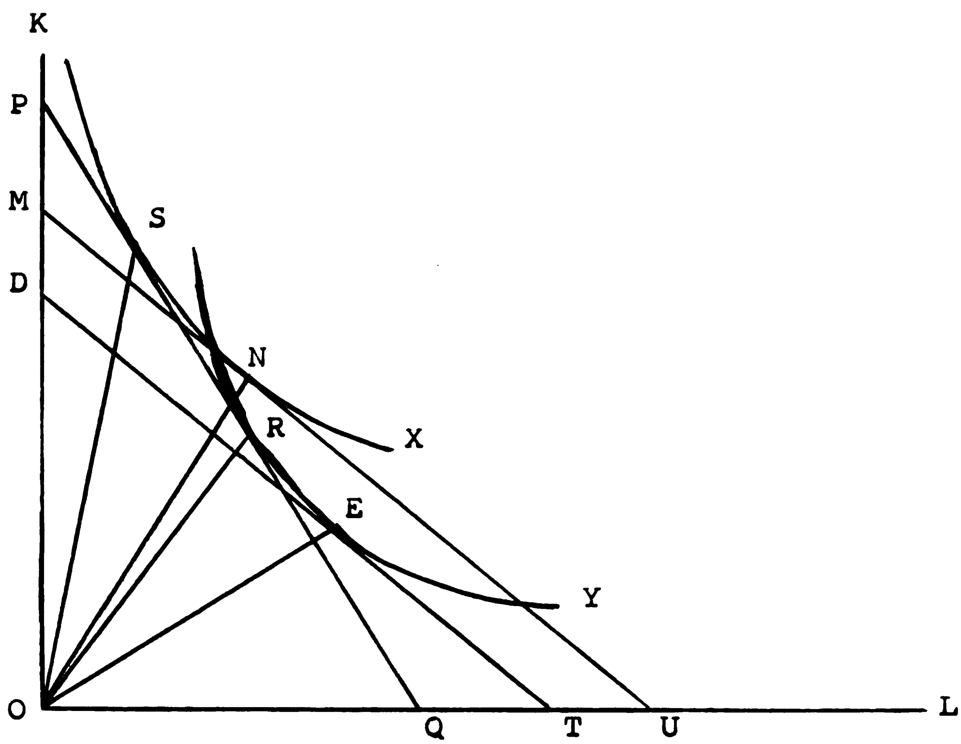

Figure I

By finding the relative costs of producing x and y in the two countries, we know relative commodity prices. Dividing total cost by the units of output gives us average cost. Line PSRQ is the total expenditure line for factors of production, and the total cost of producing each good can be expressed in terms of either of the two factors.

Distance OP represents the cost, in terms of capital, of producing _n_ units of x or y, given factor prices as they would be if used in the proportions OS and OR. Because total cost and units of output are equal for x and y in country A, average costs are also equal. In country B, using the same cost measure with factor proportions ON and OE, OM represents the total cost of producing x while OD represents total cost of y. Because OM $>$ OD, the $AC_x > AC_y$ in country B.

Comparing country A with country B, we find relative average costs are such that $\left(\frac{AC_x}{AC_y}\right)_A < \left(\frac{AC_x}{AC_y}\right)_B$. Because commodity prices directly reflect production costs, country A will sell good x at a relatively lower price, export it to country B, and specialize in its production. Country B will export and specialize in good y. The statement about trade flows assumes similar demand structures between A and B. To summarize, the Heckscher-Ohlin model predicts that a country tends to specialize in producing those goods requiring intensively the use of the relatively abundant factor of that country.

A question often raised concerning the Heckscher-Ohlin theory is whether a reversal of factor intensity in production is possible.[14] Factor intensity reversal would

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[14]Clement _et al._
Romney Robinson, "Factor Proportions and Comparative

occur if the relative capital-labor intensities in the production of two goods changed as a result of a change in relative factor prices. When such a reversal occurs, the goods obviously can no longer be classified categorically as either capital or labor intensive.

Reversal is most likely to occur as a result of wide differentials in factor price ratios between countries, coupled with different elasticities of substitution between capital and labor in the production of x and y. Under the Heckscher-Ohlin assumptions, relative factor price ratios are reflected in commodity price ratios before trade. As free trade opened, demand would rise for the relatively abundant factor and fall for the relatively scarce factor. Thus, in the example considered above, $\left(\frac{r}{w}\right)_A$ would rise and $\left(\frac{r}{w}\right)_B$ would fall, and the two ratios would tend to equality. Equalization would occur, however, only if, say, good x were always capital intensive in both countries regardless of any change in relative factor prices. If factor-intensity reversal occurred, it would be possible for a capital abundant country to have a comparative advantage in a labor intensive good and the Heckscher-Ohlin theory would break down as an explanation of trade.

Figure II can be used to illustrate the above point.

Advantage," Quarterly Journal of Economics, Part I, LXX (May, 1956), pp. 169-92.
Caves.

Let x and y be two isoquants representing given output rates of goods x and y. The factor price ratio for country A is shown by line CEFG, indicating that capital is relatively cheap. Equilibrium points of optimum output are at E and F, showing that good x is relatively capital intensive. The factor price ratio for country B is shown by line MNPR where capital is relatively expensive. Equilibrium points are at N and P, and by comparing factor proportion lines $\left(\frac{K}{L}\right)_{y'}$ and $\left(\frac{K}{L}\right)_{x'}$, good x is found to be relatively labor intensive. Hence the relative intensities of x and y are reversed between countries A and B.

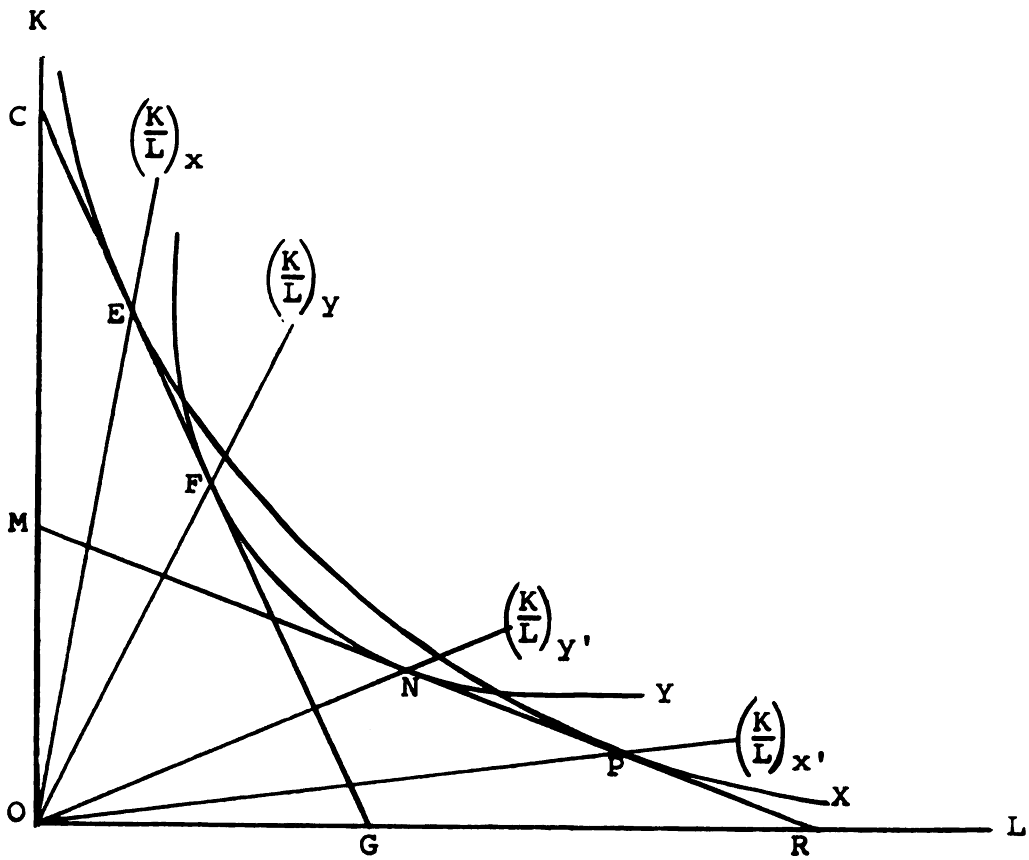

Figure II

From Figure II, we can derive Figure III. Here factor-ratio curves show changes in the capital-labor ratio for the two goods as relative factor prices change. Below factor price ratio M, good x is relatively capital intensive, while for factor price ratios above M, good y is relatively capital intensive.

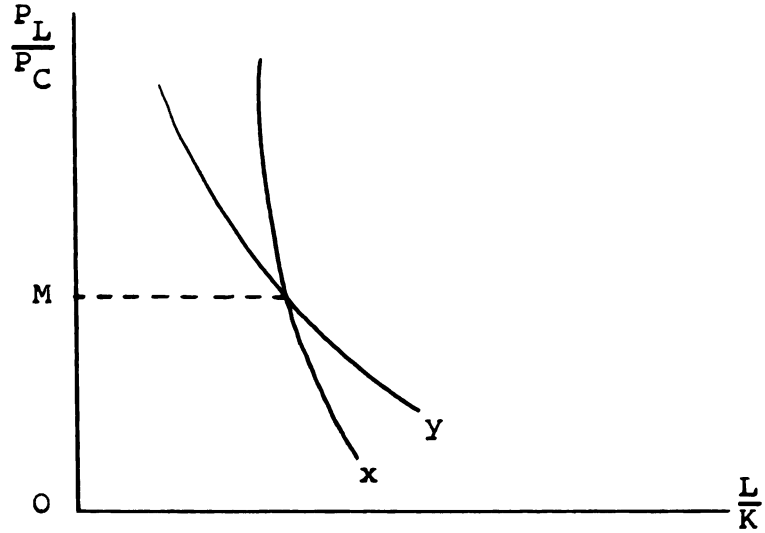

Figure III

If the factor price ratios of the two countries lie on either side of M, that good which is relatively labor intensive in one country is relatively capital intensive in the other and factor reversal exists.[15]

In general, the possibility of factor reversal was left open due to the vagueness of Heckscher's assumption

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[15]M. Michaely, "Factor Proportions in International Trade: Current State of the Theory," Kyklos, XVII (1964), Fasc. 4, pp. 529-50.

of different factor intensities for different goods. Samuelson, in proving factor price equalization as a result of trade under the Heckscher-Ohlin conditions, restated the assumption as the strong factor-intensity hypothesis.[16] This hypothesis simply states that goods will maintain their relative factor intensity regardless of factor price ratios. The hypothesis is derived by beginning with the two key Heckscher-Ohlin assumptions: (1) different production functions between goods, but always exhibiting constant returns to scale, and (2) different factor prices due to different factor endowments. It follows then that for optimum resource allocation, the two goods will have two different factor proportions in production, irrespective of relative factor prices.[17]

Summary and Preview of Following Chapters

The two theories of international trade under review are without doubt the two most prominent theories of trade, and therefore it is important that their empirical usefulness

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[16] P. A. Samuelson, "International Trade and Equalisation of Factor Prices," Economic Journal, LVIII (June, 1948), pp. 163-84.

P. A. Samuelson, "International Factor Price Equalisation Once Again," Economic Journal, LIX (June, 1949), pp. 181-97.

P. A. Samuelson, "A Comment on Factor-Price Equalisation," Review of Economic Studies, XIX, No. 2 (1951-52), pp. 121-22.

[17] R. W. Jones, "Factor Proportions and the Heckscher-Ohlin Theorem," Review of Economic Studies, XXIV, No. 1 (1956-57), pp. 1-10.

be tested. The purpose of this dissertation will be to undertake these tests.

A number of empirical tests have been done, but all, with a single exception, have used international data.[18] The tests to be performed in this dissertation will be based on interregional data within the United States.

There are several reasons why interregional data may be more suitable for testing the theories than international data. In particular, consider the two crucial assumptions common to both theories: (1) free trade and (2) the absence of transportation costs. Interregional trade within the United States fully satisfies the first. And the second assumption may be more nearly applicable to interregional than international trade. Both theories assume comparable factor quality between trade areas. Less diversity in cultures and technology between regions in the United States than between nations justifies the notion that capital and labor quality are more nearly uniform across regions in the United States than between countries.

The assumptions concerning production conditions differ between the two theories, and evaluation of the usefulness of interregional versus international data is difficult. The Heckscher-Ohlin model is based on similarity of production functions between trading areas, but not

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[18] Previous empirical tests are reviewed in Chapters II and III.

between goods, while the Classical model relies on the contrary assumption of similarity of production functions within a region but dissimilarity across regions. There appears to be some support for preferring interregional data for the Heckscher-Ohlin test. Two studies of capital-labor substitution using international data found that different countries producing the same goods were operating on different production functions.[19] Gallaway, however, rejected the hypothesis of dissimilar production functions, as an explanation for regional wage differences.[20]

A final argument for using interregional data is that the potential problem of factor intensity reversal does not seem to be present. If such reversal occurs, it becomes impossible to classify goods unequivocally as either labor or capital intensive. A recent test of the "strong factor-intensity" hypothesis that involved rank correlation tests of capital-labor ratios for two-digit Standard Industry Classification (SIC) industries among the nine census regions

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[19]K. Arrow et al., "Capital-Labor Substitution and Economic Efficiency," The Review of Economics and Statistics, XLIII (August, 1961), pp. 225-50.

Victor R. Fuchs, "Capital-Labor Substitution: A Note," The Review of Economics and Statistics, XLV (November, 1963), pp. 436-38.

[20]Lowell E. Gallaway, "The North-South Wage Differential," The Review of Economics and Statistics, XLV (August, 1963), p. 270.

of the United States did not reject the hypothesis.[21] A test using international data, however, yielded somewhat inconclusive results.[22] In addition, based on theoretical considerations, smaller differentials in factor-price ratios between regions give less reason to expect reversal within the United States.

In testing both theories in this thesis, the location of industries will be used as an indicator of comparative advantage. Both theories predict that trade will lead to specialization in export products; thus, areas of concentration of production of a good are assumed to exist because the areas possess a comparative cost advantage in the production of that good. In fact, Heckscher explicitly states that "[in the absence of mobility] . . . the different kinds of production will be located where the necessary factors of production are present."[23] The use of location rather

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[21] John R. Moroney, "The Strong-Factor-Intensity Hypothesis: A Multisectoral Test," The Journal of Political Economy, LXXV (June, 1967), pp. 241-49.

[22] B. S. Minhas, "The Homohypallagic Production Function, Factor-Intensity Reversals, and the Heckscher-Ohlin Theorem," The Journal of Political Economy, LXX (April, 1962), pp. 138-56.

Wassily Leontief, "An International Comparison of Factor Cost and Factor Use," The American Economic Review, LIV, No. 4 (June, 1964), pp. 335-45.

David Stafford Ball, "Factor-Intensity Reversals in International Comparison of Factor Cost and Factor Use," The Journal of Political Economy, LXXIV (February, 1966), pp. 77-80.

[23] Heckscher, p. 289.

than export and import flows also eliminates the need for assuming equivalent demand functions within each region.[24]

A test of the Heckscher-Ohlin hypothesis concerning regional production concentration is presented in Chapter II. The test involves finding the rank correlation between industry concentration ratios and capital-labor ratios for 71 three-digit SIC industries.

Chapter III presents a test of the Classical theory of trade. The Classical model postulates that comparative cost advantages result from higher relative labor productivity. The hypothesis to be tested is that relative labor productivity should be positively correlated with industry concentration ratios in each region.

Chapter IV takes into consideration the role of natural resources and an industry's dependency on external sources of raw materials. It is hypothesized that a high level of dependency on external sources of raw materials will influence industry concentration and may override either the factor proportions or labor productivity determinants of trade.

The final chapter consists of a summary and review of the conclusions resulting from the tests.

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[24]Jones, p. 6.

CHAPTER II

TESTS OF THE HECKSCHER-OHLIN MODEL

Introduction and Review of the Literature

Only since the early 1950's has a concentrated effort been made to test empirically the Heckscher-Ohlin hypothesis. The earliest test was part of an extensive United States-Britain trade study by MacDougall.[1] His purpose was to determine whether United States exports were relatively more capital intensive than British exports. If this was the case, the United States should show a larger share of the world market, relative to the United Kingdom, in relatively capital intensive commodities.[2] He found, however, that Britain's largest export industries, for exports to third countries, had capital-labor ratios above the average for Britain and the United States; while United States export industries, for exports to third countries, had capital-labor ratios below the average. He thus concluded that his evidence rejected the Heckscher-Ohlin hypothesis.

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[1] G. D. A. MacDougall, "British and American Exports: A Study Suggested by the Theory of Comparative Costs," Economic Journal (Part I: December, 1951, pp. 697-724; Part II: September, 1952, pp. 487-521).

[2] Clement et al., p. 99.

The most controversial test of the Heckscher-Ohlin theory was conducted by Wassily Leontief using 1947 input-output data for the United States.[3] His purpose was ". . . to find out whether it is true that the United States exports commodities the domestic production of which absorbs relatively large amounts of capital and little labor and imports foreign goods and services which, if we had produced them at home, would employ a great quantity of indigenous labor but a small amount of domestic capital."[4] With the available data, Leontief determined the capital and labor needed to produce a desired dollar value of some output. He then considered a one million dollar decrease in exports and competing imports, all goods being reduced in equal proportion. In order to replace the competing imports by domestic production, using resources from the reduced export good production, Leontief found that less labor, but more capital would be required than would be released from export production. In other words, United States exports were labor intensive relative to import substitutes produced

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[3]W. W. Leontief, "Domestic Production and Foreign Trade; the American Capital Position Re-examined," Proceedings of the American Philosophical Society, XCVII (September, 1953), pp. 332-49.

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

[4]Leontief, Proceedings, p. 339.

in the United States. This conclusion contradicts the Heckscher-Ohlin hypothesis and is known as the Leontief scarce-factor paradox.

Leontief's explanation was that because United States labor productivity exceeded that of the rest of the world by approximately 200 percent, the United States could be considered as having three times as much labor using the world productivity standard. The United States is, in this sense, a labor abundant country, and it "resorts to foreign trade to save its capital and to dispose of its relative surplus labor."[5]

Immediately after the Leontief paper was published, a rash of critiques emerged, generally arguing that the Heckscher-Ohlin hypothesis was not credited and that Leontief had mis-interpreted his results, selected a poor year for his tests, or erred in applying input-output analysis to international trade.

One of the earliest criticisms of Leontief was by P. T. Ellsworth.[6] Ellsworth felt that to determine the relative factor intensity of import substitution goods, their production coefficients should be compared to those of the same goods in the foreign country, not to other goods

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[5] Ibid., p. 344.

[6] P. T. Ellsworth, "The Structure of American Foreign Trade: A New View Examined," The Review of Economics and Statistics, XXXVI, No. 3 (August, 1954), pp. 279-85.

within the United States. Thus, labor intensive import substitutes relative to other goods in the United States may not be contradictory to the Heckscher-Ohlin hypothesis, as these goods may be capital intensive relative to actual import goods from foreign countries. This observation receives some empirical support from later tests. (See pages 26-28.) He also offered an explanation of higher United States labor productivity in terms of a more abundant supply of complementary factors such as entrepreneurship, natural resources, and capital.

Kravis[7] also showed little concern about the so-called paradox. He argued that many goods are imported because they are products of natural resources which have become relatively scarce in the United States. To assure a continuing supply of these products, the United States financed the construction of facilities abroad with the result that these goods are produced under capital intensive conditions and therefore explain some of the capital intensive imports.

A group of writers including Kenen, Becker, Colberg, and Swerling criticized the paradox conclusion by arguing that capital was poorly defined by Leontief because he

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[7]Irving B. Kravis, "'Availability' and Other Influences on the Commodity Composition of Trade," The Journal of Political Economy, LXIV, No. 2 (April, 1956), pp. 143-55.

excluded human capital.[8] Colberg perhaps expresses their position best: "The simplest explanation of the paradox may be that the term 'labor' has included too much, while the term 'capital' has comprehended too little of our productive resources."[9] Kenen finds that the paradox does in fact disappear in the limiting case where skill differentials of labor are assumed to be due to the quantity of capital invested in man.[10]

A last group of writers is concerned with Leontief's contention that United States labor productivity is three times that of the world average. From data obtained by means of a questionnaire, Kreinin found Leontief's labor productivity differential too high, and maintains that United States labor productivity is $1\frac{1}{5}$ to $1\frac{1}{4}$ times as great as foreign labor.[11]

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[8]Peter B. Kenen, "Nature, Capital, and Trade," The Journal of Political Economy, LXXIII, No. 5 (October, 1965), pp. 437-60.

Gary Becker, "Investments in Human Capital: A Theoretical Analysis," The Journal of Political Economy Supplement (October, 1962), pp. 9-49.

Boris C. Swerling, "Capital Shortage and Labor Surplus in the United States?" The Review of Economics and Statistics, XXXVI, No. 3 (August, 1954), pp. 286-89.

Marshall R. Colberg, "Human Capital as a Southern Resource," Southern Economic Journal, XXIX (January, 1963), pp. 157-66.

[9]Colberg, p. 158.

[10]Kenen, p. 457.

[11]Mordechai E. Kreinin, "Comparative Labor Effectiveness and the Leontief Scarce-Factor Paradox," The American Economic Review, LV, No. 1 (March, 1965), pp. 131-39.

He concludes that such a small margin of superior productivity is insufficient to make the United States a "labor abundant" country.

Studying the same problem, Diab and Bhagwati obtained conflicting conclusions, although both estimated capital-labor ratios with Cobb-Douglas production functions. Diab, holding capital productivity constant over all countries, agrees with Leontief's conclusions, while Bhagwati, holding labor productivity constant, agrees with Kreinin.[12]

In an effort either to lend more substantive support or to reject the Leontief paradox, four input-output studies have been undertaken. The first used a "replacement" approach similar to Leontief's, applying it to Japan.[13] An index of comparative capital-labor intensities was computed, and it was found that an average one million yens worth of exports embodies more capital and less labor than is required to replace, domestically, one million yens worth of competitive imports.

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[12] M. A. Diab, The United States Capital Position and the Structure of its Foreign Trade (Amsterdam: North-Holland Publishing Co., 1956).

Jagdish N. Bhagwati, "Some Recent Trends in the Pure Theory in International Trade," International Trade Theory in a Developing World, eds. Roy Harrod and Douglas Hague (New York: St. Martin's Press, 1963).

[13] Masahiro Tatemoto and Shinichi Ichimura, "Factor Proportions and Foreign Trade: The Case of Japan," The Review of Economics and Statistics, XLI, No. 4 (November, 1959), pp. 442-46.

If Japan is assumed to be relatively labor abundant, then those results appear at variance with the Heckscher-Ohlin model. Nonetheless, because only 25 percent of her trade is with developed nations while 75 percent is with underdeveloped nations, Japan can be considered capital abundant relative to underdeveloped countries and would therefore export relatively capital intensive goods.[14] The opposite would be true with developed nations. And, in fact, the capital-labor ratio of her exports to the United States is lower than that for all other exports. Thus, when Japan's trade is broken down with respect to her trading partners, the Heckscher-Ohlin theory is supported, and the Leontief paradox is rejected.

A second study using East German data was done by Stolper and Roskamp.[15] Their findings showed East German exports to be relatively capital intensive. Because East Germany is probably the most capital abundant of the East Bloc countries, with which she carries on 75 percent of her trade, this study also supports the Heckscher-Ohlin hypothesis.

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[14] *Ibid.*, p. 445.

[15] Wolfgang F. Stolper and Karl W. Roskamp, "An Input-Output Table for East Germany with Applications to Foreign Trade," *Bulletin of the Oxford University Institute of Statistics*, XXIII, No. 4 (November, 1961), pp. 379-92.

A third study concerned the Canadian trade structure.[16] The results were that Canada's exports were found capital intensive while imports were relatively labor intensive. This held for total exports, exports to the United Kingdom, and exports to the United States. Such results tend to reject the Heckscher-Ohlin hypothesis.

A fourth study considered the structure of Indo-United States trade.[17] The hypothesis tested was that "Indian exports to the United States absorb in their production relatively more labor than her competitive imports from the United States which, if produced at home [in India] would require relatively more capital."[18] The findings of the study support the Leontief paradox as Indian exports were found more capital intensive than imports.

Finally, two "indirect" tests of the Heckscher-Ohlin theory imply support for the hypothesis. In the first, Kravis considered wage rates in export and import industries.[19]

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[16] Donald F. Wahl, "Capital and Labour Requirements for Canada's Foreign Trade," The Canadian Journal of Economic and Political Science, XXVII, No. 3 (August, 1961), pp. 349-58.

[17] R. Bharadwaj, "Factor Proportions and the Structure of Indo-United States Trade," The Indian Economic Journal, X, No. 2 (October, 1962), pp. 105-16.

[18] Ibid., p. 105.

[19] Irving B. Kravis, "Wages and Foreign Trade," The Review of Economics and Statistics, XXXVIII, No. 1 (February, 1956), pp. 14-30.

He found that a relatively high share of United States exports are produced by high-wage industries, and a relatively high share of competing imports consist of goods produced domestically by low-wage industries. Hypothesizing that the higher wages are due to a greater supply of capital and therefore higher productivity, this would tend to support the Heckscher-Ohlin hypothesis. No data on capital per unit of output was offered, however.

In the second indirect test, Tarshis analyzed relative commodity prices in hopes of drawing some conclusions about trade flows.[20] He found that price ratios of capital intensive goods relative to labor intensive goods were lower in the United States, while the opposite held for less capital abundant countries. The implications of these relative price ratios for trade are consistent with the Heckscher-Ohlin hypothesis.

Two implications of these tests exist for this dissertation. First, because of the inconclusiveness of the results using international data, tests using regional data may be preferred.

The second implication stems from the fact that in virtually all of the studies some comments exist about the

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[20]Lorie Tarshis, "Factor Inputs and International Price Comparisons," The Allocation of Economic Resources, ed. M. Abramovitz (Stanford, California: Stanford University Press, 1959), pp. 236-44.

drawbacks and problems of the tests such as the influence of different demand conditions between countries, the possibility of different production functions between countries, the differences in the quality of factors between countries, and the influence of tariffs and other trade restrictions. As indicated in Chapter I, these are essentially eliminated with the use of regional rather than international data.

Only one previous study has dealt with regional data of the United States.[21] Dividing the United States into South and non-South regions and using location rather than trade flows as indicators of comparative advantage, Moroney and Walker hypothesized that: "There is an inverse rank ordering between capital-labor ratios and location quotients" in the South.[22] The rank correlation was positive, however, although not highly significant. This result gives some indication that the South has a comparative advantage in producing relatively capital intensive goods, a conclusion inconsistent with the Heckscher-Ohlin hypothesis. The authors then eliminated certain "natural resource" oriented industries from their tests, but the results were still not consistent with the Heckscher-Ohlin hypothesis.

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[21] John R. Moroney and James M. Walker, "A Regional Test of the Heckscher-Ohlin Hypothesis," The Journal of Political Economy, LXXIV (December, 1966), pp. 573-86.

[22] *Ibid*., p. 581.

<u>The Case for Regional Tests</u>

The tests of the Heckscher-Ohlin model presented in this chapter are similar to those undertaken by Moroney and Walker. Using regional data in the United States, the country was divided into two sections called the South and the non-South. This division is based on the United States Census Bureau classification of areas. The South is composed of the South Atlantic, East South Central, and West South Central census regions.

This regional division is also convenient because several studies pertaining to wage differentials have been based on the same South-non-South division. If a wage differential exists between the South and non-South, and the cost of capital differential does not offset it, there is a presumptive evidence of differential relative factor supplies in the two regions.

The evidence of wage differentials is clear. Moroney and Walker computed an index of wage differentials and found that the average hourly wage of production workers in the South was 78 percent of the non-South average, while average annual non-production salaries were 87 percent of the non-South average.[23]

A second study found Southern skilled maintenance wages to be 83 percent to 94 percent of the national median

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[23]*Ibid.*, p. 577.

and unskilled plant labor wages to be 67 percent to 79 percent of the national median.[24]

A third study points out that since 1947, relative earnings in the South have remained 20 percent to 25 percent below the national average.[25]

Evidence of regional differences in the cost of capital is scarce. However, a survey of interest rates on a geographical basis from the Federal Reserve suggests that the cost of capital in the South is at worst, equal to that in the non-South, and may even be lower.[26]

The evidence of relatively lower wages in the South suggests that the South is relatively labor abundant. Can one assume with confidence that these wage differentials result mainly from labor supply differences? In general, the answer is probably "yes." Fuchs and Perlman suggest the differences exist due to low-wage industry mix in the South plus relatively lower earnings for similar work.[27] Gallaway also feels that wage differentials imply lower

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[24]Toivo P. Kanninen, "Wage Differences Among Labor Markets," Monthly Labor Review, XLIV (June, 1962), p. 616.

[25]Victor Fuchs and Richard Perlman, "Recent Trends in Southern Wage Differentials," The Review of Economics and Statistics, XLII (August, 1960), p. 295.

[26]Board of Governors of the Federal Reserve System, Federal Reserve Bulletin, XLIV (January, 1958, and April, 1958), pp. 34, 312.

[27]Fuchs and Perlman, p. 293.

capital-labor ratios in the South.[28]

In a critique of the Moroney and Walker study, Estle suggests that in fact the South may be relatively capital abundant.[29] Estle found that some industries in 1957 have higher capital-labor ratios in the South than in the non-South, where the capital-labor ratio is measured as gross book value of capital per man year. Nonetheless, it seems that his finding is attributable mainly to the relatively more recent investment in plant and equipment in the South, rather than to a higher relative overall regional capital endowment. Therefore, Estle's study might suggest that the assumption of identical production functions between regions does not hold. There will be a further discussion of this when the results are evaluated.

The absence of overall regional capital stock estimates requires that regional factor endowments be defined in terms of relative factor prices. Thus, if the wage rate is lower in a given region relative to another, the implication is that the low wage region is relatively labor-abundant.

A potential difficulty in testing the Heckscher-Ohlin hypothesis using SIC three-digit industries is that regional

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[28]Gallaway, "The North-South . . .," p. 270.

[29]Edwin F. Estle, "A More Conclusive Regional Test of the Heckscher-Ohlin Hypothesis," The Journal of Political Economy, LXXV (December, 1967), pp. 886-88.

capital stock estimates are not available. Hence national capital-labor ratios must be used to rank the industries according to capital-intensity of production. The strong factor-intensity hypothesis, which seems to have a solid empirical basis in the United States,[30] ensures that the national ranking is preserved among regions. Thus the use of national ratios should not lead to ambiguous test results.

In this thesis the Heckscher-Ohlin hypothesis is tested in two sets of tests as follows. Firstly, two regions, the South and New England, are each identified as being relatively labor abundant by comparison with the rest of the nation. Secondly, it is well-known that a ranking of commodities according to a region's "abundant-non-abundant" input ratios provides a corresponding ranking by order of comparative advantage.[31] Hence the research hypothesis is that there is a negative correlation between industry capital-labor ratios and concentration of production in each of these regions.

By the nature of the data used in the subsequent tests, the capital-labor ratio is a sufficient determinant of a commodity's intensive factor. That is, each industry's measure of output is value added, and thus current factor input proportions determine the factor intensity.

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[30] Moroney, "The Strong-Factor Intensity. . . ."

[31] Jones, "Factor Proportions . . .," p. 6.

Tests in the South

To test the above hypothesis, gross and net capital-labor ratios were computed for 71 Standard Industry Classification three-digit manufacturing industries (see Appendix I). Data were taken from the Census of Manufactures and the Annual Survey of Manufacturers.[32]

Capital-labor ratios were computed by dividing book value of assets by employees for 1957. As mentioned earlier, national capital-labor ratios were used. These ratios are felt to be adequate for two reasons: first, the assumption of similar production functions between regions appears to be reasonable; second, under the strong factor-intensity hypothesis, rankings of capital-intensity nationally give identical regional rankings.

Concentration ratios for each industry were computed by dividing value added in the South, v_S^i, by value added in the nation, V_N^i. Regional value added data for SIC three-digit industries for the year 1957 are not published, so 1958 value added figures are used. This change should not have any significant influence on the results as capital-labor ratios are for the end of year 1957, and would not change to any significant degree in 1958.

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[32]U.S. Bureau of the Census, Annual Survey of Manufactures, 1957 (Washington: U.S. Government Printing Office, 1959).

U.S. Bureau of the Census, Census of Manufactures, 1958 (Washington: U.S. Government Printing Office, 1961).

The capital-labor and concentration ratios are then ranked in ascending order (see Appendix II, Tables 1 and 2, for rankings). Kendall's τ is used to show the degree of rank correlation. (A summary of all results of tests of the Heckscher-Ohlin model is shown in Appendix III.) Using the gross capital-labor ratios, τ is +.0632, not significant at the ten percent level. Using the net capital-labor ratios, τ is +.0664, not significant at the ten percent level. The sign of the coefficient in both cases was "wrong"; that is, the concentration ratios are somewhat higher in the South for high capital-labor industries. Clearly, the hypothesis fails to predict industry location based on relative factor endowment.

Several reasons for these results are possible. First, the model tested contains only two factors of production. Obviously, more factors play a role in production, and Heckscher and Ohlin both considered the range of possibilities. Heckscher, for example, states: "It must be stressed at this point that the term 'factor of production' does not refer simply to the broad categories of land, capital, and labor, but to the different qualities of each of these."[33] In addition to such differences in quality, natural raw materials and climate conditions are potentially important.

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[33] Heckscher, p. 279.

In order to compensate for quality differences in labor inputs, a second test was made after new capital-labor ratios were computed using labor input figures adjusted for productivity differences. Assuming competitive conditions in the labor market, wage differences will reflect productivity or skill differences. By eliminating these differences, one more closely approaches the condition of homogeneous factor inputs.

For each industry, an annual average wage was computed by dividing total annual payroll by total employees. The source of data was the Annual Survey of Manufacturers.[34] Next, an index was derived by taking a ratio of each industry average annual wage to a national all-industry average wage. Finally, the original labor input figures for each industry were weighted by the relative wage index.

Kendall's τ was computed as a measure of rank correlation. Using both gross and net capital, τ was not significant at the ten percent level in either case, although the coefficients were somewhat higher than in the earlier tests. τ in both cases was positive, the opposite of that hypothesized. Using gross capital, τ was equal to +.166, while with net capital, τ was equal to +.135. (See Appendix II, Tables 3 and 4, for rankings.)

A second possibility is that the assumption of

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[34]U.S. Bureau of the Census, Annual Survey. . . .

complete factor immobility between regions may not hold. Because of the difference in "natural" factor endowments, that is, climate and natural resources, there will exist goods which the non-South will be unable to produce, but will demand. If capital is not available in the South, it may come from the non-South with the result that some Southern industries will become capital intensive. This condition is not a complete contradiction of the Heckscher-Ohlin hypothesis, however, because the source of capital was a capital abundant region. It merely indicates that one of the Heckscher-Ohlin assumptions does not hold, a possibility that seems particularly strong when interregional rather than international data are used.[35]

A third possible explanation is that the assumption of homogeneous factors does not hold. This is most likely to be true for labor, where differences in quality will result in differences in labor productivity. An attempt was made to eliminate these differences but the disappointing results of the Heckscher-Ohlin test were not influenced to any degree.

A final possible explanation for the test results is that the South is a highly atypical region, having lagged behind the non-South in industrial development. To explore this possibility, a new region, New England, was chosen for

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[35]Kravis, "'Availability' and . . . ."

comparative purposes. New England's industrial structure is well established; and relative to the rest of the United States, it is a labor abundant region (see below).

The greater importance of recent Southern industrial development can be seen by comparing the range and direction of percentage changes in relative concentration between 1947 and 1958 in the South and New England. For the South the range was from -21 percent to +325 percent, with nine industries showing decreases and 47 showing increases. For New England, the range was from -85 percent to +238 percent, with 28 industries showing decreases and 25 showing increases. The South, then, was clearly in a developmental and growth stage; and one might not expect tests performed in a static framework to yield significant results.

To see if industrial growth patterns in the South were consistent with the Heckscher-Ohlin hypothesis, percentage changes in concentration were ranked with gross capital-labor ratios. (See Appendix II, Table 5, for ranking.) A coefficient of -.256, significant at the .005 level, was found, indicating that Southern industrial development did take place more strongly in relatively labor intensive industries. This result is in agreement with that obtained by Moroney and Walker using a sample of two-digit industries.

Tests in New England

The basis for establishing New England as a relatively labor intensive region is the same as that used for the South, that is, lower relative wage levels. Average annual wage levels for New England and non-New England for a 68 industry sample, show that the New England level is 97 percent of the non-New England level. In addition, a study by Eisenmenger found that the average hourly wage per employee man-hour in New England, 1958, is less than 100 percent of the United States average in 15 of 18 two-digit SIC industries.[36]

By performing the same rank correlation tests as were done for the South using static concentration for 1958, it is found that the structure of specialization in New England can be explained by the Heckscher-Ohlin model. This offers further evidence that the South is unique because of its comparatively recent industrial development.

The original sample of 71 SIC three-digit industries used in the South tests is reduced to 68 since New England data were not available for Industries 206, 322, and 333. It is felt that this slight difference will not invalidate any comparison between test results of the two samples. (See Appendix II, Tables 6 and 7, for rankings.)

Rank correlation tests between gross and net capital-labor ratios and concentration ratios yielded coefficients of -.228 and -.243, significant at the $P \leq .01$ and $P \leq .005$ levels respectively and of the sign hypothesized. These

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[36]Robert W. Eisenmenger, The Dynamics of Growth in New England's Economy, 1870-1964 (Middletown, Connecticut: Wesleyan University Press, 1967), p. 28.

results in three-digit industries are in agreement with those obtained by Estle in a sample of two-digit industries. For New England, then, because it is relatively labor abundant, industries with relatively low capital-labor ratios tend to be more highly concentrated there.

Although New England did not go through a period of latent industrial development as did the South, changes in relative industry concentration in New England between 1947 and 1958 took place in a pattern as would be predicted by the Heckscher-Ohlin hypothesis. That is, those industries with relatively low capital-labor ratios showed a tendency toward increasing relative concentration. (See Appendix II, Table 8, for ranking.) A rank correlation test between capital-labor ratios and percentage changes in concentration yielded a coefficient of -.129, not significant, but of the sign hypothesized. It might be noted that Estle obtained a similarly weak result in a corresponding test among two-digit industries.

Conclusions

One's impression of the comparative analysis between the two sets of tests is that the Heckscher-Ohlin model has greater explanatory power for an already industrially developed region. New England was the earliest industrially developed region in the United States. As industry expanded into other regions, industries with comparative advantages stayed and grew in New England. Those with comparative disadvantages shifted into other regions where a comparative advantage existed for them. Thus, the tendency for labor intensive industries to be concentrated in and to continue to grow in New England is consistent with the factor proportions theory of comparative advantage. Other forces, however, appear to dominate the existing pattern of industry concentration in the South, yet developmental trends appear to follow the factor proportion hypothesis.

CHAPTER III

TESTS OF THE CLASSICAL MODEL

Introduction

The Classical explanation of trade flows, as emphasized in Chapter I, is based on comparative labor costs. Although Ricardo failed to specify a complete model, his use of the labor theory of value led to the expression of comparative costs in terms of relative labor productivity. Beginning with the contention that trade occurs because of different relative prices between countries, it can be shown that these price differences are a result of differences in relative labor productivities.

Recall from Chapter I that under competition, total revenue for goods x and y were said to equal costs: $rK_x + wL_x$ and $rK_y + wL_y$.[1] With the assumption of equivalent capital-labor ratios in the production of both goods within each country, the average products of capital and labor were equated between goods by the use of a scalar, α, such that $K_y = \alpha K_x$ and $L_y = \alpha L_x$. Dividing the cost ratio, $\frac{K_x r + L_x w}{K_y r + L_y w}$, by $K_x r$, a new cost ratio expressed only in terms

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[1]See page 5.

of labor productivity is found. The use of the scalar permitted the reduction of a two-factor model to a one-factor model of the Ricardian type. Thus, an hypothesis can be derived for a two country-two commodity model which states that countries A and B export (to one another) goods x and y respectively, because $\left(\frac{P_x}{P_y}\right)_A \quad \frac{P_x}{P_y}{}_B$, which is a direct result of $\left(\frac{APL_x}{APL_y}\right)_A > \left(\frac{APL_x}{APL_y}\right)_B$.

Most tests of the Classical model have been based on the above productivity concept. Labor productivity is not the only factor determining labor costs, however, since the price of a unit of labor is a crucial determinant of cost. Thus, in some tests, the influence of wages has been included. This influence can be added into the model so that the condition for trade is written as $\left(\frac{L_x}{L_y}\right)\left(\frac{W_x}{W_y}\right)_A < \left(\frac{L_x}{L_y}\right)\left(\frac{W_x}{W_y}\right)_B$, that is, one assumes that internal price ratios are proportional to internal wage bill ratios.

Either labor costs or labor productivity can be used to form the conditions for comparative cost advantage. This is in line with the traditional Classical attachment to the labor theory of value. Its weakness, of course, is that it ignores capital costs.

Previous Tests

The first test of the Classical model was made by

MacDougall.[2] Using a two country, _n_ commodity model, he hypothesized that each country "will export those goods for which the ratio of its output per worker to that of the other exceeds the ratio of its money wage rate to that of the other."[3] Using productivity data for the year 1937, MacDougall found the United States weekly wage to be two times that of the United Kingdom. According to the hypothesis, in those industries where United States productivity is more than two times United Kingdom productivity in the same industries, the United States should have a larger share of the export market to third countries. The converse is true when United States productivity is less than twice as high as in the United Kingdom. These relationships held in 20 out of 25 industries.

Relative wages were then explicitly included as MacDougall computed relative wage costs per unit of output for each of the 25 industries. In general, these costs were found to be less in the United States in those industries where United States productivity exceeded that of the United Kingdom by more than two times. In addition, relative wage costs per unit of output were inversely related to relative

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[2]G. D. A. MacDougall _et al_., "British and American Productivity, Prices and Exports: An Addendum," _Oxford Economic Papers_ (October, 1962), pp. 297-304.

[3]MacDougall, "British and American . . .," p. 697.

export shares.[4]

Finally, MacDougall related price ratios to relative export shares with regressions for each year from 1913 to 1948. The results were favorable with the lowest correlation coefficient being -0.73.

Despite comparative advantage to third countries, United States and United Kingdom exports to these third countries and to one another were not complete. That is, the Classical consequence of comparative advantage, complete specialization, was not found to exist. MacDougall attributed this to relative tariff rate differences, transportation costs, imperfect markets, and non-homogeneous goods.[5]

Another study of the Classical theory was made by Robert Stern.[6] As productivity data were updated, Stern in effect expanded upon and further strengthened the MacDougall study. Stern's purpose was to find the "extent to which differences in the relative labour productivity and production costs . . . are reflected in differences in the relative export performance of the two countries."[7]

For the year 1950, Stern found that United States

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[4] Ibid., p. 698.

[5] Ibid., p. 699.

[6] Robert M. Stern, "British and American Productivity and Comparative Costs in International Trade," Oxford Economic Papers, XIV (October, 1962), pp. 275-96.

[7] Ibid., p. 275.

weekly wages average 3.4 times those in the United Kingdom. A productivity difference of more than 3.4 times was required if the United States was to have the larger share of exports to third markets. Twenty out of twenty-four industries conformed to expectations.

Stern then undertook three correlation studies. First, relative productivity and relative export shares were correlated, yielding a coefficient of +.44; positive as hypothesized. Second, unit labor costs were correlated with relative export shares resulting in a coefficient of -.43; negative as hypothesized. Finally, net cost ratios were correlated with relative export shares, where it was assumed that these cost ratios were indicators of comparative resource productivity rather than labor productivity alone. The coefficient obtained was -0.36; negative as hypothesized.[8]

A third study of the Classical theory was done by Balassa,[9] and it too followed the pattern set by MacDougall. The first part consisted of correlating labor productivity ratios with export ratios for 1951. The countries involved were again the United States and the United Kingdom.

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[8] *Ibid.*, p. 293.

[9] Bela Balassa, "An Empirical Demonstration of Classical Comparative Cost Theory," *The Review of Economics and Statistics*, XLV (August, 1963), pp. 231-38.

Assuming a linear relationship, the *r* coefficient was +.80, positive as hypothesized, while using a logarithmic relationship between variables yielded an *r* coefficient of +.86.[10] Both coefficients strongly supported the Classical hypothesis.

Next, Balassa considered wage ratios as an additional variable in the regression equation. The *r* coefficient, assuming a linear relation, was little changed from that found in his first test. The partial correlation coefficient between wage ratios and export ratios was only .24, positive as hypothesized, but not significant at the five percent level. Transformation to a logarithmic relation did not improve the results.[11]

Finally, Balassa correlated export ratios with net unit cost ratios finding *r* coefficients of -.60 and -.71 for linear and logarithmic relations respectively.[12]

In general, all of the above tests yielded very good results, indicating substantial evidence in support of the Classical model. These studies are not without weaknesses. Bhagwati's critique is probably the most extensive.[13]

Bhagwati is primarily concerned with the tenuous

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[10]Balassa, p. 235.

[11]*Ibid*., p. 236.

[12]*Ibid*., p. 237.

[13]Bhagwati, "The Pure Theory. . . ."

relationship between the hypotheses tested by MacDougall, Stern, and Balassa, and what he feels are the original "Ricardian" hypotheses which reflect differences in relative productivities or relative unit labor costs between countries. The breakdown occurs, according to Bhagwati, because "the assumption that the relative prices of exported goods will be lower than those of imported goods is now replaced by the postulation of some relationship between (United States-United Kingdom) price ratios of third-market exports and (United States-United Kingdom) shares in third markets."[14] Specifically, he questions the use of cross-section investigation to analyze the relation between third market export ratios between the United States and the United Kingdom, and their price ratios for any one industry.

Bhagwati also considered a problem common to any test of the Classical model. The derivations of the two "Ricardian" hypotheses suggested at the beginning of the chapter rely on the assumption that prices are closely related to labor productivities and/or unit labor costs. This assumption was also implicit in the tests of MacDougall, Stern, and Balassa. Bhagwati tested this proposition using data from the three previously mentioned studies and found that these data do not support the required assumption. He concluded that "a fullblooded test of these [Ricardian]

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[14] Ibid., p. 11.

hypotheses, directly examining the ranking of [bilateral] exports and imports by comparative labour productivities and/or unit wage-cost ratios, is impossible to carry out with this information. . . ."[15]

Preliminary Tests of the Classical Model

The tests of the Classical hypotheses to be presented in this chapter involve United States regional data rather than international data. Relative production concentration is used because relative export flows between regions are not known. The regional divisions of the United States and the production concentration ratios are the same as those used in the previous chapter to test the Heckscher-Ohlin hypothesis. Data for the year 1958 are taken from the U. S. Census of Manufactures.[16]

The first hypothesis tested is that those industries with higher labor productivity in the South relative to the non-South will be more concentrated in the South relative to the nation as a whole. Specifically, the research hypothesis is that productivity ratios will be positively correlated with production concentration ratios. This hypothesis arises from the expression of the Classical model where the initial condition for trade to take place between,

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[15] Ibid., p. 14.

[16] U.S. Bureau of the Census, Census of Manufactures. . . .

say, countries A and B, that is, $\left(\frac{P_x}{P_y}\right)_A < \left(\frac{P_x}{P_y}\right)_B$, is a result solely of differences in relative labor productivities between the two countries, that is, $\left(\frac{APL_x}{APL_y}\right)_A > \left(\frac{APL_x}{APL_y}\right)_B$. Relative labor productivities are assumed to be representative of relative costs and therefore of relative commodity prices. Productivity, measured in each industry by dividing regional value added by regional employment, is expressed as dollar value of output per man year.

To test the hypothesis, Kendall's τ was computed to measure rank correlation between production concentration ratios and productivity ratios for 71 three-digit SIC industries, where productivity ratios are the ratio of productivity in the South to productivity in the non-South. Rankings of concentration ratios and each industry's corresponding productivity ratio for all Classical tests are shown in Appendix IV and all test results are listed in Appendix V. τ was found to be -.202, significant at the five percent level but of the "wrong" sign.

In seeking an explanation for these perverse results, it seems reasonable to first consider the conditions specified for the hypothesis tested. Of primary interest is the relationship between productivity and costs. Is productivity a legitimate proxy of costs and therefore of prices? The answer depends a great deal on the role of wages in costs. If interindustry wage differences exist and wages reflect skill differences as they would under competitive conditions and moderate labor mobility, high wages are paid to highly skilled, and therefore productive workers. Relatively high productivity in isolation does not insure relatively low unit costs, however. Thus, the strict Ricardian model expressed in terms of productivity may be insufficient to explain trade flows or industry location concentration.

Opinions differ as to the relative role of wages and productivity. Forcheimer feels that wages may play a significant role in the structure of comparative costs.[17] In consideration of the important determinants of comparative advantage, he suggests wages, productivity, and the ratio of average total costs to average wages. If relative wage differences are to play a leading role, the other two items must have minor effects or offset one another. Under certain conditions this will occur. When manufacturing industries are considered, productivity differences due to "natural" conditions may be minor, allowing wage differences to exert the primary net effect on total costs. In addition, industries whose transportation costs are low relative to total costs and whose purchase of raw materials can be made at world prices are likely candidates for wages to dominate

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[17]Karl Forcheimer, "The Role of Relative Wage Differences in International Trade," The Quarterly Journal of Economics, LXII (November, 1947), pp. 1-30.

cost determination. Specifically, Forcheimer feels that light manufacturing industries seem to fit these conditions.[18]

Kravis, on the other hand, feels that wage differences are not likely to alter the productivity determinants of comparative advantage, and in fact shows that export industries in the United States pay relatively <u>high</u> wages.[19] In addition, by comparing hourly earnings of different industries between the United States and Japan, he finds evidence that wage structures of noncompeting groups are similar in different countries, and therefore wage differences between industries have little effect on comparative advantage between countries.[20]

Kravis also finds that the average wage level in a country is representative of average productivity in that country, and therefore differences in industry costs between countries are more apt to be a function of productivity differences between industries.[21]

Because of the possibility that wage differentials may have influenced the "pure" productivity tests, a second test of the Classical model is undertaken, in which concentration ratios are ranked with average labor cost ratios

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[18] <u>Ibid</u>., p. 24.

[19] Kravis, "Wages and Foreign. . . ."

[20] Kravis, "'Availability' . . .," p. 146.

[21] <u>Ibid</u>.

for each industry. Average labor costs are computed by dividing the average annual wage per man by productivity, that is, by value added per man year. Costs can then be expressed by stating that each $1.00 of value added per man year costs $X in wages.

Specifically, the hypothesis tested is that average labor cost ratios will be negatively correlated with concentration ratios. Using Kendall's rank correlation test, τ is +.116, not significant, but of the "wrong" sign.

Both models considered thus far fail to explain relative production location in the South and non-South. One possible explanation is that average labor cost is an insufficient cost concept to be a price proxy. Capital and raw material costs certainly are a part of the average total cost or the marginal cost of producing any good. Thus, it is possible that neither labor costs nor labor productivity by themselves are sufficient to indicate comparative advantage in the production of any one good between regions.

In order to reduce the influence of other factors of production and to more closely approximate the condition implied in the Classical labor theory of value, additional tests were made which included only labor intensive industries; that is, those industries in which labor costs account for 60 percent or more of total costs. Sixteen industries are tested for rank correlation between concentration ratios and average labor cost ratios and labor productivity ratios.

Using cost ratios, Kendall's τ is -.183, negative as hypothesized but not significant. Using productivity ratios, τ is +.033, positive as hypothesized but also not significant. Although these results are not statistically significant, the fact that the signs were reversed in both tests gives some indication that in non-labor intensive industries other variables override labor cost differences.

A weakness in all of the preceding tests is that they were performed in a framework that is rigorously suggested by the Ricardian "two country, two commodity" model. Hence the model is not strictly appropriate for multi-commodity tests.

Tests of an Alternative Classical Model

Frank Graham's effort to expand trade theory to a multi-country, multi-commodity setting while still basing comparative advantage on labor costs yields several ideas for a more comprehensive testing of the Classical model.[22] In his article "The Theory of International Values Re-examined," Graham states that, "It is to the assumptions of trade between two countries only and in but two commodities that attention will here be drawn in an endeavor to show

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[22]Frank D. Graham, The Theory of International Values (Princeton: Princeton University Press, 1948).
Frank D. Graham, "The Theory of International Values Re-examined," Quarterly Journal of Economics, XXVIII (November, 1923), pp. 54-86.

that to construct a theory of international values in this piecemeal way is a method so faulty as to have issued in wholly unwarranted inferences."[23]

With that statement, Graham launched into a series of numerical examples indicating gains from trade, the role of demand, and the basis behind relative ranking of more than two commodities according to comparative advantage. These were, in effect, general equilibrium models whose solutions were points of competitive equilibrium.[24] In these models, Graham assumed labor to be the sole source of productive power and that all goods were produced at constant labor costs.[25]

In Graham's more complete model, a country or region, rather than specializing in only the one good in which it had a comparative advantage under the two commodity case, is now faced with a problem of optimal allocation of its labor among several uses. This problem is analogous to that of a firm choosing the optimal product mix in order to maximize profits, subject to the constraint of resource limitation, and where each product requires factors in different

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[23]Graham, "The Theory of . . ." (1923), p. 55.

[24]Lionel W. McKenzie, "Specialization and Efficiency in World Production," Review of Economic Studies, XXI, No. 1 (1954), pp. 165-80.

[25]Lloyd Metzler, "Graham's Theory of International Values," The American Economic Review, XL (June, 1950), pp. 301-22.

proportions.

The problem is simply a case in which two or more activities are competing for limited resources. If it can be assumed that all relationships are linear, then the optimal solution can be found by solving the problem as a linear program. This is, in effect, a trial and error approach. First, some initial obvious and feasible output combination is stated. For example, all resources may be allocated to the production of the good whose profit per unit is the highest. It is likely, however, that not all resources will be fully used, and an additional product will be included and a new combination of outputs considered. This search process continues until an optimal solution is reached, that is, one that maximizes profits.

The important fact is that Graham had this general approach in mind. Thus, in a multi-commodity example, goods with the highest comparative advantage are more intensively produced and traded first, while those with lower comparative advantage are added in and are profitable only after the demand for the initial goods has been sufficiently satisfied to lower their gains from trade.[26]

Following this approach, the relevant concentration index for rank correlation tests should show the share of each industry in its region's output relative to that industry's

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[26]Graham, "The Theory of . . ." (1923), p. 64.

share for the rest of the nation. Thus, a testable hypothesis will read: The South has a comparatively larger share of its own regional value added in those industries in which the South has the largest labor productivity advantage.

For the two region study of this paper, the alternative concentration measure would be a ratio of relative output concentration between the South and non-South. Thus, if the South has a labor productivity advantage over the non-South in a given industry, a higher percentage of resources in the South should be allocated to this industry than in the non-South, resulting in value added being relatively higher in the South. This concentration can be computed as the percent of value added in the South by an industry, $\frac{v_s^i}{V_s}$, divided by the percent of value added in the non-South by that industry, $\frac{v_{ns}^i}{V_{ns}}$. Letting $\frac{v_s^i}{V_s}$ equal C_s and $\frac{v_{ns}^i}{V_{ns}}$ equal C_n, the concentration measure is $\frac{C_s}{C_n}$. For testing purposes, one can hypothesize a positive rank correlation between relative industry concentration and labor productivity ratios, and a negative rank correlation when labor costs are used.

Rank correlation tests of the Classical model were made using the original sample of 71 industries and the concentration concept suggested above. The results show that τ is of the "wrong" sign for both labor variables used and is significantly different from zero at the five percent level for labor productivity (-.199) and the ten percent level for labor costs (+.131).

These results are clearly contrary to those predicted by the hypotheses. The tests show that there is a statistically significant indication that industries having relatively low labor costs in the South are more heavily concentrated in the non-South, and those industries having relatively high labor productivity in the South are more heavily concentrated in the non-South.

It becomes obvious then, that factors other than labor costs and productivity play a dominant role in determining relative industry concentration between the two regions. Other possible factors are: the combination of demand and high transportation costs for the output of these industries, the dependency on raw materials from external sources and the location of these raw materials, and differential rates of industrial development between the two regions.

Because of the difficulty in finding any strong relationship between labor costs or labor productivity and some measure of production concentration, it seemed useful to attempt to determine in which industries and to what extent comparative advantage should exist in the South under the Classical conditions. With this in mind, consideration was given to several articles which, based on Graham's works, are concerned with expanding the Classical model beyond the two-country, two-commodity stage and with putting it in a form more conducive to empirical analysis.[27]

A solution of production specialization can be put in geometrical terms by use of a world production transformation curve and the world price ratio line. Once the problem goes beyond the three commodity stage, however, diagrams become impossible. With _n_ commodities, the production transformation curve becomes an _n_ dimensional polyhedron and the optimal solution is a point of tangency with the price hyperplane.

The intriguing thing about this model is that the optimal solution can be obtained by the application of linear programming. Whitin, giving credit to Graham as his source of inspiration, suggests an objective function of maximizing the value of world trade where labor is the sole source of factor inputs.[28] McKenzie demonstrates the application of "activity analysis," the goal of which is "the selection of productive processes which can be used to provide a maximum output from given resources."[29] Jones'

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[27]McKenzie.

T. M. Whitin, "Classical Theory, Graham's Theory, and Linear Programming in International Trade," Quarterly Journal of Economics, LXVII (November, 1953), pp. 520-44.

Ronald W. Jones, "Comparative Advantage and the Theory of Tariffs: A Multi-Country, Multi-Commodity Model," Review of Economic Studies, XXVIII (June, 1961), pp. 161-175.

[28]Whitin, p. 542.

[29]McKenzie, p. 165.

approach is similar to that of McKenzie as he suggests solving for the pattern of complete specialization lying on the world efficiency locus, although he considers minimizing labor inputs as well as maximizing output as a goal.[30]

Following the suggestion by the above writers that the Graham-Classical model can be solved through linear programming, an attempt was made to compare the optimal output predicted under the strict labor productivity theorem with the actual value added data for 71 SIC three-digit industries for 1958. The problem, then, becomes one of finding the optimal allocation of labor between industries and regions so as to maximize total value added. It was assumed that constant costs prevail, and that labor is the sole input factor.

The objective function to be maximized is $V=\sum_{i=1}^{71} b_{ij}L_{ij}$, where V is value added for the nation; b_{ij} is labor productivity, value added per man year, for all i industries and j regions, and where L is the number of man years allocated in each industry in each region.

The function is subject to two sets of constraints. First, in each region, the sum of labor used in the industries where output activity occurs cannot exceed the total labor supply available for that region, that is, $\sum_{i=1}^{71} L_{ij} \leq L_j$.

Second, a minimum value added must be produced in

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[30]Jones, p. 164.

each industry in the nation in order that the demand for the output from each industry be satisfied. This can be written as: $v_i \geq v_i'$, where v_i' is the actual value added in the nation for the ith industry in 1958 and is used as the demand indicator for each industry's output. If this constraint were not imposed, all labor would go to the one most efficient industry in each region and only one "product" would be produced.

The revised simplex method of solving for the objective function was used.[31] The method required that the problem be put in matrix form, where each row represented either the objective function equation or a constraint equation. The first row gave the objective function and was therefore named MAX. The second and third rows contained the labor supply constraints for the South (STH) and the non-South (NSH) respectively. Since this constraint is expressed as a "less than or equal to" condition, a positive slack variable was inserted in these two rows to permit them to be treated as equalities during the solution process. The remaining rows were the output constraints (C_n). Expressed as "greater than or equal to" conditions, they required the insertion of a negative slack variable.

The equations, in the order they appeared in the matrix are found in Figure IV.

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[31] Calculation of Linear Programming Problems on the AESLP, AESLPED, and EDITLP Routines, Michigan State University Agricultural Experiment Station, 1968.

MAX row	$b_{1s}L_{1s}+b_{2s}L_{2s}+..+b_{71s}L_{71s}+b_{1n}L_{1n}+b_{2n}L_{2n}+..+b_{71n}L_{71n}$
STH row	$L_{1s} + L_{2s} + \ldots\ldots\ldots L_{71s} + 0 + 0 + \ldots\ldots 0 \leq L_s$
NSH row	$0 + 0 + \ldots\ldots\ldots 0 + L_{1n} + L_{2n} + \ldots\ldots L_{71n} \leq L_n$
C_n rows	$b_{1s}L_{1s} + 0 + 0 \ldots\ldots\ldots + b_{1n}L_{1n} + 0 + 0 \ldots \geq v_1'$
	$0 + b_{2s}L_{2s} + 0 \ldots\ldots\ldots + 0 + b_{2n}L_{2n} + 0 \ldots \geq v_2'$

for all 71 industries

Figure IV

In the MAX row, the b coefficients were labor productivity data as used in earlier tests in the paper. The L coefficients were the unknowns, that is, the labor allocation for which the problem was being solved. In the labor constraint rows, the L coefficient is again the unknown, and the only entry was a coefficient of 1. For the demand constraint rows, labor productivity was again as b, while L is still unknown. There were 143 columns in the fully written matrix. One hundred forty-two columns represented all combinations of the 71 industries and the two regions, while the 143rd was the "right hand side" column containing the values of the constraint equations. The solution yielded the number of man years of labor which should be allocated to the various industries in the two regions so as to maximize value added for the nation, while at the same time operating within the constraints specified.

To anticipate the results, two factors were noted. First, the suggestion by Bhagwati, that in a Ricardian model expanded beyond two commodities, "there will be a chain in which all commodities are ranked in terms of their comparative factor-productivity ratios such that it will always be true that each of a country's exports will have a higher factor-productivity ratio than each of its imports."[32]

Second, a comparison of labor productivities between

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[32]Bhagwati, "The Pure Theory. . .," p. 5.

the two regions shows that the South has an absolute advantage in only 12 of the 71 industries, that is, where the ratio of productivity in the South to that in the non-South is greater than one. For the remaining 59 industries, the productivity ratios ranged from +.993 to +.617. The productivity ratios and the optimum allocation of labor are shown in Table 1.

As might be expected, the South's labor was first allocated to those industries in which an absolute advantage existed. Thus, the South was shown to specialize in the production of those goods and supply the entire amount demanded by the nation. The remaining labor in the South was then allocated according to the ranking of productivity ratios. First, enough labor was given to SIC industry 366, whose productivity ratio was .993, to satisfy total national demand. The next allocation went to industry 356 with a ratio of .988. This continued until the labor supply in the South was exhausted. The result was that two industries in the South were allocated labor based on "pure" comparative advantage, that is, with no absolute advantage already existing. Of these, industry 366 output will be entirely produced in the South, while industry 356 output will be divided between the South and non-South.

The actual output data for the year 1958 are quite different from the results of the linear programming solution. Both regions produce in all 71 industries. And as

Table 1. Linear programming allocation of labor inputs between industries and regions for maximization of national value added

Industry	Labor Productivity Ratio	Units of Labor Allocated	Region
201	.750	291693.9	N
202	.904	284318.1	N
203	.652	202966.2	N
204	.716	110130.1	N
205	.935	296689.9	N
206	.871	27332.0	N
207	.688	76670.0	N
208	.803	194090.4	N
209	.740	124168.6	N
225	.644	169781.9	N
228	.814	92404.1	N
229	.786	64510.7	N
231	.929	122522.9	N
232	.730	232260.9	N
233	.670	345419.9	N
234	1.020	109705.2	S
236	.737	76178.4	N
238	.751	57409.0	N
239	.850	124758.4	N
243	.634	121601.6	N
244	.787	35056.9	N
249	.774	53501.7	N
251	.788	228898.1	N
252	.801	22855.6	N
253	.640	13694.2	N
265	.938	179170.6	N
273	.617	65682.4	N
278	.962	39883.1	N
279	.906	41604.2	N
283	.940	95494.2	N
284	.893	613551.4	N
285	.967	58487.6	N
287	.865	35837.3	N
295	.854	22453.3	N
299	.793	9505.4	N
314	1.004	226108.1	S
317	.949	35551.8	N
322	.971	91390.2	N
325	.790	65726.1	N
326	.785	42419.2	N
327	.830	141151.7	N
329	.984	91099.5	N
332	.927	179844.9	N

Table 1 (continued)

Industry	Labor Productivity Ratio	Units of Labor Allocated	Region
333	1.513	37308.6	S
335	1.058	152662.4	S
339	1.136	46118.3	S
342	.902	134884.7	N
343	.771	68843.6	N
344	.831	327279.4	N
346	.874	124315.1	N
348	.977	55338.4	N
349	1.069	129617.9	S
351	.643	95525.1	N
352	.787	105995.9	N
353	.974	198765.8	N
354	1.030	226757.3	S
355	.909	160135.1	N
356	.988	190149.5	N
		21343.7	S
357	1.504	82129.9	S
362	1.295	123066.4	S
366	.993	216348.8	S
369	1.180	67286.3	S
371	1.147	509292.7	S
372	.908	754943.1	N
373	.887	137219.2	N
384	.871	41362.2	N
391	.679	41557.3	N
394	.926	97949.4	N
395	.903	28737.4	N
396	1.090	51841.5	S
399	.926	325353.4	N

seen in earlier tests, the relative intensity of production between industries and regions is not correlated with productivity ratios as the program results indicate they should be. Of the 14 industries that should produce solely in the South according to Classical optimization, only two have very high rankings in the concentration ratios computed. A list of ranks for the relative regional concentration concept, $\frac{C_s}{C_n}$, is shown below:

Industry	Concentration Ranking (out of 71)	Labor Productivity Ratios
234	57	1.020
314	31	1.004
333	69	1.513
335	35	1.058
339	4	1.136
349	36	1.069
354	5	1.030
356	8	.988
357	6	1.504
362	17	1.295
366	27	.993
369	14	1.180
371	16	1.147
396	7	1.090

The poor predictive content of the Classical model indicates that other factors play a dominant role in industrial location. This conclusion seems to be highly plausible in industries where total labor costs, as measured by total wage bill, make up only a small portion of the total costs of value added.

To deal with this circumstance, reconsideration was given to the Graham-modified Classical model for industries in which at least 50 percent of total costs could be attributed to labor. Remaining was a sample of industries where non-labor costs such as capital and raw material costs would play a subordinate role. From the original sample of 71 industries, 38 met this condition and were subjected to the same rank correlation tests as performed earlier. Using both labor cost and productivity ratios, both correlation coefficients were of the "wrong" sign (.013 and -.180 respectively). The level of significance fell in both tests, however, thus indicating some improvement over the full-sample tests.

One explanation of the apparent randomness of association between labor cost or productivity ratios and relative concentration can be based on the concept of differential rates of industrial development between the South and non-South. In the earlier linear programming solution, only 12 industries had an absolute advantage in the South based on labor productivity. (See page 68.) Of these, only two actually show high concentration in the South. Of the remaining ten, seven could be classified as being involved in heavy industrial output. They are: 335, nonferrous metal rolling and drawing; 339, primary metal industries, n.e.c.; 349, fabricated metal products, n.e.c.; 354, metalworking machinery; 362, electric industrial apparatus; 369, electrical products; 371, motor vehicles and equipment.

Because of the more recent industrial development in the South, these industries have more modern capital equipment, making their labor inputs more productive. These same industries in the non-South, however, must allow for depreciation of older equipment before replacing it with newer machinery or even a new scale of operations. In addition, because the non-South did develop earlier, the sources of demand for these products are still mostly located in the non-South; and thus, despite the labor productivity disadvantage, most of the nation's output in those industries is still produced in the non-South.

Some Comparative Static Tests

In an effort to investigate further the idea of different regional development rates, percentage changes in the relative concentration ratios were computed for the period between 1947 and 1958. If during this period, industry in the South had been developing at a faster rate than in the non-South in those industries in which the South had a comparative labor cost advantage, the above explanation of the earlier test results could have some validity. To test this, rank correlation tests were performed between the rankings of percentage change in $\frac{C_s}{C_n}$ and both average labor cost ratios and labor productivity ratios. The hypothesis was that industries with relative cost or productivity advantages would be positively correlated with percentage changes in relative concentration in the South. In the case of average labor costs, the rank correlation coefficient should be negative, while with labor productivity, it should be positive.

Due to changes in SIC classifications between 1947 and 1958, 21 of the industries had to be eliminated as data were not available or not comparable between the two years, leaving a sample of 50 SIC three-digit industries. The respective coefficients of the two tests were -.231, significant at the 6 percent level, and .062, not significant. Both were of the hypothesized sign. Ranks are shown in Tables 2 and 3.

Analysis of the rankings spotlights several interesting points. First, Industry 273, book printing and publishing, performs very poorly, regardless of whether labor cost ratios or labor productivity ratios are compared with concentration changes. That is, the data show a large percentage increase in relative concentration in the South for Industry 273, despite a high labor cost ratio and low productivity ratio for the South. However, when Industry 273 is considered in the context of static concentration for 1958 alone, it performs very well. In a sample of 71 industries, it ranks 70th in labor cost ratios and only 13th in concentration, a definite negative relationship as hypothesized.

Thus, despite a substantial percentage shift to the South over the period covered, the industry remained primarily

Table 2. Ranks of average labor cost ratios and percentage changes in relative concentration in the South, 1947-1958

SIC Code	Average Labor Cost Ratio Rank	Percentage Changes in Relative Concentration Ratio Ranks	SIC Code	Average Labor Cost Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks
279	1	18	267	26	27
354	2	44	251	27	24
317	3	50	205	28	15
314	4	30	228	29	2
384	5	42	231	30	28
348	6	35	249	31	20
234	7	48	295	32	29
229	8	40	225	33	25
342	9	45	394	34	41
332	10	31	344	35	14
349	11	46	204	36	6
395	12	38	209	37	11
327	13	19	284	38	9
208	14	7	238	39	33
355	15	36	346	40	12
244	16	32	373	41	8
399	17	34	243	42	5
201	18	22	326	43	4
287	19	1	203	44	21
202	20	26	343	45	17
285	21	13	236	46	49
322	22	10	233	47	43
278	23	23	232	48	37
325	24	16	352	49	39
239	25	3	273	50	47

Table 3. Ranks of labor productivity ratios and percentage changes in relative concentration in the South, 1947-1958

SIC Code	Labor Productivity Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks	SIC Code	Labor Productivity Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks
273	1	47	287	26	1
243	2	6	384	27	42
225	3	25	346	28	12
203	4	21	373	29	9
233	5	43	284	30	5
204	6	7	342	31	45
232	7	37	395	32	38
236	8	49	202	33	26
209	9	11	279	34	18
201	10	22	355	35	36
238	11	33	394	36	41
343	12	17	399	37	34
249	13	20	332	38	31
326	14	4	231	39	28
229	15	40	205	40	15
352	16	39	267	41	27
244	17	32	317	42	50
251	18	24	278	43	23
325	19	16	285	44	13
208	20	8	322	45	10
228	21	2	348	46	35
327	22	19	314	47	30
344	23	14	234	48	48
239	24	3	354	49	44
295	25	29	349	50	46

located in the non-South as predicted by the static hypotheses. The reason for the shift can be attributed to changes in income and population, movement to an area of absolutely lower labor costs, and a small shift in paper industries to the South.[33]

With Industry 273 not included in the tests, the coefficients were -.245, significant at the five percent level, and +.146, significant at the 15 percent level.

A second point of interest is the performance of the apparel industry group, made up of Industries 231, 232, 233, 234, 236, 238, and 239. Four of these industries, 232, 233, 236, and 238, perform very poorly in the tests. All four have relatively high labor cost ratios and low labor productivity ratios, yet show a relatively high movement to the South, a condition contrary to the hypothesis.

To explain this, several characteristics of the apparel industry must be noted. First, these four are quite labor intensive industries; that is, at least 60 percent of their total cost is attributed to labor.

Second, although the productivity ratios are low for these industries, the absolute level of productivity is also low for these industries in the non-South relative to all other industries in the non-South. Thus, although the non-South may have an absolute advantage over the South

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[33] Victor Fuchs, Changes in the Location of Manufacturing in the United States Since 1929 (New Haven: Yale University Press, 1962), p. 254.

in these industries, they are characterized by very low productivity throughout the non-South. Third, all apparel industries are generally regarded as requiring unskilled labor.[34]

The relatively large shift to the South, then, can be attributed to several interacting conditions. The apparel industries require large amounts of unskilled and therefore low productivity labor. Because of the relative shortage of this type of labor in the non-South, wages are higher. At the same time, improved technology in agriculture has freed much unskilled labor in the South. Thus, the attraction of a substantial supply of unskilled labor has been a major cause of the movement to the South.[35]

An additional factor is that the source of raw materials, Industry 22, textile mill products, is concentrated in the South and has shown signs of further movement to the South.[36]

The other three apparel industries, 231, 234, and 239, show mixed results in the rank tests. Industry 234 definitely supports the hypotheses, 239 probably does, while 231 is difficult to judge. The reason these three vary from

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[34] _Ibid_., p. 172.

[35] _Ibid_., pp. 24, 25, 172.

[36] For sub-industries 225, 228, and 229, the percentages of output produced in the South are 46, 68, and 25. Industries 225 and 228 rank 35th and 38th (out of 50) in movement to the South.

the others is explained by their difference in the intensity of labor required. Industry 234 has the lowest labor requirement of all apparel industries, 48 percent, and therefore was not under as much pressure to seek new sources of unskilled labor. Industries 239 and 231 have labor requirements of 56 and 62 percent of value added.

After omitting the seven apparel industries, the new rank correlation coefficients were -.349, significant at the .0005 percent level, and +.181, significant at the ten percent level.

These results constitute very strong evidence that although the composition of the industrial structure in the South in 1958 did not conform to that which would be expected under the Classical hypothesis, it was due in part to the differences in the vintage of capital employed between the South and the non-South, and not because the Classical model in general has no predictive power. In fact, changes in the industrial structure of the South did take place in accordance with expectations derived from the Classical model.

Because of the latent industrial development of the South, a comparative set of tests was performed between New England and non-New England. The same variables are used and rankings are shown in Appendix IV.

For a sample of 68 industries, the rank correlation test between labor productivity ratios and relative concentration ratios yielded a coefficient of +.221, significant at the one percent level and positive as hypothesized. This result shows strong evidence that those industries with relatively high labor productivity in New England tend to be relatively highly concentrated there. This is, of course, contrary to the relation between those two variables in the South, providing further evidence that because the South did not have a fully developed industrial structure, its industry concentration could not be explained by either the Heckscher-Ohlin or the Classical model. When average labor cost ratios are substituted for labor productivity ratios, the coefficient is -.076, not significant, but of the hypothesized sign.

Although the industrial structure of New England is regarded as being relatively well established, changes during the 1947-1958 period took place in a manner expected under the Classical hypothesis. That is, those industries with relatively high labor productivity in New England generally experienced increases in relative concentration in New England. A coefficient of +.249 is obtained when labor productivity ratios are ranked with percentage changes in relative concentration, and a coefficient of -.138 is found for average labor costs. The former is significant at the one percent level, while the latter is not significant.

Conclusions

From these comparative tests, several conclusions can be drawn. In a rapidly developing region, the Classical model does not predict accurately the relative industry concentration at any one point in time. It can, however, predict which industries have shown and will continue to show relatively higher growth rates as indicated by increases in their relative concentration in that region. On the other hand, for a region with an historically established industrial structure, the Classical model predicts with tolerable accuracy the relative concentration at any point in time as well as <u>changes</u> in relative concentration over time.

CHAPTER IV

THE ROLE OF DEMAND AND NATURAL RESOURCES

Introduction

To this point, neither the Heckscher-Ohlin nor the Classical hypothesis has very well explained the static levels of industry concentration in the South. That the South had not yet reached industrial maturity seemed to offer a partial explanation; however, it is felt that other variables might play a significant role.

In an effort to isolate these other variables, reconsideration was given to the rank correlation test for the 38 labor intensive industries discussed in the previous chapter. Rankings of relative concentration ratios and labor productivity ratios are shown in Table 4. A sample of industries selected in such a way as to give the Classical model every chance of indicating some predictability of relative industry concentration in the South is shown. The test result indicated, however, that the rankings were distributed in a random manner, and therefore the model had no explanatory power. Eight industries which clearly violated the hypothesized relation are subjected to a more detailed analysis. The industries are: 243, 253, 225, 232, 278, 354, 356, and 339.

Table 4. Ascending ranks of relative concentration ratios, $\frac{C_s}{C_n}$, labor productivity ratios, and average labor cost ratios for industries in which at least 50 percent of total costs are labor costs

SIC Industry Classification	Relative Concentration Ranks	Labor Productivity Ratios Ranks	Average Labor Cost Ranks
351	1	4	36
391	2	7	34
339	3	38	2
354	4	35	1
356	5	32	4.5
273	6	1	37
233	7	6	32
352	8	15.5	35
278	9	30	11
394	10	25.5	22.5
399	11	25.5	9
366	12	33	20
314	13	34	3
355	14	24	7
238	15	11	25
372	16	23	27
335	17	36	16
349	18	37	6
343	19	12	30
332	20	27	4.5
326	21	14	29
265	22	29	14
236	23	9	31
353	24	31	21
231	25	28	17.5
239	26	21	12.5
243	27	2	28
344	28	20	24
201	29	10	10
253	30	3	38
249	31	13	19
325	32	18	12.5
251	33	17	15
373	34	22	26
225	35	5	22.5
232	36	8	33
244	37	15.5	8
228	38	19	17.5

These industries fall into two distinct groups. The first four have relatively low labor productivity ratios, yet show relatively high concentration in the South. Some other influence appears to be offsetting the low labor productivity such that it is profitable for these industries to produce quite intensively in the South. The second group has the opposite relation; that is, relatively high labor productivity ratios, yet relatively low concentration in the South.

Two variables felt most likely to influence concentration are the location of demand for the output of an industry and the location of an industry's sources of raw materials. In some cases, sources of demand or raw materials were specifically spelled out in the Census of Manufactures.[1] More often, however, a look at four or five-digit sub-industries gave a clue as to potential sources of raw materials and to other industries which use the output of the industry under consideration as an input and thus create a demand for it.

The detailed analysis for the eight industries appears in Appendix IV, and only the conclusion drawn for each industry will be presented here. An examination of the industries seemed to indicate that an important role is played

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[1]U.S. Bureau of the Census, Census of Manufactures, 1958, Vol. II, Parts 1 and 2 (Washington: U.S. Government Printing Office, 1961).

by the location of demand and of raw material sources.

For Industry 243, millwork and related products, both sources of demand and raw materials are reasons for locating in the South. For Industry 253, public building furniture, a lack of concrete relationships existed, and no explanation is offered for its relative rankings. For Industry 225, knitting mills, and Industry 232, men's and boys' furnishings, the sources of raw materials are the major determinants of regional concentration.

For Industry 278, bookbinding and related work, uncertainty about the sources of both demand and raw materials makes any judgment difficult. A lack of strong demand in the South could be important. For the remaining three industries, 356, general industrial machinery; 354, metalworking machinery; and 339, primary metal industries, n.e.c.; high demand and raw material concentration in the non-South explains the high production concentration in the non-South.

Because the more detailed examination of the eight industries seemed to indicate that an important role is played by the location of demand and of raw material sources, further investigation was undertaken. If demand location does influence the relative concentration of some industries, those industries' elimination from the sample could cause the hypothesized relationships between variables within the two models to be more closely approached.

A Test for the Role of Demand

In an effort to classify which of the 71 three-digit industries are "market-oriented," a characteristic of these industries as described by Victor Fuchs was used as a starting point. According to Fuchs, "their [market-oriented industries] distribution throughout the country tends to conform to the distribution of income and population."[2]

This statement implicitly assumes that one demand structure exists across the United States, and therefore within each of the nine census regions. Thus, demand for the output of each of the 71 industries exists in all nine regions, where the level of demand is a function of per capita income.

A demand-oriented industry can then be defined as an industry that is located in all nine regions and whose relative level of output in each region is the same as each region's relative level of demand. To find demand-oriented industries, each region is ranked according to per capita income, weighted by a population index. Then, for each industry, each region is ranked according to its percentage of national value added for that industry. Industries whose regional output ranks closely approximate (Kendall's τ of at least +.666) the regional demand indicator ranks are considered to be demand-oriented industries. Of the 71

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[2]Fuchs, Changes in the Location . . ., p. 152.

industries, 30 meet these requirements. Industries, τ coefficients, and level of significance are listed in Table 5.

These industries are then eliminated from the sample, and new tests are performed. For the reduced sample, rank correlation tests between measures of concentration and labor productivity ratios, average labor cost ratios, and gross capital-labor ratios, yielded no significant improvements over the same tests when the full sample of 71 industries was included. The comparative results are shown in Table 6, while the relative rankings for the limited sample tests are listed in Appendix III and IV.

The Role of Natural Resources

The location of sources of raw materials remains a potentially important explanatory variable. A measure of the relationship between value added and cost of materials would appear to give some indication as to how sensitively industries depend upon raw materials from sources outside the plant. Industries that depend heavily on raw material inputs are apt to have their concentration more strongly related to the concentration of their sources of these materials than industries that are not so "raw materials-oriented."

The determination of the sensitivity of an industry's dependence on raw materials is formulated from three accounts kept by the United States Bureau of the Census and

Table 5. Rank correlation coefficients and levels of significance by industry for tests between regional concentration ranks and regional demand ranks

SIC Industry Classification	Kendall's τ	Level of Significance
201	.611	.025
202	.833	.001
203	.889	.001
204	.555	.025
205	.778	.005
206	-.555	n.s.
207	.722	.005
208	.778	.005
209	.778	.005
225	.444	.100
228	.000	n.s.
229	.333	.200
231	.555	.025
232	.389	.100
233	.722	.005
234	.389	.100
236	.389	.100
238	.555	.025
239	.722	.005
243	.722	.005
244	.278	.200
249	.611	.025
251	.500	.050
252	.722	.005
253	.722	.005
265	.833	.001
273	.722	.005
278	.778	.005
279	.833	.001
283	.611	.025
284	.778	.005
285	.833	.001
287	.333	.200
295	.833	.001
299	.666	.010
314	.278	.200
317	.278	.200
322	.555	.025
325	.500	.050
326	.611	.025
327	.778	.005
329	.666	.010
332	.611	.025

Table 5 (continued)

SIC Industry Classification	Kendall's τ	Level of Significance
333	-.166	n.s.
335	.333	.200
339	.389	.100
342	.555	.025
343	.611	.025
344	.889	.001
346	.666	.010
348	.722	.005
349	.500	.050
351	.167	n.s.
352	.500	.050
353	.555	.025
354	.555	.025
355	.666	.010
356	.611	.025
357	.389	.100
362	.666	.010
366	.555	.025
369	.611	.025
371	.666	.010
372	.500	.050
373	.222	n.s.
384	.389	.100
391	.444	.100
394	.889	.001
395	.722	.005
396	.500	.050
399	.722	.005

Table 6. Comparison of results between full sample tests and non-market oriented tests: South

Explanatory Variable	Concentration Ratios	Sample Size	Sign Hypothesized	τ	Level of Significance
Labor Productivity	$\frac{C_s}{C_n}$	71	+	-.199	5%
Labor Productivity	$\frac{C_s}{C_n}$	41	+	-.193	10%
Average Labor Cost	$\frac{C_s}{C_n}$	71	-	+.136	10%
Average Labor Cost	$\frac{C_s}{C_n}$	41	-	+.144	n.s.
$\frac{K_G}{L}$	$\frac{v_s^i}{V_N^i}$	71	-	+.078	n.s.
$\frac{K_G}{L}$	$\frac{v_s^i}{V_N^i}$	41	-	+.037	n.s.

published in the *Census of Manufactures*.[3] One measure of the value of output for a final consumption good is the "value of shipments." This concept is defined as "received or receivable net selling values, f.o.b. plant, after discounts and allowances, and excluding freight charges and excise taxes."[4]

To find the net contribution of any one industry, that is, its value added, an account of that industry's cost of materials is required. Included in the cost of materials account are total delivered costs of all raw materials, semifinished goods, parts, components, scrap, containers, supplies, electrical energy, fuel, and contract work.[5] Subtracting the cost of materials from the value of shipments yields value added.

Using data from the *Census of Manufactures, 1958*, ratios of value added to value of shipments are computed. These ratios, hereafter called coefficients of resource dependency, indicate the percentage of value of shipments by an industry attributable to value added. Hence, the lower the ratio, the more dependent the industry is on external resources.

In Table 7, industries for which data were available

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[3]U.S. Bureau of the Census, *Census of Manufactures*, Vol. I, 1958.

[4]*Ibid*., p. 11.

[5]*Ibid*.

Table 7. List of industries in ascending order according to the coefficient of resource dependency

SIC Industry Classification	Coefficient of Resource Dependency	SIC Industry Classification	Coefficient of Resource Dependency
201	.157	353	.505
206 S	.230	317 N	.507
209 S	.257	391 N	.510
204	.269	369	.517
202	.284	205	.518
287 S	.301	372	.523
203	.342	349	.525
228 S	.349	394	.525
335	.360	314	.530
229 S	.362	396 N	.538
299	.364	253	.541
295	.369	395	.545
239	.380	329	.547
207	.394	373 S	.547
243	.410	355	.551
265	.418	284	.563
232 S	.421	356 N	.564
244 S	.427	357 N	.575
285	.429	342 N	.585
344	.448	384 N	.585
233	.451	332	.588
236	.452	362	.593
234	.465	252	.598
238	.465	273	.606
327 S	.467	322	.646
249	.468	354 N	.648
339 N	.476	278	.663
251 S	.483	326	.677
343	.487	325	.680
231	.496	283 N	.703
		279	.834

S denotes one of the ten industries with highest concentration in the South.

N denotes one of the ten industries with highest concentration in the non-South.

are listed in ascending order according to the coefficient of resource dependency. If the earlier considered relation between dependency on raw materials and concentration holds, we should hypothesize that industries highly concentrated in either region would tend to cluster at the end of the industry rankings where cost of materials were the highest percentage of value of shipments, that is, at low values of the coefficient of resource dependency. This does not occur, and in fact the distribution is quite evenly spread.

An interesting pattern developed, however. Those industries with relatively high concentration in the South had a tendency to cluster at the low end of the ranking, while the reverse is true for those industries with relatively high concentration in the non-South. To further analyze this pattern, a rank correlation test between relative concentration ratios, $\frac{C_s}{C_n}$, and coefficients of resource dependency was made.

This test seems warranted for the following reason. Some output is produced in all industries in the South despite some comparative disadvantages in terms of labor productivity and labor costs. A high dependency on raw materials purchased from external sources might be the overriding influence. Thus, an industry at a disadvantage in terms of labor productivity in the South may depend enough on materials available in the South that the industry may be highly concentrated in the South. If this is true, a negative relation would exist between relative concentration ratios and coefficients of resource dependency. And in fact, the rank correlation coefficient was -.365, significant at $P \leq .0001$, indicating that those industries more dependent on raw materials tend to be concentrated in the South.

Regression Analysis

To this point, several empirical variables have been suggested as explanatory factors in the determination of relative industry concentration between the South and the non-South. In order to see the interaction of these variables, and to compare further the South with New England, multiple regression analysis was undertaken. The variables included were: relative concentration ratios for the South and New England, percentage changes in concentration ratios between 1947 and 1958 for the South and New England, average labor cost ratios, labor productivity ratios, and coefficients of resource dependency. The static and dynamic concentration variables are, of course, the dependent variables.

Regression equations and results for the South are listed in Table 8. The test of significance for the regression coefficient is a test of the null hypothesis that $b_i=0$; that is, that the independent variable, X_i, does not account for any variation in Y, the dependent variable. A criterion of significance of $P \leq .10$ is used to reject the null hypothesis.

Table 8. Regression variables, equations, and results for Modified Classical Model: South

Variables: Y_1 Relative concentration ratios, $\frac{C_s}{C_n}$

Y_2 Percentage change in relative concentration, 1947-1958

X_1 Average labor cost ratios

X_2 Labor productivity ratios

X_3 Coefficient of resource dependency

Matrix of Simple Correlations:

Y_1	1.00000				
Y_2	-0.33037	1.00000			
X_1	0.10703	0.00580	1.00000		
X_2	-0.17319	0.11913	-0.60510	1.00000	
X_3	-0.35518	0.15228	-0.30866	0.36897	1.00000
	Y_1	Y_2	X_1	X_2	X_3

Equation I:

$$Y_1 = b_o + b_1X_1+b_3X_3+e_1$$

$r^2 = .1262$

Standard error of estimate = 1.4465

Regression coefficients (standard errors)

$\hat{b}_1 = -0.0310$ (1.6585)

$\hat{b}_3 = -4.1149$ (1.7738)

t test for regression coefficients

b_1 : .985 level of significance

b_3 : .025 level of significance

Table 8 (continued)

Partial correlation coefficients

$X_1 = -0.00292$

$X_3 = -0.34064$

Equation II:

$Y_1 = a_o+a_2X_2+a_3X_3+e_2$

$r^2 = .1282$

Standard error of estimate = 1.44484

Regression coefficients (standard errors)

$\hat{a}_2 = -0.67112$ (2.1583)

$\hat{a}_3 = -3.89663$ (1.8131)

t test for regression coefficients

a_2: .757 level of significance

a_3: .038 level of significance

Partial correlation coefficients

$X_2 = -0.04851$

$X_3 = -0.31820$

Equation III:

$Y_2 = d_o+d_1X_1+d_3X_3+e_3$

$r^2 = .0263$

Standard error of estimate = 109.892

Regression coefficients (standard errors)

$\hat{d}_1 = 45.38514$ (125.9972)

$\hat{d}_3 = 141.63216$ (134.7502)

Table 8 (continued)

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t test for regression coefficients

d_1: .721 level of significance

d_3: .299 level of significance

Partial correlation coefficients

X_1 = .05617

X_2 = .16198

Equation IV:

$$Y_2 = g_o + g_2X_2 + g_3X_3 + e_4$$

r^2 = .0278

Standard error of estimate = 109.807

Regression coefficients (standard errors)

$\hat{g}_2$ = 72.14239 (164.02995)

$\hat{g}_3$ = 104.28977 (137.79403)

t test for regression coefficients

g_2: .662 level of significance

g_3: .453 level of significance

Partial correlation coefficients

X_2 = .06853

X_3 = .11738

As in the rank correlation tests, neither average labor cost ratios nor labor productivity ratios can be said to be important factors in determining relative industry location, and the null hypothesis is not rejected in either case. The coefficient of resource dependency, however, is a significant variable and the null hypothesis can be rejected with a high degree of significance.

In seeking an explanation for the change in relative concentration, none of the variables included make a significant contribution. This is interesting from the standpoint that results of earlier rank correlation tests indicated that average labor costs had a significant rank correlation with concentration changes. Such contradictory results also appear in regression analysis for New England using the Classical variables (see Table 9).

The two types of tests do not, of course, have to yield the same results. Maurice Kendall, the pioneer in rank correlation methods, states that "by a replacement [of variates] with ranks we effectively standardize the scale of the variate and fix the mean, a procedure which might in some instances lead us astray."[6] In this instance, the difference in assumptions for the two tests leads to different results.

The rank correlation test is non-parametric, that

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[6]Maurice G. Kendall, Rank Correlation Methods (New York: Hafner Publishing, 1955), p. 125.

is, it makes no assumptions about the distribution of the sample variables. Consequently, the range and distribution of the variables is unimportant. In regression analysis, however, the distribution of the dependent variable is important. For example, let the independent variable change in small proportions and in an even way. If the dependent variable for the same observation changes in a very volatile manner so that the deviations from the mean will be much larger, a regression test will suggest that the independent variable has little explanatory power. Indeed, the standard error of the estimated regression coefficient is $\sqrt{\frac{S^2}{\Sigma x_i'^2}}$ where S^2 is the variance of residuals and Σx_i^2 is variation of the regressor. If the latter is relatively small, $S_{\hat{b}}$ is quite large and the regression coefficient will not be significant. In a rank correlation test, however, this would make no difference.

In the regression variables used, the percentage changes in relative industry concentration are often very large. But the industry variation in labor productivity or labor cost ratios is comparatively small. In view of these considerations, the rank correlation test may be the more appropriate method of determining the role of relative labor productivity or labor cost. In summary, the substantive empirical contribution of the regression analysis is confirmation of the importance of resource dependency.

The relation between the coefficient of resource dependency and concentration suggests that the dominant basis for initial location of an industry may be the source of raw materials. Once the nation's location pattern is established according to these "natural" conditions, however, relative regional growth rates of industries depend upon relative average labor costs between regions.

As in previous chapters, a comparison between the South and New England yields some interesting results. Because New England concentration could be explained by relative labor productivity ratios and by the combination of factor abundance and intensity, it might be expected that the coefficient of resource dependency would have little influence on relative concentration in New England. This is confirmed by evidence that there exists an inverse relation between an industry's dependency on raw materials and its relative concentration in New England. A rank correlation test between the two variables shows a positive coefficient, +.187, significant at the 5 percent level.

Regression analysis for New England using Classical variables fails to indicate any explanatory variable for static concentration. For changes in concentration, however, average labor cost ratios are shown to be weakly significant, while labor productivity ratios are highly significant. These results are shown in Table 9.

Regression analysis was also undertaken using the

Table 9. Regression variables, equations, and results for Modified Classical Model: New England

Variables: Y_1 Relative concentration ratios, $\frac{C_{ne}}{C_{nne}}$

Y_2 Percentage change in relative concentration, 1947-1958

X_1 Average labor cost ratios

X_2 Labor productivity ratios

X_3 Coefficient of resource dependency

Matrix of Simple Correlations:

Y_1	1.00000				
Y_2	-0.00896	1.00000			
X_1	0.14956	-0.23674	1.00000		
X_2	0.09112	0.43615	-0.74894	1.00000	
X_3	0.16600	0.13822	-0.02961	0.04423	1.00000
	Y_1	Y_2	X_1	X_2	X_3

Equation I:

$$Y_1=b_o+b_1X_1+b_3X_3+e_1$$

$r^2 = 0.0514$

Standard error of estimate = 1.9202

Regression coefficients (standard errors)

$\hat{b}_1 = 2.7461\ (2.6703)$

$\hat{b}_3 = 2.6441\ (2.3305)$

t test for regression coefficients

b_1 : .310 level of significance

b_3 : .263 level of significance

Table 9 (continued)

Partial correlation coefficients

$X_1 = 0.15672$

$X_3 = 0.17244$

Equation II:

$Y_1=a_o+a_2X_2+a_3X_3+e_2$

$r^2 = 0.0346$

Standard error of estimate = 1.9372

Regression coefficients (standard errors)

$\hat{a}_2 = 1.4223$ (2.5715)

$\hat{a}_3 = 2.5156$ (2.3524)

t test for regression coefficients

a_2 : .583 level of significance

a_3 : .291 level of significance

Partial correlation coefficients

$X_2 = 0.08503$

$X_3 = 0.16281$

Equation III:

$Y_2=d_o+d_1X_1+d_3X_3+e_3$

$r^2 = 0.0733$

Standard error of estimate = 71.9467

Regression coefficients (standard errors)

$\hat{d}_1 = -156.7754$ (100.0539)

$\hat{d}_3 = 77.1648$ (87.3213)

Table 9 (continued)

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t test for regression coefficients

d_1 : .125 level of significance

d_3 : .382 level of significance

Partial correlation coefficients

$X_1 = -0.23501$

$X_3 = 0.13511$

Equation IV:

$Y_2 = g_o+g_2X_2+g_3X_3+e_4$

$r^2 = 0.2044$

Standard error of estimate = 66.6628

Regression coefficients (standard errors)

$\hat{g}_2 = 276.7611$ (88.4902)

$\hat{g}_3 = 70.0165$ (80.9520)

t test for regression coefficients

g_2 : .003 level of significance

g_3 : .392 level of significance

Partial correlation coefficients

$X_2 = 0.43463$

$X_3 = 0.13229$

variables from the earlier Heckscher-Ohlin model tests for both the South and New England. The variables included are: concentration ratios, $\frac{V_s^i}{V_N^i}$ and $\frac{V_{ne}^i}{V_N^i}$, percentage changes in these ratios for the period 1947-1958, gross capital-labor ratios, net capital-labor ratios, and coefficients of resource dependency. The results are shown in Tables 10 and 11.

The regression results lend strong support to the conclusions reached by the application of rank correlation tests to the Heckscher-Ohlin model. For the South, the coefficient of resource dependency plays a significant role ($P \leq .025$) in determining relative industrial concentration, while factor proportions had no significant influence. These two variables reversed roles, however, when changes in concentration for the South were considered. That is, the coefficient of resource dependency had no apparent effect on the determination of industrial growth in the South between 1947 and 1958, while factor proportions were the primary influence.

For New England, the existing industrial structure of 1958 had been established according to the factor proportion hypothesis, and the coefficient of resource dependency had no significant effect. Neither variable, however, offered any significant explanation for changes in concentration for New England prior to 1958. This is as one would expect due to the essentially equilibrium status of the New England industrial structure for the period of 1947 to 1958.

Table 10. Regression variables, equations, and results for Modified Heckscher-Ohlin Model: South

Variables: Y_1 Concentration ratios, $\frac{v_s^i}{V_N^i}$

Y_2 Percentage change in concentration, 1947-1958

X_1 National gross capital-labor ratios

X_2 National net capital-labor ratios

X_3 Coefficient of resource dependency

Matrix of Simple Correlations:

Y_1	1.00000				
Y_2	-0.34411	1.00000			
X_1	0.17356	-0.38169	1.00000		
X_2	0.18353	-0.37543	0.97003	1.00000	
X_3	-0.37292	0.19507	-0.28996	-0.24714	1.00000
	Y_1	Y_2	X_1	X_2	X_3

Equation I:

$Y_1=b_o+b_1X_1+b_3X_3+e_1$

$r^2 = 0.1437$

Standard error of estimate = 0.10889

Regression coefficients (standard errors)

$\hat{b}_1 = 0.00266\ (0.00562)$

$\hat{b}_3 = -0.32211\ (0.13809)$

t test for regression coefficients

b_1:.639 level of significance

b_3:.025 level of significance

Tabl

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Table 10 (continued)

Partial correlation coefficients

$X_1 = 0.07368$

$X_3 = -0.34227$

Equation II:

$Y_1=a_o+a_2X_2+a_3X_3+e_2$

$r^2 = 0.1480$

Standard error of estimate = 0.10862

Regression coefficients (standard errors)

$\hat{a}_2 = 0.00661$ (0.01011)

$\hat{a}_3 = -0.31906$ (0.13606)

t test for regression coefficients

a_2:.517 level of significance

a_3:.024 level of significance

Partial correlation coefficients

$X_2 = 0.10162$

$X_3 = -0.34389$

Equation III:

$Y_2=d_o+d_1X_1+d_3X_3+e_3$

$r^2 = 0.1535$

Standard error of estimate = 77.18056

Regression coefficients (standard error)

$\hat{d}_1 = -9.41801$ (3.98350)

$\hat{d}_3 = 60.07074$ (97.88109)

Table 10 (continued)

t test for regression coefficients

d_1: .023 level of significance

d_3: .543 level of significance

Partial correlation coefficients

$X_1 = -0.34638$

$X_3 = 0.09541$

Equation IV:

$Y_2 = g_o + g_2 X_2 + g_3 X_3 + e_4$

$r^2 = 0.1521$

Standard error of estimate = 77.24309

Regression coefficients (standard errors)

$\hat{g}_2 = -16.88451$ (7.19023)

$\hat{g}_3 = 71.02057$ (96.75331)

t test for regression coefficients

g_2: .024 level of significance

g_3: .467 level of significance

Partial correlation coefficients

$X_2 = -0.34431$

$X_3 = 0.11389$

Table 11. Regression variables, equations, and results for Modified Heckscher-Ohlin Model: New England

Variables: Y_1 Concentration ratios, $\frac{v^i_{ne}}{V^i_N}$

Y_2 Percentage change in concentration, 1947-1958

X_1 National gross capital-labor ratios

X_2 National net capital-labor ratios

X_3 Coefficients of resource dependency

Matrix of Simple Correlations:

Y_1	1.00000				
Y_2	0.08311	1.00000			
X_1	-0.34518	-0.18050	1.00000		
X_2	-0.31800	-0.16341	0.97003	1.00000	
X_3	0.16128	0.21073	-0.28996	-0.24714	1.00000
	Y_1	Y_2	X_1	X_2	X_3

Equation I:

$Y_1=b_o+b_1X_1+b_3X_3+e_1$

$r^2 = 0.1232$

Standard error of estimate = 0.081832

Regression coefficients (standard errors)

$\hat{b}_1 = -0.00900\ (0.00422)$

$\hat{b}_3 = 0.04538\ (0.10378)$

t test for regression coefficients

b_1: .039 level of significance

b_3: .664 level of significance

Table 11 (continued)

Partial correlation coefficients

$X_1 = -0.31595$

$X_3 = 0.06813$

Equation II:

$Y_1 = a_o + a_2X_2 + a_3X_3 + e_2$

$r^2 = 0.1084$

Standard error of estimate = 0.08252

Regression coefficients (standard errors)

$\hat{a}_2 = -0.01495$ (0.00768)

$\hat{a}_3 = 0.05982$ (0.10336)

t test for regression coefficients

a_2: .058 level of significance

a_3: .566 level of significance

Partial correlation coefficients

$X_2 = -0.29085$

$X_3 = 0.09001$

Equation III:

$Y_2 = d_o + d_1X_1 + d_3X_3 + e_3$

$r^2 = 0.0600$

Standard error of estimate = 57.89128

Regression coefficients (standard errors)

$\hat{d}_1 = -2.46176$ (2.98793)

$\hat{d}_3 = 80.24545$ (73.41825)

Table 11 (continued)

t test for regression coefficients

d_1: .415 level of significance

d_3: .281 level of significance

Partial correlation coefficients

$X_1 = -0.12762$

$X_3 = 0.16826$

Equation IV:

$Y_2 = g_o + g_2X_2 + g_3X_3 + e_4$

$r^2 = 0.0576$

Standard error of estimate = 57.96398

Regression coefficients (standard errors)

$\hat{g}_2 = -4.089085$ (5.39562)

$\hat{g}_3 = 84.18623$ (72.60463)

t test for regression coefficients

g_2: .453 level of significance

g_3: .253 level of significance

Partial correlation coefficients

$X_2 = -0.11754$

$X_3 = 0.17819$

The combinations of all tests indicate that relatively highly concentrated industries in New England, unlike those in the South, do not rely on external sources of raw materials and therefore their location is based on labor productivity advantages and a combination of relative factor abundance with relative factor intensity.

The conclusion from the work undertaken in this chapter is that the two models of comparative advantage are insufficient to predict regional industrial location patterns in all cases. There seem to be two dominant reasons. First, the assumption of costless trade, including zero transportation costs, does not hold between regions. Second, it has been confirmed empirically that additional factors besides labor costs, labor productivity, or factor proportions, exert a significant influence. In particular, it has been shown that the coefficient of resource dependency is a crucial determinant of industrial location in the South.

CHAPTER V

SUMMARY AND CONCLUSIONS

The goal of the research undertaken in this dissertation has been to test empirically the Heckscher-Ohlin and Classical trade models. The uniqueness of these tests is that United States regional data were employed rather than international data. There were several reasons for undertaking regional tests. First, with the exception of one case, all previous empirical tests of the Heckscher-Ohlin model have used international data. In addition, there has not been intensive regional testing of the Classical model.

Second, certain assumptions of the two models are more closely approximated when regional data are used. For example, free trade between trade areas is realized and the condition of zero transportation costs is more closely approached. In addition, the possibility of factor intensity reversal, a potentially serious hazard to testers of the Heckscher-Ohlin model, seems to be eliminated using United States interregional data.

One potential problem encountered in using regional data is that trade flows between regions are not available. Relative industry concentration is therefore used as a proxy. Industry concentration should be a good indicator of which industries possess comparative advantages since both models suggest a trend toward specialization within each region for such industries. Two sets of comparative regions were used: South-non-South and New England-non-New England.

Incorporating the regional approach into the two models, they could be stated in a form leading directly to empirically testable hypotheses. The Heckscher-Ohlin model brings together a combination of relative factor endowments and relative factor intensity in production as determinants of comparative advantage. Specifically, the model predicts that a region tends to specialize in producing those goods requiring intensively the use of the relatively abundant factor of that region.

Studies showing that relative wages are lower in the South constitutes presumptive evidence that the South is relatively labor abundant. It should therefore possess a comparative advantage in the production of labor intensive goods; that is, goods whose production requires a relatively low capital-labor ratio. Stated as an empirically testable hypothesis: industry rankings of concentration in the South will be negatively correlated with industry capital-labor ratios.

The Classical model, resting on the labor theory of value, bases comparative advantage on relative labor productivity advantage. With the inclusion of wages, the determinant of comparative advantage becomes relative average labor cost. Both labor variables were considered in the study, the empirically testable hypotheses being that ratios of labor productivity in the South to that in the non-South will be positively correlated with concentration in the South, while South-non-South average labor cost ratios will be negatively correlated with concentration in the South.

Two measures of production concentration were used. The first is the same as was used in testing the Heckscher-Ohlin hypothesis. The second is a ratio of the percent of total value added in the South contributed by each industry, to the percent of total value added in the non-South contributed by each corresponding industry. Data for all variables were obtained from the Census of Manufactures, 1958.

Tests of the above hypotheses permit the following tentative conclusions. Both models failed to predict industry concentration in the South. In fact, rank correlation coefficients were of a sign opposite of that hypothesized. These coefficients were not significant for the Heckscher-Ohlin hypotheses, but significant for the Classical tests. These results held in the full sample of 71 industries.

For New England, using a sample of 68 industries, both models predicted with tolerable precision the relative industry concentration. Tests of the Heckscher-Ohlin hypothesis, using both gross and net capital, yielded coefficients of the hypothesized sign and significant at $P \leq .01$.

For the Classical hypotheses, the rank correlation coefficient is also significant at $P \leq .01$ when labor productivity is used. In tests using average labor costs, the coefficient was not significant, but was of the hypothesized sign.

The difference in test results between the two regions was attributed essentially to one basic difference in the characteristics of the two regions. The South has been experiencing during the past three decades very rapid industrial development relative to the rest of the nation. It therefore does not have a sufficiently well established equilibrium industrial structure within which the two models can be properly tested. New England, on the other hand, is much more nearly in an equilibrium state for the postulated tests.

The unique characteristic of the South does not mean that the tests and subsequent analysis of that region is irrelevant. To the contrary, it has prompted the search for other variables which might determine comparative advantage and has led to some important conclusions concerning the applicability of the two models and concerning the nature of regional industrial growth.

The basic industrial structure of the South appears to be a function of the location of sources of raw materials. Thus, industries with a relatively high degree of dependence on external sources of raw materials are more highly concentrated in the South. The rank correlation coefficient

between the coefficient of resource dependency and relative concentration in the South is significant at $P \leq .0001$.

It is important to note, however, that recent (1947-1958) changes in relative concentration in the South have taken place in a pattern so as to suggest the eventual establishment of an industrial structure as predicted under the two models. For example, the rank correlation coefficient between gross capital-labor ratios and the percentage changes in relative concentration is of the hypothesized sign and significant at $P \leq .005$. The evidence is strong that the industries experiencing relatively higher growth rates in the labor abundant South are those with relatively low capital-labor ratios. The same relatively higher growth rates also hold for industries with labor cost advantages, although the level of significance is somewhat lower.

The results of the rank correlation tests are, for the most part, strongly substantiated by multiple regression analysis. This is particularly true when the Heckscher-Ohlin model variables were considered for both the South and New England. The variables which were significant in the rank correlation tests have regression coefficients also significant at the $P \leq .10$ level.

Two broad conclusions can be drawn from these tests. First, an already industrially developed region can be expected to display patterns of specialization in those industries which have a comparative advantage with respect to labor productivity as well as those industries whose production functions require more of the relatively abundant factor of that region.

Second, for a newly developing region, initial attraction of industries is likely to be based directly on sources of raw materials and on the endowment of natural resources of that region. As development proceeds, however, there will be a relatively higher growth in those industries which can achieve a comparative advantage based on labor productivity or on intensive utilization of the relatively abundant and therefore relatively cheap factor of production.

Further work along these lines should be interesting. At present, the models of regional comparative advantage are not complete. But the empirical results in this thesis suggest some avenues for increased theoretical sophistication. In addition, some of the empirical procedures developed in this thesis might be applied with some success to international statistics.

The principal finding of this study seems to be a confirmation that the basic trade models do have relevance to regional location analysis. An additional variable, the coefficient of resource dependency, was incorporated into the models and found to be a relevant factor. Although this is a step forward in the inclusion of the influence of natural resources into trade models, an explicit and rigorously formulated theoretical model is still lacking. This area would seem to be a fruitful one for future research.

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APPENDICES

APPENDIX I

STANDARD INDUSTRIAL CLASSIFICATION OF 71 THREE-DIGIT INDUSTRIES

		Heckscher-Ohlin Tests					Classical Model Tests							
SIC Code	Industry Title[a]	Static South-non-South Tests	% Change in South Tests	Non-market Oriented in South	Static New England non-New England Tests	% Change in New England Tests	Static South-non-South Tests	% Change in South Tests	Non-market Oriented Tests	60% Labor Intensive Tests	50% Labor Intensive Tests	Static New England-non-New England Tests	% Change in New England Tests	SIC Code
201	Meat products	•	•		•	•	•	•			•	•	•	201
202	Dairies	•	•	•	•	•	•	•	•			•	•	202
203	Canned and frozen foods	•	•	•	•	•	•	•	•			•	•	203
204	Grain mills	•	•		•	•	•	•				•	•	204
205	Bakery products	•	•	•	•	•	•	•	•			•	•	205
206	Sugar	•	•				•	•						206
207	Candy and related products	•	•	•	•		•	•	•			•		207
208	Beverages	•	•	•	•	•	•	•	•			•	•	208
209	Miscellaneous foods and kindred products	•	•	•	•	•	•	•	•			•	•	209
225	Knitting mills	•	•		•	•	•	•			•	•	•	225
228	Yarn and thread mills	•	•		•		•	•			•	•		228
229	Miscellaneous textile goods	•	•		•	•	•	•				•	•	229
231	Men's and boys' suits and coats	•	•		•	•	•	•		•	•	•	•	231
232	Men's and boys' furnishings	•	•		•	•	•	•		•	•	•	•	232
233	Women's and misses' outerwear	•	•	•	•	•	•	•	•	•	•	•	•	233
234	Women's and children's underwear	•	•		•	•	•	•				•	•	234
236	Children's outerwear	•	•		•	•	•	•		•	•	•	•	236
238	Miscellaneous apparel	•	•		•	•	•	•		•	•	•	•	238
239	Fabricated textiles, n.e.c.	•	•	•	•	•	•	•	•		•	•	•	239
243	Millwork and related products	•	•	•	•	•	•	•	•	•	•	•	•	243
244	Wooden containers	•	•		•	•	•	•		•	•	•	•	244
249	Miscellaneous wood products	•	•		•	•	•	•			•	•	•	249
251	Household furniture	•	•		•	•	•	•			•	•	•	251
252	Office furniture	•	•	•	•	•	•	•	•			•	•	252
253	Public building furniture	•		•	•		•		•	•	•	•		253
265	Paperboard containers and boxes	•	•	•	•	•	•	•	•		•	•	•	265
273	Books	•	•	•	•	•	•	•	•		•	•	•	273
278	Bookbinding and related work	•	•	•	•	•	•	•	•	•	•	•	•	278
279	Printing trades services	•	•	•	•	•	•	•	•			•	•	279
283	Drugs and medicines	•			•		•					•		283
284	Cleaning and toilet goods	•	•	•	•	•	•	•	•			•	•	284
285	Paint and allied products	•	•	•	•	•	•	•	•			•	•	285
287	Agricultural chemicals	•	•		•	•	•	•				•	•	287
295	Paving and roofing materials	•	•	•	•		•	•	•			•		295
299	Petroleum and coal products, n.e.c.	•	•	•	•	•	•	•	•			•	•	299
314	Footwear, except rubber	•	•		•	•	•	•			•	•	•	314
317	Purses and small leather goods	•	•		•	•	•	•				•	•	317
322	Pressed and blown glassware	•	•				•	•						322
325	Structural clay products	•	•		•	•	•	•			•	•	•	323
326	Pottery and related products	•	•		•	•	•	•		•	•	•	•	326
329	Nonmetallic mineral products	•	•	•	•		•	•	•			•		329
327	Concrete and plaster products	•	•	•	•	•	•	•	•			•	•	327
332	Iron and steel foundries	•	•		•	•	•	•		•	•	•	•	332
333	Primary nonferrous metals	•	•				•	•						333
335	Nonferrous rolling and drawing	•			•		•				•	•		335
339	Primary metal industries, n.e.c.	•			•		•				•	•		339
342	Cutlery, hand tools, hardware	•	•		•	•	•	•				•	•	342
343	Plumbing and heating, except electric	•	•		•	•	•	•			•	•	•	343
344	Structural metal products	•	•	•	•	•	•	•	•	•	•	•	•	344
346	Metal stampings	•	•	•	•	•	•	•	•			•	•	346
348	Fabricated wire products, n.e.c.	•	•	•	•	•	•	•	•			•	•	348
349	Fabricated metal products, n.e.c.	•	•		•	•	•	•			•	•	•	349
351	Engines and turbines	•			•	•	•			•	•	•	•	351
352	Farm machinery and equipment	•	•		•	•	•	•			•	•	•	352
353	Construction and like equipment	•	•		•	•	•	•			•	•	•	353
354	Metalworking machinery	•			•		•				•	•		354
355	Special industry machinery	•	•	•	•	•	•	•	•		•	•	•	355
356	General industrial machinery	•			•		•				•	•		356
357	Office machines, n.e.c.	•			•	•	•					•	•	357
362	Electrical industrial apparatus	•		•	•		•		•			•		362
366	Communication equipment	•			•		•				•	•		366
369	Electrical products, n.e.c.	•			•		•					•		369
371	Motor vehicles and equipment	•		•	•		•		•			•		371
372	Aircraft and parts	•			•		•			•	•	•		372
373	Ship and boat building	•	•		•	•	•	•		•	•	•	•	373
384	Medical instruments and supplies	•	•		•	•	•	•				•	•	384
391	Jewelry and silverware	•	•		•	•	•	•		•	•	•	•	391
394	Toys and sporting goods	•	•	•	•	•	•	•	•		•	•	•	394
395	Pens, pencils, and office supplies	•	•	•	•	•	•	•	•			•	•	395
396	Costume jewelry and notions	•			•	•	•					•	•	396
399	Miscellaneous manufactures	•	•	•	•	•	•	•	•		•	•	•	399

[a]SIC code and industry title from Census of Manufactures, 1958
U.S. Department of Commerce, Bureau of Census.

APPENDIX II

LIST OF RANKINGS, IN ASCENDING ORDER, OF VARIABLES FOR EACH HECKSCHER-OHLIN TEST

Table 1. Ranks of gross capital-labor ratios and concentration ratios, $\frac{V_S^i}{V_N^i}$, for the South

SIC Code	Gross Capital-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Gross Capital-Labor Ratio Ranks	Concentration Ratio Ranks
233	1	18	356	36	8
317	2	3	207	37	24
236	3	42	353	38	43
232	4	67	342	39	10
231	5	44	369	40	19
314	6	31	355	41	32
238	7	34	203	42	46
234	8	57	332	43	39
239	9	45	229	44	58.5
372	10	33	343	45	38
394	11	21	265	46	41
278	12	22	354	47	4
391	13	2	228	48	71
396	14	7	351	49	1
251	15	64	322	50	55
244	16	68	357	51	6
399	17	25	352	52	20
249	18	56	325	53	61
253	19	49.5	349	54	36
366	20	27	202	55	52
225	21	66	339	56	5
279	22	23	299	57	30
373	23	65	371	58	15
243	24	47	329	59	28
395	25	29	285	60	37
384	26	9	204	61	49.5
252	27	14	283	62	12
344	28	48	327	63	62
273	29	13	209	64	58.5
362	30	16	335	65	35
205	31	53	284	66	17
348	32	26	208	67	60
326	33	40	295	68	54
346	34	11	287	69	70
201	35	51	206	70	63
			333	71	69

Table 2. Ranks of net capital-labor ratios and concentration ratios, $\frac{v_s^i}{V_N^i}$, for the South

SIC Code	Net Capital-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Net Capital-Labor Ratio Ranks	Concentration Ratio Ranks
233	1	18	369	36	19
236	2	42	346	37	11
317	3	3	356	38	8
231	4	44	353	39	43
232	5	67	355	40	32
238	6	34	201	41	51
314	7	31	351	42	1
234	8	57	354	43	4
239	9	45	343	44	38
394	10	21	332	45	39
372	11	33	203	46	46
391	12	2	229	47	58.5
244	13	68	228	48	71
278	14	22	352	49	20
396	15	7	322	50	55
249	16	56	265	51	41
279	17	23	299	52	30
251	18	64	325	53	61
225	19	66	202	54	52
399	20	25	349	55	36
373	21	65	357	56	6
253	22	49.5	339	57	5
366	23	27	329	58	28
243	24	47	285	59	37
395	25	29	371	60	15
273	26	13	209	61	58.5
384	27	9	204	62	49.5
205	28	53	335	63	35
344	29	48	327	64	62
362	30	16	283	65	12
326	31	40	208	66	60
348	32	26	295	67	54
252	33	14	284	68	17
207	34	24	287	69	70
342	35	19	206	70	63
			333	71	69

Table 3. Ranks of gross capital-weighted labor ratios and concentration ratios, $\frac{v_s^i}{V_N^i}$, for the South

SIC Code	Gross Capital Weighted-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Gross Capital Weighted-Labor Ratio Ranks	Concentration Ratio Ranks
233	1	18	355	36	32
231	2	44	201	37	51
317	3	3	342	38	10
236	4	42	351	39	1
314	5	31	225	40	66
232	6	67	369	41	19
238	7	34	326	42	40
372	8	33	332	43	39
234	9	57	343	44	38
279	10	23	357	45	6
239	11	45	265	46	41
399	12	25	352	47	20
278	13	22	207	48	24
391	14	2	349	49	36
394	15	21	322	50	55
373	16	65	229	51	58.5
366	17	27	339	52	5
253	18	49.5	299	53	30
251	19	64	371	54	15
396	20	7	202	55	52
344	21	48	325	56	61
361	22	16	329	57	28
252	23	14	285	58	37
395	24	29	203	59	46
384	25	9	283	60	12
273	26	13	284	61	17
243	27	47	222	62	71
356	28	8	335	63	35
244	29	68	204	64	49.5
348	30	26	295	65	54
353	31	43	208	66	60
249	32	56	327	67	62
354	33	4	209	68	58.5
205	34	53	287	69	70
346	35	11	206	70	63
			333	71	69

Table 4. Ranks of net capital-weighted labor ratios and concentration ratios, $\frac{V_S^i}{V_N^i}$, for the South

SIC Code	Net Capital Weighted-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Net Capital Weighted-Labor Ratio Ranks	Concentration Ratio Ranks
233	1	18	355	36	32
231	2	44	342	37	10
317	3	3	369	38	19
236	4	42	225	39	66
232	5	67	346	40	11
314	6	31	326	41	40
238	7	34	201	42	51
234	8	57	332	43	39
372	9	33	343	44	38
279	10	23	299	45	30
239	11	45	352	46	20
391	12	2	207	47	24
278	13	22	229	48	58.5
394	14	21	322	49	55
373	15	65	267	50	41
399	16	25	357	51	6
396	17	7	349	52	36
251	18	64	339	53	5
244	19	68	202	54	52
273	20	13	325	55	61
249	21	56	371	56	15
366	22	27	285	57	37
344	23	48	329	58	28
253	24	49.5	203	59	46
361	25	16	335	60	35
384	26	9	222	61	71
395	27	29	283	62	12
243	28	47	204	63	49.5
354	29	4	209	64	58.5
205	30	53	295	65	54
351	31	1	284	66	17
348	32	26	208	67	60
356	33	8	327	68	62
353	34	43	287	69	70
252	35	14	206	70	63
			333	71	69

Table 5. Ranks of gross capital-labor ratios and percentage changes in concentration ratios, $\frac{V_S^i}{V_N^i}$, in the South, 1947-1958

SIC Code	Gross Capital-Labor Ratio Ranks	Percentage Change in Concentration Ratio Ranks	SIC Code	Gross Capital-Labor Ratio Ranks	Percentage Change in Concentration Ratio Ranks
287	55	1	299	46	29
239	9	2	201	30	30
249	16	3	203	35	31
353	32	4	295	54	32
204	49	5.5	278	11	33
243	20	5.5	202	45	34
228	40	7	267	39	35
208	53	8	231	5	36
373	19	9	332	36	37
284	52	10	314	6	38
322	41	11	232	4	39
209	51	12	238	7	40
329	47	13	399	15	41
206	56	14	395	21	42
346	29	15	355	34	43
285	48	16	229	37	44
205	26	17	333	57	45
326	28	18	352	42	46
325	43	19.5	394	10	47
344	24	19.5	384	22	48
327	50	21	252	23	49
391	12	22	348	27	50
343	38	23	233	1	51
225	17	24	342	33	52
207	31	25	349	44	53
251	13	26	317	2	54
279	18	27	234	8	55
244	14	28	273	25	56
			236	3	57

Table 6. Ranks of gross capital-labor ratios and concentration ratios, $\frac{v_s^i}{v_N^i}$, for non-market oriented industries

SIC Code	Gross Capital-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Gross Capital-Labor Ratio Ranks	Concentration Ratio Ranks
317	1	3	342	22	10
236	2	23	369	23	12
232	3	37	332	24	21
231	4	25	229	25	31
314	5	15	343	26	20
238	6	17	354	27	4
234	7	30	228	28	41
372	8	16	351	29	1
391	9	2	322	30	28
396	10	7	357	31	6
251	11	34	352	32	13
244	12	38	325	33	32
249	13	29	349	34	19
366	14	14	339	35	5
225	15	36	204	36	26
373	16	35	283	37	11
384	17	9	335	38	18
326	18	22	287	39	40
201	19	27	206	40	33
356	20	8	333	41	39
353	21	24			

Table 7. Ranks of gross capital-labor ratios and concentration ratios, $\frac{V_{ne}^{i}}{V_{N}^{i}}$, in New England

SIC Code	Gross Capital-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Gross Capital-Labor Ratio Ranks	Concentration Ratio Ranks
233	1	35	201	35	15
317	2	61	356	36	57
236	3	32	207	37	42
232	4	20	353	38	6
231	5	30	342	39	64
314	6	66	369	40	24
238	7	53	355	41	62
234	8	44	203	42	19
239	9	37	332	43	14
372	10	38	229	44	65
394	11	54	343	45	11
278	12	45	267	46	40
391	13	68	354	47	58
396	14	67	228	48	59
251	15	27	351	49	52
244	16	26	357	50	55
399	17	47	352	51	1
249	18	56	325	52	4
253	19	48	349	53	43
366	20	50	202	54	29
225	21	31	339	55	51
279	22	34	299	56	8
373	23	63	371	57	2
243	24	13	329	58	49
395	25	39	285	59	18
384	26	41	204	60	7
252	27	10	283	61	9
344	28	21	327	62	22
273	29	46	209	63	12
362	30	16	335	64	60
205	31	25	284	65	33
348	32	36	208	66	17
326	33	5	295	67	28
346	34	23	287	68	3

Table 8. Ranks of net capital-labor ratios and concentration ratios, $\frac{v_{ne}^{i}}{v_{N}^{i}}$, in New England

SIC Code	Net Capital-Labor Ratio Ranks	Concentration Ratio Ranks	SIC Code	Net Capital-Labor Ratio Ranks	Concentration Ratio Ranks
233	1	35	342	35	64
236	2	32	369	36	24
317	3	61	346	37	23
231	4	30	356	38	57
232	5	20	353	39	6
238	6	53	355	40	62
314	7	66	201	41	15
234	8	44	351	42	52
239	9	37	354	43	58
394	10	54	343	44	11
372	11	38	332	45	14
391	12	68	203	46	19
244	13	26	229	47	65
278	14	45	228	48	59
396	15	67	352	49	1
249	16	56	267	50	40
279	17	34	299	51	8
251	18	27	325	52	4
225	19	31	202	53	29
399	20	47	349	54	43
373	21	63	357	55	55
253	22	48	339	56	51
366	23	50	329	57	49
243	24	13	285	58	18
395	25	39	371	59	2
273	26	46	209	60	12
384	27	41	204	61	7
205	28	25	335	62	60
344	29	21	327	63	22
362	30	16	283	64	9
326	31	5	208	65	17
348	32	36	295	66	28
252	33	10	284	67	33
207	34	42	287	68	3

Table 9. Ranks of gross capital-labor ratios and percentage changes in concentration ratios in New England, 1947-1958

SIC Code	Percentage Change in Concentration Ratio Ranks	Gross Capital-Labor Ratio Ranks	SIC Code	Percentage Change in Concentration Ratio Ranks	Gross Capital-Labor Ratio Ranks
299	1	46	384	27	23
287	2	53	351	28	40
343	3	38	249	29	17
244	4	15	284	30	51
352	5	42	279	31	19
399	6	16	314	32	6
232	7	4	344	33	25
394	8	10	285	34	47
357	9	41	251	35	14
346	10	30	396	36	13
348	11	28	204	37	48
349	12	44	231	38	5
332	13	36	201	39	31
205	14	27	209	40	50
342	15	33	208	41	52
203	16	35	327	42	49
234	17	8	225	43	18
243	18	21	273	44	26
278	19	11	202	45	45
355	20	34	395	46	22
267	21	39	233	47	1
353	22	32	236	48	3
391	23	12	238	49	7
239	24	9	317	50	2
229	25	37	326	51	29
325	26	43	252	52	24
			373	53	20

APPENDIX III

RANK CORRELATION TEST RESULTS FOR THE HECKSCHER-OHLIN MODEL

Explanatory Variable	Concentration Ratios	Sample Size	Sign Hypothesized	τ	Level of Significance
$\frac{K_G}{L}$	$\frac{v_s^i}{V_N^i}$	71	-	+.078	n.s.
$\frac{K_N}{L}$	$\frac{v_s^i}{V_N^i}$	71	-	+.091	n.s.
$\frac{K_G}{L_W}$	$\frac{v_s^i}{V_N^i}$	71	-	+.174	10%
$\frac{K_N}{L_W}$	$\frac{v_s^i}{V_N^i}$	71	-	+.168	10%
$\frac{K_G}{L}$	$\frac{v_s^i}{V_N^i}$	41 non-market oriented	-	+.037	n.s.
$\frac{K_G}{L}$	% change in $\frac{v_s^i}{V_N^i}$	51	-	-.256	.5%
$\frac{K_G}{L}$	$\frac{v_{ne}^i}{V_N^i}$	68	-	-.228	1.0%
$\frac{K_N}{L}$	$\frac{v_{ne}^i}{V_N^i}$	68	-	-.243	.5%
$\frac{K_G}{L}$	% change in $\frac{v_{ne}^i}{V_N^i}$	53	-	-.129	n.s.

APPENDIX IV

LIST OF RANKINGS, IN ASCENDING ORDER, OF VARIABLES FOR EACH CLASSICAL MODEL TEST

Table 1. Ranks of average labor cost ratios and concentration ratios, $\frac{v_s^i}{v_N^i}$, for the South

SIC Code	Average Labor Cost Ratio Ranks	Concentration Ratio Ranks	SIC Code	Average Labor Cost Ratio Ranks	Concentration Ratio Ranks
279	1	25	325	36.5	61
357	2	6	239	36.5	45
362	3	20	265	38	41
333	4	69	299	39	30
371	5	15	251	40	64
396	6	7	205	41	53
354	7	4	335	42	35
317	8	3	228	43.5	71
339	9	5	231	43.5	44
369	10	19	249	45	56
314	11	31	295	46	54
384	12	9	366	47	27
348	13	26	353	48	43
329	14	28	394	49.5	21
283	15	12	225	49.5	66
234	16	57	344	51	48
229	17	58.5	204	52	49.5
342	18	10	209	53.5	58.5
332	19.5	39	284	53.5	17
356	19.5	8	238	55	34
349	21	36	207	56	24
395	22	29	346	57	11
327	23	62	373	58	65
208	24	60	372	59	33
355	25	32	243	60	47
244	26	68	326	61	40
399	27	25	203	62	46
201	28	51	343	63	38
287	29	70	236	64	42
202	30.5	52	233	65	18
285	30.5	37	232	66	67
322	32	55	391	67	2
206	33	63	352	68	20
252	34.5	14	351	69	1
278	34.5	22	273	70	13
			253	71	49.5

Table 2. Ranks of labor productivity ratios and concentration ratios, $\frac{v_s^i}{v_N^i}$, for the South

SIC Code	Productivity Ratio Ranks	Concentration Ratio Ranks	SIC Code	Productivity Ratio Ranks	Concentration Ratio Ranks
273	1	13	373	36	65
243	2	47	284	37	17
253	3	49.5	342	38	10
351	4	1	395	39	29
225	5	66	202	40	52
203	6	46	279	41	23
233	7	18	372	42	33
391	8	2	355	43	32
207	9	24	394	44	21
204	10	49.5	399	45	25
232	11	67	332	46	39
236	12	42	231	47	44
209	13	58.5	205	48	53
201	14	51	265	49	41
238	15	34	283	50	12
343	16	38	317	51	3
249	17	56	278	52	22
326	18	40	285	53	37
229	19	58.5	322	54	55
244	20	68	353	55	43
352	21	20	348	56	26
251	22	64	329	57	28
325	23	61	356	58	8
299	24	30	366	59	27
252	25	14	314	60	31
208	26	60	234	61	57
228	27	71	354	62	4
327	28	62	335	63	35
344	29	48	349	64	36
239	30	45	396	65	7
295	31	54	339	66	5
287	32	70	371	67	15
206	33	63	369	68	19
384	34	9	362	69	16
346	35	11	357	70	6
			333	71	69

Table 3. Ranks of average labor cost ratios and relative concentration ratios, $\frac{C_s}{C_n}$, for the South

SIC Code	Average Labor Cost Ratio Ranks	Relative Concentration Ratio Ranks	SIC Code	Average Labor Cost Ratio Ranks	Relative Concentration Ratio Ranks
279	1	22	325	36	61
357	2	6	239	37	45
362	3	17	267	38	41
333	4	69	299	39	29
371	5	16	251	40	64
396	6	7	205	41	53
354	7	5	335	42	35
317	8	3	228	43.5	71
339	9	4	231	43.5	44
369	10	14	249	45	56
314	11	31	295	46	54
384	12	9	366	47	27
348	13	26	353	48	43
329	14	28	394	49	23
283	15	12	225	50	66
234	16	57	344	51	48
229	17	59	204	52	49
342	18	10	209	53	58
332	19	39	284	54	18
356	20	8	238	55	33
349	21	36	207	56	24
395	22	30	346	57	11
327	23	62	373	58	65
208	24	60	372	59	34
355	25	32	243	60	47
244	26	68	326	61	40
399	27	25	203	62	46
201	28	50	343	63	38
287	29	70	236	64	42
202	30	52	233	65	19
285	31	37	232	66	67
322	32	55	391	67	2
206	33	63	352	68	20
252	34	15	351	69	1
278	35	21	273	70	13
			253	71	51

Table 4. Ranks of labor productivity ratios and relative concentration ratios, $\frac{C_s}{C_n}$, in the South

SIC Code	Labor Productivity Ratio Ranks	Relative Concentration Ratio Ranks	SIC Code	Labor Productivity Ratio Ranks	Relative Concentration Ratio Ranks
273	1	13	373	36	65
243	2	47	284	37	18
253	3	51	342	38	10
351	4	1	395	39	30
225	5	66	202	40	52
203	6	46	279	41	22
233	7	19	372	42	34
391	8	2	355	43	32
207	9	24	394	44	23
204	10	49	399	45	25
232	11	67	332	46	39
236	12	42	231	47	44
209	13	58	205	48	53
201	14	50	267	49	41
238	15	33	283	50	12
343	16	38	317	51	3
249	17	56	278	52	21
326	18	40	285	53	37
229	19	59	322	54	55
244	20	68	353	55	43
352	21	20	348	56	26
251	22	64	329	57	28
325	23	61	356	58	8
299	24	29	366	59	27
252	25	15	314	60	31
208	26	60	234	61	57
228	27	71	354	62	5
327	28	62	335	63	35
344	29	48	349	64	36
239	30	45	396	65	7
295	31	54	339	66	4
287	32	70	371	67	16
206	33	63	369	68	14
384	34	9	362	69	17
346	35	11	357	70	6
			333	71	69

Table 5. Ranks of average labor cost ratios and percentage changes in relative concentration in the South, 1947-1958

SIC Code	Average Labor Cost Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks	SIC Code	Average Labor Cost Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks
279	1	18	267	26	27
354	2	44	251	27	24
317	3	50	205	28	15
314	4	30	228	29	2
384	5	42	231	30	28
348	6	35	249	31	20
234	7	48	295	32	29
229	8	40	225	33	25
342	9	45	394	34	41
332	10	31	344	35	14
349	11	46	204	36	6
395	12	38	209	37	11
327	13	19	284	38	9
208	14	7	238	39	33
355	15	36	346	40	12
244	16	32	373	41	8
399	17	34	243	42	5
201	18	22	326	43	4
287	19	1	203	44	21
202	20	26	343	45	17
285	21	13	236	46	49
322	22	10	233	47	43
278	23	23	232	48	37
325	24	16	352	49	39
239	25	3	273	50	47

Table 6. Ranks of labor productivity ratios and percentage changes in relative concentration in the South, 1947-1958

SIC Code	Labor Productivity Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks	SIC Code	Labor Productivity Ratio Ranks	Percentage Changes in Relative Concentration Ratio Ranks
273	1	47	287	26	1
243	2	6	384	27	42
225	3	25	346	28	12
203	4	21	373	29	9
233	5	43	284	30	5
204	6	7	342	31	45
232	7	37	395	32	38
236	8	49	202	33	26
209	9	11	279	34	18
201	10	22	355	35	36
238	11	33	394	36	41
343	12	17	399	37	34
249	13	20	332	38	31
326	14	4	231	39	28
229	15	40	205	40	15
352	16	39	267	41	27
244	17	32	317	42	50
251	18	24	278	43	23
325	19	16	285	44	13
208	20	8	322	45	10
228	21	2	348	46	35
327	22	19	314	47	30
344	23	14	234	48	48
239	24	3	354	49	44
295	25	29	349	50	46

Table 7. Ranking of relative concentration in the South, $\frac{C_s}{C_n}$, labor productivity ratios, and average labor cost ratios for non-market oriented industries

SIC Code	Relative Concentration Ratio Ranks	Labor Productivity Ratio Ranks	Average Labor Cost Ratio Ranks
351	1	1	41
391	2	3	39
317	3	27	5
339	4	38	6
354	5	34	4
357	6	40	1
396	7	37	3
356	8	30	15
384	9	20	9
342	10	22	13
283	11	26	10
369	12	39	7
352	13	14	40
366	14	31	28
314	15	32	8
238	16	8	32
372	17	23	34
335	18	35	24
349	19	36	16
343	20	9	36
332	21	24	14
326	22	11	35
236	23	6	37
353	24	29	29
231	25	25	26
204	26	4	31
201	27	7	18
322	28	28	20
249	29	10	27
234	30	33	11
229	31	12	12
325	32	16	22
206	33	19	21
251	34	15	23
373	35	21	33
225	36	2	30
232	37	5	38
244	38	13	17
333	39	41	2
287	40	18	19
228	41	17	25

Table 8. Ranks of average labor cost ratios and relative concentration ratios, $\frac{C_{ne}}{C_{nne}}$, in New England

SIC Code	Average Labor Cost Ratio Ranks	Relative Concentration Ratio Ranks	SIC Code	Average Labor Cost Ratio Ranks	Relative Concentration Ratio Ranks
253	1	50	332	35	14
357	2	55	369	36	24
399	3	47	362	37	16
366	4	49	295	38	27
352	5	1	317	39	61
201	6	15	284	40	32
373	7	63	229	41	65
204	8	8	353	42	6
239	9	37	355	43	62
225	10	31	349	44	43
278	11	46	238	45	53
326	12	5	395	46	39.5
342	13	64	391	47	68
351	14	52	243	48	12
273	15	45	394	49	54
232	16	20	314	50	66
234	17	44	372	51	38
236	18	33	231	52	30
356	19	57	203	53	19
343	20	11	205	54	25
344	21	21	209	55	13
265	22	39.5	371	56	2
279	23	34	249	57	56
339	24	51	207	58	41
285	25	18	348	59	36
327	26	22	299	60	7
354	27	58	325	61	4
228	28	59	287	62	3
251	29	28	244	63	26
335	30	60	384	64	42
208	31	17	396	65	67
202	32	29	283	66	10
233	33	35	329	67	48
252	34	9	346	68	23

Table 9. Ranks of labor productivity ratios and relative concentration ratios, $\frac{C_{ne}}{C_{nne}}$, in New England

SIC Code	Labor Productivity Ratio Ranks	Relative Concentration Ratio Ranks	SIC Code	Labor Productivity Ratio Ranks	Relative Concentration Ratio Ranks
346	1	23	265	35	39.5
384	2	42	343	36	11
283	3	10	238	37	53
287	4	3	352	38	1
252	5	9	356	39	57
371	6	2	396	40	67
209	7	13	372	41	38
203	8	19	314	42	66
329	9	48	295	43	27
231	10	30	229	44.5	65
243	11	12	284	44.5	32
349	12	43	339	46	51
362	13	16	342	47	64
205	14	25	344	48	21
244	15.5	26	239	49	37
394	15.5	54	234	50	44
249	17	56	273	51	45
325	18	4	251	52	28
353	19	6	357	53	55
208	21	17	236	54	33
332	21	14	278	55	46
355	21	62	399	56	47
369	23	24	317	57	61
207	24	41	366	58	49
354	25	58	201	59	15
299	26	7	204	60	8
335	27	60	327	61	22
233	28	35	351	62	52
391	29	68	326	63	5
285	30	18	232	64	20
279	31.5	34	228	65	59
348	31.5	36	225	66	31
202	33	29	373	67	63
395	34	39.5	253	68	50

Table 10. Ranks of average labor cost ratios and percentage changes in relative concentration in New England, 1947-1958

SIC Code	Average Labor Cost Ratio Rank	Percentage Change in Concentration	SIC Code	Average Labor Cost Ratio Rank	Percentage Change in Concentration
357	1	6	332	28	10
399	2	38	317	29	50
352	3	4	284	30	26
201	4	36	229	31	21
373	5	53	353	32	20
204	6	31	355	33	14
239	7	22	349	34	8
225	8	42	238	35	47
278	9	16	395	36	45
326	10	51	391	37	17
342	11	9	243	38	15
351	12	25	394	39	5
273	13	43	314	40	28
232	14	34	231	41	33
234	15	12	203	42	13
236	16	48	205	43	11
343	17	2	209	44	39
344	18	37	249	45	27
265	19	18	348	46	19
279	20	29	299	47	49
285	21	30	325	48	23
327	22	41	287	49	1
251	23	32	244	50	3
208	24	40	384	51	24
202	25	44	396	52	35
233	26	46	346	53	7
252	27	52			

Table 11. Ranks of labor productivity ratios and percentage changes in relative concentration in New England, 1947-1958

SIC Code	Labor Productivity Rank	Percentage Change in Concentration Rank	SIC Code	Labor Productivity Rank	Percentage Change in Concentration Rank
346	1	7	343	28	2
384	2	24	238	29	47
287	3	1	352	30	4
252	4	52	396	31	35
209	5	39	314	32	28
203	6	13	284	33	26
231	7	33	229	34	21
243	8	15	342	35	9
349	9	8	344	36	37
205	10	11	239	37	22
394	11	5	234	38	12
244	12	3	273	39	43
249	13	27	251	40	32
325	14	23	357	41	6
353	15	20	236	42	48
208	16	40	278	43	16
332	17	10	399	44	38
355	18	14	317	45	50
299	19	49	201	46	36
233	20	46	204	47	31
391	21	17	327	48	41
285	22	30	351	49	25
279	23	29	326	50	51
348	24	19	232	51	34
202	25	44	225	52	42
395	26	45	373	53	53
265	27	18			

APPENDIX V

RANK CORRELATIONS TEST RESULTS FOR THE CLASSICAL MODEL

Explanatory Variable	Concentration Ratios	Sample Size	Sign Hypothesized	τ	Level of Significance
Labor Productivity	$\frac{v_s^i}{V_N^i}$	71	+	-.202	5%
Average Labor Cost	$\frac{v_s^i}{V_N^i}$	71	-	+.116	n.s.
Labor Productivity	$\frac{v_s^i}{V_N^i}$	16 60% Labor intensive	+	+.033	n.s.
Average Labor Cost	$\frac{v_s^i}{V_N^i}$	16 60% Labor intensive	-	-.183	n.s.
Labor Productivity	$\frac{C_s}{C_n}$	71	+	-.199	5%
Average Labor Cost	$\frac{C_s}{C_n}$	71	-	+.136	10%
Labor Productivity	$\frac{C_s}{C_n}$	38 50% Labor intensive	+	-.183	10%
Average Labor Cost	$\frac{C_s}{C_n}$	38 50% Labor intensive	-	+.013	n.s.
Labor Productivity	$\frac{C_s}{C_n}$	41 Non-market oriented	+	-.193	10%
Average Labor Cost	$\frac{C_s}{C_n}$	41 Non-market oriented	-	+.144	n.s.

Explanatory Variable	Concentration Ratios	Sample Size	Sign Hypothesized	τ	Level of Significance
Labor Productivity	% change in $\frac{C_s}{C_n}$	50	+	+.062	n.s.
Average Labor Cost	% change in $\frac{C_s}{C_n}$	50	-	-.231	6%
Labor Productivity	$\frac{C_{ne}}{C_{nne}}$	68	+	+.221	1%
Average Labor Cost	$\frac{C_{ne}}{C_{nne}}$	68	-	-.076	n.s.
Labor Productivity	% change in $\frac{C_{ne}}{C_{nne}}$	53	+	+.249	1%
Average Labor Cost	% change in $\frac{C_{ne}}{C_{nne}}$	53	-	-.138	n.s.

APPENDIX VI

ANALYSIS OF EIGHT SIC THREE-DIGIT INDUSTRIES

ANALYSIS OF EIGHT INDUSTRIES TO DETERMINE SOURCES OF DEMAND AND RAW MATERIALS[a]

1. Industry 243--Millwork and related products

   Sub-industries: millwork plants, veneer and plywood plants, prefabricated wooden buildings and structural members

   Raw Material Sources:

   Industry 2421: sawmills and planing mills; 23 percent of total output in the South; mills produce rough lumber, dressed lumber, and softwood cut stock

   Industry 3553: woodworking machinery; 20 percent of total output in the South

   Demand for Industry 243 Products:

   Industry 244: wooden containers; 47.5 percent of total output in the South

   Conclusion: Both sources of demand and raw materials are reasons for locating in the South.

2. Industry 253--Public building furniture

   Raw Material Sources: Difficult to discern; possibly Industry 243, just analyzed, which has a high South concentration

   Demand for Industry 253 Products:

   No industrial demand as these goods are sold for direct use, not as raw materials,

   Conclusion: No explanation for its ranking.

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[a]U. S. Bureau of the Census, Census of Manufactures, 1958, Vol. II, Parts 1 and 2 (Washington: U. S. Government Printing Office, 1961).

3. Industry 225--Knitting mills

<u>Sub-industries</u>: hosiery, knit outerwear and underwear, knit fabrics

<u>Raw Material Sources</u>: Knit products from yarns

Industry 228: yarn and thread mills; 68 percent of total output in the South

<u>Demand for Industry 225 Products</u>: Non-industrial demand

<u>Conclusion</u>: Sources of raw materials are the major factor in the regional concentration of this industry.

4. Industry 232--Men's and boys' furnishings

<u>Sub-industries</u>: dress shirts, underwear, neckwear, trousers, and work clothing

<u>Raw Material Sources</u>: Goods manufactured from purchased woven or knit fabric

Industry 2256: knit fabric mills; 27 percent of total output in the South

Industry 2211: weaving mills, cotton; 91 percent of total output in the South

Industry 2221: weaving mills, synthetics; 70 percent of total output in the South

<u>Demand for Industry 232 Products</u>: Non-industrial demand

<u>Conclusion</u>: Sources of raw materials are the major factor in the regional concentration of this industry.

5. Industry 278--Bookbinding and related work

<u>Sub-industries</u>: blankbooks and looseleaf binders; bronzing, gilding, and edging; map and sample mounting

<u>Raw Material Sources</u>: Difficult to condense

Industry 262: paper mills; 29 percent of total output in the South

Industry 264: paper and paperbound products

<u>Demand for Industry 278 Products</u>:

Industry 273: publishing and printing of books; 7.4 percent of total output in the South

Industry 2761: manifold business forms; 16 percent of total output in the South

Industry 2771: greeting cards; 1.2 percent of total output in the South

Industry 275: general commercial printing; 13 per cent of total output in the South

<u>Conclusion</u>: Uncertainty about the sources of both demand and raw materials makes any judgment difficult. A lack of strong demand in the South could be important.

6. Industry 356--General industrial machinery

<u>Sub-industries</u>: pumps and compressors, ball and roller bearings, blowers and fans, power transmission equipment, and industrial ovens and furnaces

<u>Raw Material Sources</u>:

Industry 34: fabricated metal products; 13 percent of total output in the South

<u>Demand for Industry 356 Products</u>:

The general level of industrial activity is probably the best indicator due to the diversity of products in Industry 356. Thus, most demand is in the non-South.

<u>Conclusion</u>: Relative concentration of both demand and raw material sources in the non-South explains output concentration in the non-South.

7. Industry 354--Metalworking machinery

<u>Sub-industries</u>: metal cutting and forming machine tools; special dies and tools; machine tool accessories

<u>Raw Material Sources</u>:

Industry 331: steel rolling and finishing; 17 percent of total output in the South

Industry 335: nonferrous rolling and drawing; 14 percent of total output in the South

<u>Demand for Industry 354 Products</u>:

Industry 34: fabricated metal products; 13 percent of total output in the South

<u>Conclusion</u>: High demand and raw material concentration in the non-South explains the high production concentration in the non-South.

8. Industry 339--Primary metal industries, n.e.c.

<u>Sub-industries</u>: iron and steel forgings and nonferrous forgings

<u>Raw Material Sources</u>:

Industry 331 and 335 as analyzed above

<u>Demand for Industry 339 Products</u>:

Industry 34 as analyzed above

<u>Conclusion</u>: High demand and raw material concentration in the non-South explains the high production concentration in the non-South.

APPENDIX VII

RANKS OF SIC THREE-DIGIT INDUSTRIES BY COEFFICIENT OF RESOURCE DEPENDENCY

Table 1. Ranks of coefficients of resource dependency and relative concentration ratios in the South

SIC Code	Coefficient of Resource Dependency	Relative Concentration Ratios	SIC Code	Coefficient of Resource Dependency	Relative Concentration Ratios
201	1	43	353	31	36
206	2	55	317	32	2
209	3	51	391	33	1
204	4	42	369	34	12
202	5	45	205	35	46
287	6	60	372	36	27
203	7	39	349	37	29
228	8	61	394	38	19
335	9	28	314	39	24
229	10	52	396	40	6
299	11	22	253	41	44
295	12	47	395	42	23
239	13	38	329	43	21
207	14	20	373	44	57
243	15	40	355	45	25
265	16	34	284	46	15
232	17	58	356	47	7
244	18	59	357	48	5
285	19	30	342	49	9
344	20	41	384	50	8
233	21	16	332	51	32
236	22	35	362	52	14
238	23	26	252	53	13
234	24	50	273	54	11
327	25	54	322	55	48
249	26	49	354	56	4
339	27	3	278	57	17
251	28	56	326	58	33
343	29	31	325	59	53
231	30	37	283	60	10
			279	61	18

Table 2. Ranks of coefficients of resource dependency and relative concentration ratios for New England

SIC Code	Coefficient of Resource Dependency Ranks	Relative Concentration Ratio Ranks	SIC Code	Coefficient of Resource Dependency Ranks	Relative Concentration Ratio Ranks
201	1	11	231	29	24
209	2	10	353	30	4
204	3	6	317	31	50
202	4	23	391	32	57
287	5	1	369	33	18
203	6	14	205	34	19
228	7	48	372	35	30
335	8	49	349	36	35
229	9	54	394	37	43
299	10	5	314	38	55
295	11	21	396	39	56
239	12	29	253	40	40
207	13	33	395	41	32
243	14	9	329	42	39
265	15	31	373	43	52
232	16	15	355	44	51
244	17	20	284	45	25
285	18	13	356	46	46
344	19	16	357	47	44
233	20	28	342	48	53
236	21	26	384	49	34
238	22	42	362	50	12
234	23	36	252	51	7
327	24	17	273	52	37
249	25	45	354	53	47
339	26	41	278	54	38
251	27	22	326	55	3
343	28	8	325	56	2
			279	57	27