RICE UNIVERSITY

CAPITAL-LABOR RATIOS GENERATED BY FAMILY CONSUMPTION

by

Mark W. Osterberg

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Arts

Thesis Director's signature:

Houston, Texas

September, 1973
The determination of capital and labor use is generally framed in terms of profit maximizing and technological considerations. This thesis suggests that an important relationship between the level of family income and the use of factors of production also exists. The finding of this empirical study is that different income-classes have consumption patterns which require different mixtures of labor and capital. The implications for developmental economics, industrial organization and public finance of this empirical observation are reviewed in the paper.
ACKNOWLEDGEMENT

I wish to thank my parents for their morale and financial support.
# Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter I</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Chapter II</td>
<td>The Model</td>
<td>6</td>
</tr>
<tr>
<td>Chapter III</td>
<td>The Estimates</td>
<td>17</td>
</tr>
<tr>
<td>Chapter IV</td>
<td>Implications</td>
<td>32</td>
</tr>
<tr>
<td>Chapter V</td>
<td>Extensions</td>
<td>40</td>
</tr>
<tr>
<td>Appendix I</td>
<td>Capital-Labor Ratios</td>
<td>43</td>
</tr>
<tr>
<td>Appendix II</td>
<td>A Redistribution Simulation</td>
<td>45</td>
</tr>
<tr>
<td>Bibliography</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
INTRODUCTION

Consumers do not purchase capital and labor, but instead purchase goods and services that are produced by capital and labor. This thesis focuses on the relative amounts of capital and labor used in the production of the consumption patterns of nine income-classes in the United States. The paper shows that consumption decisions do affect the aggregate capital-labor ratio.

Because firms purchase capital and labor, discussions of the relative amounts of capital and labor used in production are usually framed in terms of technological and profit maximizing considerations. However, an observed capital-labor ratio in the aggregate is a weighted average of production decisions, with the firms deciding the relative amounts of capital and labor to be employed in the various industries and consumers deciding indirectly how the industries are to be weighted.

A description of how the capital-labor ratios for the consumption patterns were computed is contained in Chapter II. A linear model is used to calculate estimates of the capital-labor ratio used in the production of the observed consumption expenditures of a representative family of four from each income group. A representative family's consumption expenditures are the averages of the observed consumption expenditures of all the families of four in the income-class. In this linear model a capital-labor ratio for aggregate expenditures depends on the distribution of expenditures across industries. In other words,
the capital-labor ratio used in the production of consumption expendi-
tures is determined by the relative importance of different industries.

Two definitions of consumption were used in calculating the relative amounts of capital and labor used in the production of goods and services demanded by a representative family of four in each income-class. One definition limits consumption to market expenditures. Market consumption expenditures are all expenditures by a family unit to provide itself with goods and services with the exception of the purchase of housing space. The other definition of consumption includes both market expenditures and an imputed value of housing consumption.\footnote{The purchase of a house is viewed as an investment expenditure, but consumers do derive a service from housing. The second definition of consumption involves assigning a value to a family's housing consumption.} The purchase of a house is viewed as an investment expenditure, but consumers do derive a service from housing. The second definition of consumption involves assigning a value to a family's housing consumption.

The third chapter presents the empirical results of the study. The calculations demonstrate that the middle income-classes have the market consumption patterns which generate the highest capital-labor ratios and the high income-classes have the market consumption patterns which generate the lowest capital-labor ratios.

Since homes are very durable goods, assigning a value to the current consumption of housing space poses a problem. There is wide-spread dis-

\footnote{In this paper, if the discussion applies only to the first definition, the phrase 'market consumption' will be used, and if the discussion applies only to the second definition the phrase 'all consumption' will be used.}
agreement about the income-elasticity of housing services, and when the second definition of consumption is used, the results are sensitive to the assumed income-elasticity of housing that is used. With an income-elasticity of .6, the ratio of capital to labor used in the production of all consumption decreases as income increases. In other words, the capital-labor ratio of all consumption expenditures of a low income family is higher than the capital-labor ratio of all consumption of a family in a high income-class. With an income-elasticity of 1, the ratio of capital to labor used in production of all consumption expenditures increases as the level of family income increases.

While the model in its linear form was designed to calculate the capital-labor ratios generated by consumption patterns of nine U.S. income groups observed in 1959 and 1960, the results and the approach taken do have macro implications. Chapter IV contains a discussion of the implications of this thesis for developmental economics, industrial organization, and public finance.

Capital and labor are important concepts in the current discussions of growth, tax incidence and macro economics. The primary reason that this study was undertaken was to complement work done in the area of developmental economics. Empirical and theoretical studies suggest that a lack of capital acts to constrain economic growth in underdeveloped

---

Two income-elasticities of housing were used in the calculations. The two elasticities, 1 and .6, are typical estimates. For a good review article see: Frank de Leeuw, "The Demand for Housing: A Review of the Cross-Section Evidence," The Review of Economics and Statistics, February 1971, pp. 1-10.
countries. Labor is observed to be a redundant resource. Gustavo Jimenez observed that in Colombia the poor tend to consume goods and services which require low levels of capital relative to labor in production, and the rich tend to consume goods and services which require high levels of capital relative to labor in production. In other words, in Colombia, as the level of family income rises, the capital labor ratio generated by consumption also rises. As noted above, the tendencies observed in the U.S. are different. The primary conclusion of the paper is that the state of development does affect the relative usage of capital and labor.

The study also has implications for future factor usage in the United States. At present, the upper income-classes have consumption patterns which generate low capital-labor ratios. If the average level of family income continues to increase the aggregate capital-labor ratio may decrease as more families move into the upper income-classes.

Finally, this thesis supports those who suggest that there is a need to develop a general equilibrium tax model. Theorists now believe that both the sources and uses of income must be examined to determine the effects of some taxes. For example, Peter Mieszkowski reports that:

---

3 James W. Land and Ronald Soligo, "Models of Development Incorporating Distribution Aspects," The Program of Development Studies - Paper Number 22 (Rice University, Houston, Fall 1972).

4 Gustavo Jiménez, The Capital, Labor and Import Content of Urban Consumption Patterns in Colombia (Houston, June 1972).

it may be that capitalists gain from the substitution of a tax on capital in a capital intensive sector for a proportional income tax if capitalists spend a high proportion of their income on the commodities produced by the untaxed sectors. The unfavorable source of income effects of the tax substitution may be outweighed by the favorable use of income effects.

Therefore, it has been theoretically established that taxes on input factors may affect different groups differently because of differences in consumption. But, do the groups in the economy have different consumption patterns which are produced with different intensities of capital and labor? In other words, are the theoretical questions important from an empirical point of view?

The empirical results reported in this paper do indicate that the theoretical issues being raised in the discussions of growth and taxes are important. Different income-classes do seem to have consumption patterns which are produced with different intensities of capital and labor. Neither a general equilibrium nor a macro model is presented here, but the results do have implications for general equilibrium and macro models.

Finally, Chapter V contains a discussion of the importance of the capital concept, and suggests that the results might be modified with the use of other definitions and assumptions.
THE MODEL

The fundamental idea in this thesis is that the distribution and level of national income matter in the determination of the relative amounts of capital and labor used in the production of goods and services. This notion was developed by Professors Land and Soligo at Rice University.¹,² This chapter presents both the linear model that will be used to calculate the capital-labor ratio used in production of the consumption expenditures of a representative family for each of nine U.S. income-classes, and a discussion of this linear formulation.

A. Presentation of the Model³,⁴

In order to estimate the capital-labor ratios for a representative


² The distribution of income was considered to be important in Classical Economics in the determination of capital accumulation through its effect on the savings rate. In modern economics the distribution of income has been considered to be relatively unimportant in its effect on industry.

³ Appendix I contains a discussion of capital-labor ratios, and how consumption patterns determine capital-labor ratios, given certain assumptions about production.

⁴ In this paper, capital letters refer to vectors and matrices, and small subscripted letters refer to scalers. The subscripts j and f indicate representative families in the j and f income-classes and the subscripts i and e refer to commodities. Also note that the structure of the production functions, demand schedules and capital-labor ratios are consistent with each other: ie industry i produces commodity i.
family of four from each income-class, a linear model will be used.\textsuperscript{5,6}

Let:

\[ y_j \]
be the income of the representative family in the jth income-class.

\[ C_j \]
be the vector of commodities demanded by family j (the representative family in the jth income-class).

\[ c_{ij} \]
be the dollar value of good i demanded by family j. \( c_{ij} \) is the ith element of \( C_j \).

\[ G_j \]
be a vector of commodities describing the direct and indirect demands of family j.\textsuperscript{7}

\[ g_{ij} \]
be the direct and indirect demand of family j for commodity i. \( g_{ij} \) is the ith element of \( G_j \).

\textsuperscript{5} Two assumptions were made about the income-elasticity of housing and so two capital-labor ratios for all consumption were computed for the representative family from each income-class.

\textsuperscript{6} The model in a slightly modified form was used to calculate the average capital content of a consumption pattern (which is equal to the total capital requirements of production divided by the value of consumption) and the average labor content of consumption patterns (which is defined analogously).

\textsuperscript{7} Family j demands electricity directly (for example, for lighting) and also indirectly because it is used in the production of goods and services demanded directly by the family.
A be a matrix of input coefficients, with each column representing the input requirements of an industry for the production of $1.00 of output.

a_{ie} be a typical element of A showing the amount of good i used for the production of a dollars worth of good e.

R be a vector of capital coefficients. The ith component of this vector is the dollar value of the capital stock required to produce $1.00 of output of commodity i.

S be a vector of labor coefficients. The ith component of the vector is the man-years required to produce $1.00 of output of commodity i.

\[(k/l)_{j,\text{market}}\] be a scaler describing the ratio of capital to labor used in production to fulfill the market consumption demands of family j.
be a scaler describing the ratio of capital
to labor used in production to fulfill
all consumption demands of family j. Both
market consumption expenditures and an
estimated value of housing services are
defined as consumption for the purpose of
estimating this scaler. 8

The following procedure was used to estimate values of \( (k/l)_{j,\text{market}} \)

and \( (k/l)_{j,\text{all}} \) for nine representative families (one from each income-
class) in the American economy:

1. An estimate of the market consumption expenditures of nine
income-classes was obtained from cross-section consumer budget
studies. 9 Estimates of the value of housing services was
obtained independently of the budget studies. 10 It was postu-
lated that consumption expenditures were a function of

---

8 The symbol \( (k/l)_{j} \) will be used when the discussion is general and
the definition (market or all) of consumption is not important. The
description of the estimating procedure is a general one (it applies to
either definition).

9 Bureau of Labor Statistics in the U.S. Department of Labor,
Consumer Expenditures and Income, BLS Report Number 237-38 (Washington,
April 1964).

10 See: Frank de Leeuw, "The Demand for Housing: A Review of the
Cross-Section Evidence," The Review of Economics and Statistics,
February 1971, pp. 1-10.
The direct and indirect demands of each representative family were computed. In order to determine the amount of capital and labor used in the production of the goods and services purchased by a family it is necessary to determine how much of every commodity will need to be produced. Goods and services are purchased both directly and indirectly. For example, no family buys iron ore directly, yet iron ore is necessary for the production of goods and services that a family consumes.

The following system of equations describes the relationship between total (direct plus indirect) demand and final (direct) demand.

\[(I-A)^{-1} \cdot G_j = C_j,\]

where \(I\) is the identity matrix. By computing the Leontief inverse matrix, \((I-A)^{-1}\), a system of equations results which yields a solution directly:

\[(I-A)^{-1} \cdot C_j = G_j.\]

Given a vector of final demands, \(C_j\), it is a simple matter to determine the total amount of every commodity that must be produced.\(^{12}\)

---

\(^{11}\) The procedure that is being undertaken in step 2 is outlined by Alpha Chiang. Source: Alpha C. Chiang, *Fundamental Methods of Mathematical Economics* (New York, 1967), pp. 120-125.

\(^{12}\) It is assumed that only goods produced in the U.S. are purchased by consumers.
3. Two dot products, \( R \cdot G_j \) and \( S \cdot G_j \), were taken to find the total amounts of labor and capital used in the production of the goods and services demanded by a representative family. The scaler, \( \left( \frac{k}{L} \right) \), is the ratio of the amounts of capital and labor used in the production of the goods and services demanded by family \( j \).

B. Limitations of the Linear Model

A strength and a weakness of all models is that they serve to limit our vision of events and relationships. This section contains a discussion of some of the viewpoints that economists have generally taken that are left out of the model presented in this chapter. Economists believe, first, that relative prices are important in the determination of production and consumption decisions, second, that there may be other factors affecting consumption decisions besides the level of current income and relative prices, and third that linear relationships used to describe production might not be accurate. If the model is going to be used for predictions very far into the future, a fourth problem exists, namely technological change. Even if the description of production is correct for a point in time, it may not be correct for a future point in time. Capital-labor ratios are dependent upon production decisions; if the description of production is incorrect, the capital-labor will be incorrect. It should also be noted that an important assumption in this analysis is that consumer preferences do not change over time.

First the problems associated with changes in relative prices will be addressed. If the model is to be used to predict the effects on the
capital or labor requirements of production of either a change in the
distribution of income or a change in the level of national income,
the results may be modified by changes in relative prices. For example,
if the government moves to make the distribution of income more equal,
and if there are decreasing returns to scale involved in producing what
the middle income-classes originally demanded, the prices of these goods
may increase as more people move into the middle of the income distri-
bution. This change in relative prices may change the composition of
demand by the middle income-classes.

Another limitation of the formulation of the model is the consump-
tion function. Economists generally agree that income is an important
factor. Some argue, however, that the relative position of a person in
the income distribution also affects his consumption decisions. While
there is reason for suspecting that the relative position of a person
does affect consumption decisions, the income variable will be used as
the determinant of consumption decisions. Prais and Houthakker report
that the level of income is more important in the determination of con-
sumer expenditures than is the relative position of a person in the
income distribution. They state, "the basic postulate of family-budget
analysis... is in its simplest form that the effects of income changes on

---

13 Most of the consumption studies done by economists are done in
an attempt to isolate factors which influence decisions about consump-
tion versus saving.

14 James S. Duesenberry, Income, Saving, and the Theory of Consumer
consumption may be forecast by examining the consumption patterns of households with differing incomes at the same time.\textsuperscript{15}

Current annual income is used as the determinant of consumption decisions for each consuming unit. It should be noted that Friedman's theory of consumption asserts that it is the consumer's notion of his permanent income (which is related to his expected future income) that determines his total consumption expenditures and his total savings in any time period.\textsuperscript{16} Margaret Reid, a student of Friedman's, has applied his theory to the demand for the services of housing space.\textsuperscript{17} However, $y_j$ will not be defined as permanent income for two reasons. First of all, permanent income is very hard to measure since it is a subjective estimate.\textsuperscript{18,19} Secondly, Reid argues that the planning horizon differs for different goods, the shorter the durability of the good the shorter is the time period over which the consumer estimates what his income is

\textsuperscript{16} Milton Friedman, \textit{A Theory of the Consumption Function} (Princeton, 1957).
\textsuperscript{17} Margaret G. Reid, \textit{Housing and Income} (Chicago, 1962).
\textsuperscript{18} Reid describes how she tried to estimate permanent income relationships. See \textit{Ibid.}, p. 26.
\textsuperscript{19} Since the results of this study will be compared with results from Brazil and Colombia, it is interesting to note that the lack of credit available in underdeveloped countries lessens the need to consider whether it is permanent or current annual income which is important in consumption decisions.
likely to be. This argument implies the need for many income terms and that current income may be a good estimate of permanent income for nondurable goods. The observable value, current annual income, will be used as the independent variable in the consumption function.

The use of an input-output table (ie: A), and capital and labor vectors (ie: R and S) to describe the production process implies that a firm will not change its input mix or the relative amounts of capital and labor used in production. In reality, a firm might wish to change its input mix in response to a change in input prices or a change in the scale of its operations. If a firm produces k dollars of output, it is assumed to use $ka^i_\text{dollars of input } i$. Alpha Chiang\(^{21}\) provides a list of assumptions that are generally made when input-output tables are used:

1. Each industry produces only one homogeneous commodity.
2. Each industry uses a fixed input ratio for the production of its output.
3. Production in every industry is subject to constant returns to scale.

The assumed fixed relations between capital and output and labor and output, which imply a fixed relationship between capital and labor

\(^{20}\) Ibid., p. 12.
\(^{21}\) Alpha C. Chiang, Fundamental Methods of Mathematical Economics (New York, 1967), pp. 120-121.
\(^{22}\) Anne P. Carter notes that the use of input-output tables blurs the usual distinction that is made between technological change and the effects of changes in the scale of operations. Source: Anne P. Carter, Structural Change in the American Economy (Cambridge, Mass., 1970), p. 10.
for every firm, carry similar dangers to those discussed above that relate to the use of an input-output framework. At different scales of operation, or with different prices on capital and labor, a firm might use a different mix of labor and capital. It is hoped that the assumed fixed relationships will approximate reality.

C. Consumption, Savings, and Capital

This last section contains discussions of the differences between capital goods and intermediate input purchases, and the nature of the capital stock. It is not the author's intention to solve the definitional problems that have long been in economics, but rather to point out where our definitions are arbitrary.

The distinction between a stock and a flow item is an arbitrary one, depending on how the time period is defined. A good is generally considered to be part of the capital stock if the firm uses it for more than one period. Capital is an economic term that lends itself to an intuitive understanding but not a precise definition. Several definitions of capital might be appropriate:

a) the owner's equity part of the balance sheets for the firms in the economy

b) the asset part of the balance sheets for the firms

Anne Carter puts the problem in the following terms: "The analytical distinction between capital and current account items is not clear at all. In fact, all inputs are both flows and stocks as they proceed through the productive pipeline. In prevailing accounting practice, inputs are classified as current or as capital depending on whether they stay in the pipeline for a relatively short time...or a relatively long time. ...Thus capital and current inputs are in practice distinguished arbitrarily by dividing a continuous spectrum of longevities." Source: Ibid., p. 20.
c) estimates of the physical capital, financial capital and human capital that the firms use
d) the estimated value of plant and equipment that the firms use (excluding the housing stock)
e) definition d) plus the estimated value of the housing stock.

Two definitions were used in this thesis. Definitions d and e were used because data was available on them.

Similar problems are encountered when a distinction is made between a family's consumption and investment expenditures. Many of the goods that a family buys will be used over a period of several years. For the purpose of this study, all purchases made to provide a family with goods and services were considered as current market consumption expenditures with the exception of the purchase of a house, which is viewed as an investment expenditure.

An implicit assumption made in the model is that savings decisions by various income-classes do not affect the aggregate amount of capital used by industry. This thesis is concerned with the capital-labor ratios generated by consumption expenditures and any effect that savings decisions may have on the creation of capital is ignored.
CHAPTER III

ESTIMATES OF THE CAPITAL-LABOR RATIOS GENERATED BY FAMILY CONSUMPTION EXPENDITURES

This chapter contains the results of the calculations described in Chapter II. Specifically, estimates of the ratio of capital to labor used in producing the consumption demands of every representative family; an explanation of the observed differences in the estimates; and a discussion of the reliability of the results, are presented. The primary conclusions derived from the results presented in this chapter are:

1) the market consumption expenditures of the representative families in the middle income-classes generated higher capital-labor ratios than did the market consumption expenditures of the representative families in the low and high income-classes. The capital-expenditure and labor-expenditure ratios generated by family market consumption expenditures generally rise with family income.

2) using an income elasticity of .6 (1) for housing consumption, the capital-labor ratio for all consumption decreases (increases) as the level of family income increases.

Estimates of how the various income-classes allocate their market consumption expenditures were obtained from a survey done by the Bureau of Labor Statistics in the years 1960 and 1961.1,2,3 This author

---

3 The sampling was done by interviewing urban families, and the results might be modified if rural families were also included.
rearranged the detailed data on market consumption expenditures so that the estimates would fit into the input-output table.  

The BLS study was concerned only with market expenditures, and estimates of the value of the housing consumption of the representative families had to be obtained elsewhere. Economists interested in the housing sector are not in agreement on the definition of housing consumption. When a family rents an apartment, the rent check pays for the use of the space and for other services (such as garbage pickup, general maintenance, club memberships, etc.). In this thesis housing consumption refers only to the act of a family using housing space. Therefore, the other services (besides housing space) provided by the rental industry are included in market consumption. The capital coefficient for the rental industry is constructed so as to exclude the value of the housing stock when a capital-labor ratio is generated by market consumption expenditures. The value of housing consumption is not an observed valuation but an imputed one. Housing has been of interest to economists for some time. Now most economists believe that current income is not the determinant of housing consumption. For example, Lee reports:

Perhaps one principal conclusion to be drawn from this study is that current disposable income, the importance of which is postulated in most consumer expenditures does not appear to be important at all in explaining the probability of buying a house in a given year.

---

4 For example, consumers purchase laundry and cleaning supplies from the chemical industry.

Therefore, our analysis of all consumption should be viewed as tentative since current income is assumed to be determinate of all consumption. Attention of economists interested in housing has been focused on Friedman's permanent income concept. There is, however, still disagreement about the elasticity of housing with respect to permanent income.\(^6\)

Two income-elasticities of housing were used to test the sensitivity of the results. The results were found to be sensitive to the elasticity used. The results obtained using income-elasticities of .6 and 1 are presented in this chapter.\(^7\)

The input-output matrix was obtained from Anne Carter's historical study of the American economy.\(^8\) This 38 sector table is based on the study of the U.S. economy in the year 1958 done by the Office of Business Economics.\(^9,10\) The capital-output (except for housing) and the

---


\(^7\) A typical estimate of the income elasticity of housing calculated when current income is used as the income variable is .6. Frank de Leeuw reports that, "estimates of the income elasticity of the demand for housing range from 0.4 to 2.1." Source: Ibid, p. 1.

\(^8\) Carter's results will be discussed in Chapter IV of this thesis. Source: Anne P. Carter, Structural Change in the American Economy (Cambridge, Mass., 1970), pp. 225-240.


\(^10\) 1958 was a recession year for the U.S. economy and this fact might distort the table. Carter states: "The 1958 recession may well have introduced some abnormalities into that year's input-output structures, but there is no satisfactory method of gauging the quantitative impact on intermediate structures." Source: Anne P. Carter, Structural Change in the American Economy (Cambridge, Mass., 1970), p. 17.
labor-output ratios also come from the Carter study.\textsuperscript{11,12,13} 

A. Estimates of \((\frac{k}{l})_{j,\text{market}}\)

The numerical estimates will be presented in chart form and the more important tendencies will be summarized qualitatively. Table I gives the consumption data used in the calculations (see columns (2) thru (10)). Given the assumptions made about production, it is the pattern of expenditures which determines a capital-labor ratio for a set of expenditures.\textsuperscript{14}

In order to isolate the effect of increases in family income, the estimates of how families of four allocate their expenditures were used. It is an observed tendency that the size of a family unit tends to rise with income.\textsuperscript{15} By holding family size constant the effects of family size on consumption expenditures were eliminated.

\textsuperscript{11} Ibid., pp. 248-249.
\textsuperscript{12} The goods and services provided by the government are not included in the table.
\textsuperscript{13} This author estimated the capital-output ratio of private housing as being approximately 18 by dividing the estimated market value of the housing stock by the estimated "space rental value" of private housing. See: Bureau of the Census, \textit{1960 Census of Housing} (Washington, 1963); and Office of Business Economics, \textit{U.S. Income and Output} (Washington, 1958) p. 150. Leo Grebler estimated a lower figure for the capital-output ratio of rental housing. See: Leo Grebler, David M. Blank and Louis Winnick, \textit{Capital Formation in Residential Real Estate}, (Princeton, 1956), p. 407. A figure of 13, which lies between the estimates, was used in this thesis as the capital-output ratio for housing. The figure 13 is a reasonable (partly subjective) estimate of the capital-output ratio in the housing sector.
\textsuperscript{14} The lowest income-class ($0 to $1000) was not used in the calculations because of the obvious transitory components of income.
TABLE I

CASH CONSUMPTION PATTERNS AND TOTAL CAPITAL/LABOR REQUIREMENTS

The column entitled "K/L Ratio" shows how much capital relative to labor is required to produce each industry's output. Each estimate allows for both the direct and indirect labor and capital involved. For example, it requires a capital-labor ratio of 7105 to produce agricultural products. The column entitled "rank" shows the rank order of the industries by their capital-labor ratios (the preceding column). The table is in two parts. The part on this page lists the capital-labor ratios for the Mining Industries (which sell no output directly to consumers). The part of the table on the next page lists the other industry capital-labor ratios. Columns (2) thru (10) on the next page show how representative families divide up their consumption expenditures. The data is in percentage terms and has been fitted to the organization of the input-output table.

<table>
<thead>
<tr>
<th>Sector</th>
<th>K/L Ratio</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Iron mining</td>
<td>12615</td>
<td>9</td>
</tr>
<tr>
<td>3 Nonferrous mining</td>
<td>17226</td>
<td>6</td>
</tr>
<tr>
<td>4 Coal Mining</td>
<td>7922.1</td>
<td>21</td>
</tr>
<tr>
<td>5 Petroleum mining</td>
<td>27003</td>
<td>3</td>
</tr>
<tr>
<td>6 Nonmetallic mining</td>
<td>12232</td>
<td>10</td>
</tr>
</tbody>
</table>

Table continued on the next page.
<table>
<thead>
<tr>
<th>Sector</th>
<th>K/L Ratio</th>
<th>Rank</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Agriculture</td>
<td>7105</td>
<td>25</td>
<td>0.2</td>
<td>0.0</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>7 Construction</td>
<td>5535</td>
<td>35</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>8 Food</td>
<td>8297</td>
<td>17</td>
<td>28.9</td>
<td>28.8</td>
<td>26.7</td>
<td>26.4</td>
<td>25.2</td>
<td>24.6</td>
<td>23.8</td>
<td>22.3</td>
<td>18.7</td>
</tr>
<tr>
<td>9 Tobacco</td>
<td>7423</td>
<td>23</td>
<td>3.0</td>
<td>2.1</td>
<td>1.9</td>
<td>2.0</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>10 Textiles</td>
<td>5552</td>
<td>34</td>
<td>6.7</td>
<td>7.9</td>
<td>7.7</td>
<td>7.1</td>
<td>7.6</td>
<td>7.8</td>
<td>7.9</td>
<td>8.9</td>
<td>8.1</td>
</tr>
<tr>
<td>11 Wood</td>
<td>6051</td>
<td>32</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>12 Publishing, etc.</td>
<td>8469</td>
<td>16</td>
<td>1.8</td>
<td>1.4</td>
<td>1.5</td>
<td>1.4</td>
<td>1.5</td>
<td>1.5</td>
<td>1.4</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>13 Chemicals</td>
<td>12671</td>
<td>8</td>
<td>1.4</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>14 Petroleum</td>
<td>24524</td>
<td>14</td>
<td>1.4</td>
<td>1.9</td>
<td>3.5</td>
<td>3.8</td>
<td>3.5</td>
<td>3.4</td>
<td>3.4</td>
<td>2.7</td>
<td>1.6</td>
</tr>
<tr>
<td>15 Rubber and plastic</td>
<td>8012</td>
<td>20</td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>16 Leather</td>
<td>4177</td>
<td>38</td>
<td>1.8</td>
<td>1.7</td>
<td>1.3</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
<td>1.2</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>17 Stone, clay, glass</td>
<td>10749</td>
<td>13</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>18 Iron and steel</td>
<td>12043</td>
<td>11</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>19 Nonferrous metals</td>
<td>11632</td>
<td>12</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>20 Metal forming</td>
<td>8089</td>
<td>19</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>21 Nonelectrical eq.</td>
<td>7204</td>
<td>24</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>22 Engines</td>
<td>7461</td>
<td>22</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>23 Electrical eq.</td>
<td>6080</td>
<td>31</td>
<td>1.0</td>
<td>0.8</td>
<td>1.3</td>
<td>1.0</td>
<td>1.1</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>24 Motor vehicles</td>
<td>8127</td>
<td>18</td>
<td>5.3</td>
<td>4.9</td>
<td>6.5</td>
<td>7.6</td>
<td>6.9</td>
<td>7.4</td>
<td>7.5</td>
<td>7.3</td>
<td>4.0</td>
</tr>
<tr>
<td>25 Aircraft</td>
<td>4927</td>
<td>36</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>26 Trains, ships</td>
<td>6915</td>
<td>27</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>27 Instruments</td>
<td>5933</td>
<td>33</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>28 Misc. manufactures</td>
<td>6962</td>
<td>26</td>
<td>4.5</td>
<td>4.1</td>
<td>5.0</td>
<td>5.3</td>
<td>5.3</td>
<td>4.9</td>
<td>5.0</td>
<td>5.0</td>
<td>4.3</td>
</tr>
<tr>
<td>29 Transportation</td>
<td>19388</td>
<td>5</td>
<td>1.9</td>
<td>1.6</td>
<td>1.3</td>
<td>1.4</td>
<td>1.1</td>
<td>1.0</td>
<td>1.2</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>30 Communications</td>
<td>28092</td>
<td>2</td>
<td>0.8</td>
<td>1.6</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.4</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>31 Utilities</td>
<td>64896</td>
<td>1</td>
<td>4.3</td>
<td>5.0</td>
<td>4.6</td>
<td>4.6</td>
<td>4.7</td>
<td>4.4</td>
<td>3.9</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>32 Trade</td>
<td>6257</td>
<td>29</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>33 Insurance, etc.</td>
<td>4256</td>
<td>37</td>
<td>4.7</td>
<td>7.2</td>
<td>8.4</td>
<td>10.5</td>
<td>12.5</td>
<td>13.4</td>
<td>13.9</td>
<td>13.3</td>
<td>12.5</td>
</tr>
<tr>
<td>34 Real estate</td>
<td>6244</td>
<td>30</td>
<td>15.3</td>
<td>13.6</td>
<td>8.4</td>
<td>8.2</td>
<td>5.5</td>
<td>4.2</td>
<td>3.4</td>
<td>2.8</td>
<td>1.7</td>
</tr>
<tr>
<td>35 Business services</td>
<td>6350</td>
<td>28</td>
<td>13.5</td>
<td>10.0</td>
<td>11.3</td>
<td>8.5</td>
<td>10.3</td>
<td>9.8</td>
<td>10.8</td>
<td>11.5</td>
<td>17.0</td>
</tr>
<tr>
<td>36 Auto repair</td>
<td>12747</td>
<td>7</td>
<td>0.3</td>
<td>0.3</td>
<td>1.0</td>
<td>1.4</td>
<td>1.1</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>37 Institutions</td>
<td>10037</td>
<td>14</td>
<td>2.2</td>
<td>4.7</td>
<td>5.5</td>
<td>5.5</td>
<td>6.8</td>
<td>8.3</td>
<td>9.0</td>
<td>11.6</td>
<td>19.0</td>
</tr>
<tr>
<td>38 Scrap</td>
<td>9872</td>
<td>15</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
The numerical results of the calculations are shown in Table II (on p. 24). Table II shows how the representative families of the various income-classes rank by the capital-labor ratios generated by their market consumption expenditures. The family whose income is $4500 has the consumption pattern with the highest capital-labor ratio, and the family whose income is $12,500 has the consumption pattern with the lowest capital-labor ratio. The family whose income is $1500 has a market consumption pattern with a capital-labor ratio that ranks in the middle of the observed capital-labor ratios. In summary, the middle income-classes (income levels between $2000 and $7500) generate high capital-labor ratios and the high income-classes generate low capital-labor ratios. Table II also provides information on the range of income in each class.

B. Analysis of the Results

In order to analyze the results of the calculations, the total (direct and indirect) amount of capital relative to the total amount of labor to produce a dollars worth of output for each industry was computed (see Table I). The industries were then ranked using the scalers calculated (see Table I). Using this information and noting how the consumption patterns differed, the reasons for the differences in the capital-labor ratios become apparent (see Table III on p. 26). Table III focuses on the income-class with the highest capital-labor ratio and on the income-class with the lowest capital-labor ratio.

The differences in the observed capital-labor ratios are the result of differing consumption patterns. The table below focuses on the
### TABLE II

**ESTIMATES OF** \( \left( \frac{k}{l} \right)_{j, \text{market}} \)

The estimates of the capital-labor ratios are very large because they represent the dollar value of the capital stock needed to produce a dollar of final demand (column 5) divided by the man-years needed to produce a dollar of final demand (column 6). The mean of this group of numbers is 8727 and the standard deviation is 134.7. The column entitled "rank" shows how the representative families rank by the capital-labor ratios of their consumption patterns.

<table>
<thead>
<tr>
<th>Income Range</th>
<th>Family</th>
<th>( \left( \frac{k}{l} \right)_{j, \text{market}} )</th>
<th>Rank</th>
<th>total capital expenditure</th>
<th>total labor expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1000 to 1999</td>
<td>2</td>
<td>8633.2</td>
<td>6</td>
<td>1.44003</td>
<td>.0001668</td>
</tr>
<tr>
<td>$2000 to 2999</td>
<td>3</td>
<td>8825.5</td>
<td>3</td>
<td>1.50388</td>
<td>.0001704</td>
</tr>
<tr>
<td>$3000 to 3999</td>
<td>4</td>
<td>8885.1</td>
<td>2</td>
<td>1.55846</td>
<td>.0001754</td>
</tr>
<tr>
<td>$4000 to 4999</td>
<td>5</td>
<td>8955.4</td>
<td>1</td>
<td>1.55646</td>
<td>.0001738</td>
</tr>
<tr>
<td>$5000 to 5999</td>
<td>6</td>
<td>8790.1</td>
<td>4</td>
<td>1.58925</td>
<td>.0001808</td>
</tr>
<tr>
<td>$6000 to 7499</td>
<td>7</td>
<td>8718.8</td>
<td>5</td>
<td>1.6034</td>
<td>.0001839</td>
</tr>
<tr>
<td>$7500 to 9999</td>
<td>8</td>
<td>8591.2</td>
<td>7</td>
<td>1.60915</td>
<td>.0001873</td>
</tr>
<tr>
<td>$10000 to 14999</td>
<td>9</td>
<td>8561.9</td>
<td>9</td>
<td>1.64646</td>
<td>.0001923</td>
</tr>
<tr>
<td>$15000 and up</td>
<td>10</td>
<td>8593.7</td>
<td>8</td>
<td>1.78836</td>
<td>.0002081</td>
</tr>
</tbody>
</table>
differences in the demands for commodities produced either with a very high or a very low capital-labor ratio. A family with an income of $5500 generates a higher capital-labor ratio than does a family with an income of $12,500 because the middle income family:

1) devotes a higher percentage of its market expenditures than does the high income family to the products produced by the chemicals, petroleum, utilities, and auto repair industries which have high capital-labor ratios (relative to other industries)

2) devotes a lower percentage of its expenditures than does the high income family to the products produced by the textiles, insurance and business services industries with low capital-labor ratios.\(^{16}\)

In summary, the tendency for the middle income-classes to consume high levels of gasoline and utilities services and low levels of business services and financial services, compared to the consumption of these products by the high income-classes, accounts for the differences in the observed capital-labor ratios.

\(^{16}\) The market consumption pattern of the lowest income-class (income less than $2000) generates a capital-labor ratio which ranks in the middle of the capital-labor ratios. Representative family 2:

1) devotes high percentages (relative to the population) of its consumption expenditures to the chemicals industry (an industry with a high capital-labor ratio), and to the leather and services industries (with low capital-labor ratios)

2) devotes low percentages of its consumption expenditures to the petroleum and auto repair industries (industries with high capital-labor ratios), and to the textiles and finance industries (with low capital-labor ratios).
TABLE III

ANALYSIS OF RESULTS

<table>
<thead>
<tr>
<th>Industry</th>
<th>$d_{i5}$</th>
<th>$d_{i9}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Textiles and products</td>
<td>7.1</td>
<td>8.9</td>
</tr>
<tr>
<td>13 Chemicals</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>14 Petroleum refining</td>
<td>3.8</td>
<td>2.7</td>
</tr>
<tr>
<td>31 Electric and gas utilities</td>
<td>4.6</td>
<td>3.4</td>
</tr>
<tr>
<td>33 Finance and insurance</td>
<td>10.5</td>
<td>13.3</td>
</tr>
<tr>
<td>35 Business and personal services</td>
<td>8.5</td>
<td>11.5</td>
</tr>
<tr>
<td>36 Auto repair</td>
<td>1.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note: $d_{i5}$ is the percentage of consumption expenditures that the representative family for income-class 5 spends on good i. The estimated value of $(k/l)_{5,\text{market}}$ was higher than any other $(k/l)_{j,\text{market}}$ estimate. And the estimated value of $(k/l)_{9,\text{market}}$ was the lowest estimate.

The above discussion is concentrated on three income-classes, the following discussion is about the population as a whole. The observed pattern on capital-labor ratios is the result of many trends. For example, even though the middle income-classes generate the highest capital-labor ratios, they devote relatively low percentages of their consumption expenditures (compared to the low and high income-classes) to the transportation industry which has a high industry capital-labor ratio.

Several important trends can be discerned by examining Table I. In general, the percentage(s) of family consumption expenditures devoted to:
1) The textiles and insurance industries (which have low industry capital-labor ratios) increase as family income increases
2) The leather and real estate industries (which have low industry capital-labor ratios) decrease as family income increases
3) Chemical and utilities industries (which have high industry capital-labor ratios) decrease as family income increases
4) The food industry decreases as family income increases
5) Institutions (which include recreation, education and charity) increases as family income increases
6) Petroleum industry (with a high industry capital-labor ratio) are the highest for the middle income-classes
7) The transportation industry are the lowest for the middle-income classes
8) The business services industry (with a low industry capital-labor ratio) are lowest for the middle income-classes and the highest for the high income-classes
9) The motor vehicles industry are the highest for the middle income-classes.

C. Estimates of \((k/l)_{j,all}\)

Table IV (on page 28) presents the estimates of \((k/l)_{j,all}\).
TABLE IV

ESTIMATES OF $\left( \frac{k}{L} \right)_{j, \text{all}}$

The second column lists the capital-labor ratios generated using an income-elasticity of .6 for housing. The mean for this group of numbers is 16945 and the standard deviation is 1094. The third column lists the capital-labor ratios generated using an income elasticity of 1. The mean for this group of numbers is 15634 and the standard deviation is 825.5. The fourth (fifth) column shows each estimate of the dollar value of the capital stock needed to produce a dollar family demand, assuming an income-elasticity of .6 (1) for housing. The labor-expenditure ratios do not change with the change in the definition of consumption.

<table>
<thead>
<tr>
<th>Family</th>
<th>$\left( \frac{k}{L} \right)_{j, \text{all}, .6}$</th>
<th>$\left( \frac{k}{L} \right)_{j, \text{all}, 1}$</th>
<th>$\text{Capital} \over \text{Expenditure}^{.6}$</th>
<th>$\text{Capital} \over \text{Expenditure}^{1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>19028</td>
<td>14385</td>
<td>3.17402</td>
<td>2.3995</td>
</tr>
<tr>
<td>3</td>
<td>17496</td>
<td>14560</td>
<td>2.99837</td>
<td>2.48105</td>
</tr>
<tr>
<td>4</td>
<td>17395</td>
<td>14951</td>
<td>3.04586</td>
<td>2.62252</td>
</tr>
<tr>
<td>5</td>
<td>17515</td>
<td>15803</td>
<td>3.04412</td>
<td>2.74658</td>
</tr>
<tr>
<td>6</td>
<td>16994</td>
<td>15606</td>
<td>3.07264</td>
<td>2.8216</td>
</tr>
<tr>
<td>7</td>
<td>16775</td>
<td>15845</td>
<td>3.08495</td>
<td>2.9140</td>
</tr>
<tr>
<td>8</td>
<td>16497</td>
<td>16157</td>
<td>3.08996</td>
<td>3.026316</td>
</tr>
<tr>
<td>9</td>
<td>15646</td>
<td>16296</td>
<td>3.00883</td>
<td>3.13377</td>
</tr>
<tr>
<td>10</td>
<td>15058</td>
<td>17106</td>
<td>3.13375</td>
<td>3.55979</td>
</tr>
</tbody>
</table>
With an income elasticity of .6, the general tendency is for the capital-labor ratio for all consumption to decrease as the level of income increases. The reason for this is that families with low incomes devote a higher percentage of their total consumption expenditures to housing than do high income families. As noted before, however, the results with respect to all consumption should be viewed as tentative because economists who are interested in housing consumption generally believe that the transitory component of current income distorts the measured income-elasticity of housing. With an income-elasticity of 1 the capital-labor ratio for all consumption generally rises with income. Two income-elasticities were used because economists disagree about the income-elasticity of housing. If agreement can be reached on the income-elasticity of housing, we will be in a better position to estimate the capital-labor ratios generated by family consumption expenditures.

D. Judging the Importance of the Results

Four types of results could emerge from the approach taken in this paper. Any one of the following could be derived using the linear model:

1) historical patterns. This type of result suggests which groups had the highest capital-labor ratios and which had the lowest. This is the most reliable type of result.

2) historical numerical estimates. This type of result indicates the degree of the difference observed.

3) predictions of future patterns.

4) predictions of future numerical estimates. This type of result is the least reliable.
Conceptually, we know how to discern historical patterns of the relative capital-labor content of the consumption expenditures of various groups. We can also calculate numerical estimates of historical trends. The reliability of our estimates depends on the cost that we are willing to bear in obtaining them. For example, the results of this thesis could be improved by using a finer differentiation of goods and services. A clear pattern of one part of economic history did emerge - the middle income-groups' market consumption expenditures contained high amounts of capital relative to labor while the high income-groups' market consumption generated low amounts of capital relative to labor.

Making predictions about the future is a task of a different kind because we need to know the functional relationships. The linear model was used to predict that the aggregate capital-labor ratio would increase (decrease) if the income distribution is made more equal (unequal). Numbers which measure the degree of predicted change can be misleading because they can lead us to believe that our results are stronger than they really are. Throughout Chapter II remarks are made about the limitations of the linear model. Most importantly, no allowance is made for the effects of relative price changes on consumption and production decisions or for the effects of changes in the scale of operations on the input mix and relative amounts of capital and labor that a firm decides to use. Thus, there are forces which will modify even the predictions presented in an ordinal form.

---

17 The redistribution simulation is presented in Appendix II.
A more complete description of the economy, incorporating factors left out of the linear formulation, will have to be developed before the importance of the conclusions derived here can be judged. Work of this type is going on now in the fields of growth and public finance. The next chapter describes how the approach taken here relates to the development of a more complete and more accurate general equilibrium model. The results do suggest that the distribution of national income and the level of per capita income should be included in general equilibrium models dealing with issues of growth, tax incidence, employment and industrial structure.
CHAPTER IV

IMPLICATIONS

This chapter shows how our results relate to various areas of economics. The work here complements work in developmental economics, industrial organization and public finance. The tendencies observed:

1) coupled with empirical studies of underdeveloped countries help to illuminate one aspect of economic growth: factor usage.

2) can be used to help predict future production factor requirement in the U.S. economy.

3) support the development of a general equilibrium tax model.

In addition the results of this study have implications for short-run macro-economic problems. Lubell argues that making the income distribution more equal might relieve unemployment problems through an increase in total consumption expenditures (holding the level of income constant). The results of this study, however, indicate that a dollar of market consumption expenditure by a middle income family causes less employment than a dollar of market consumption expenditure by a high income family (see column 5 of Table II). Therefore the effect of a redistribution of income is ambiguous even if total consumption expenditures increase because the labor intensity of total consumption may change. If the government desires to increase

---


2 This simple exposition presented here ignores the differences between short and long-run changes in the level of personal income. The purpose here is simply to show the need to disaggregate the consumption (continued on next page)
employment through a decrease in total tax collections it appears that increasing the disposable incomes of the rich might increase employment more than will increasing the disposable incomes of the low and middle income-classes.

A. The Economics of Development

The motivation for this paper was the Land-Soligo approach to unemployment in underdeveloped economies.\(^3\),\(^4\) It was principally to contrast results from U.S. data with results from other countries that this study was undertaken.

Professor Land and Soligo have argued that labor is a resource which underdeveloped countries have under-utilized.\(^5\) It is reasoned that the production of different goods requires different amounts of capital and labor.

The Land-Soligo model is a general equilibrium model that permits analysis of how changes in income-distribution effect the capital and labor requirements of the production needed to satisfy consumption demands corresponding to a given distribution.\(^6\)

\(^2\) (continued)

sectors of macro models so that the effects of changes in the distribution of income on the factor intensity of total consumption can be examined.


\(^4\) James W. Land and Ronald Soligo, "Models for Development Incorporating Distribution Aspects," The Program of Development Studies - Paper Number 22 (Rice University, Houston, Fall 1972).

\(^5\) Ibid., p. 4.

\(^6\) Ibid., p. 17.
The traditional view is that a high savings rate (high savings are associated with regressive income distributions) will help achieve development and growth objectives. Land and Soligo, however, argue that growth in output can be achieved by using more of the labor resource, and that the way to encourage employment is through the demand for labor-intensive goods. Finally, it is hypothesized that the poor tend to consume labor-intensive goods, the implication being that making the income distribution more equal might contribute to growth objectives.

There are several empirical studies now underway which test the Land-Soligo model. Two studies have been completed; one on Brazil and the other on Colombia. The author of the Colombia study also used two definitions of consumption. The results from Colombia suggest that the capital-expenditure ratio for a family tends to increase with the level of family income and the labor-expenditure ratio for a family is stable with respect to family income levels. The

---

Ibid., p. 13.

Land and Soligo give a general description of how the pattern of income distribution relates to economic development. See: Ibid., p. 9.

A capital-expenditure ratio for a family is the ratio of capital used in the production of the consumption demands of a family divided by the total consumption expenditures (and a labor-expenditure ratio is defined analogously).

These tendencies are observed, using either definition of consumption. Source: Gustavo Jiménez, The Capital, Labor and Import Content of Urban Consumption Patterns in Colombia (Houston, June 1972), pp. 29-30.
conclusions of the study on Colombia\textsuperscript{12} comply with the Land-Soligo predictions:

In general, it can be observed that redistribution of income from high income to low income families will produce beneficial results on the demand for capital, labor and imports.

The study on Brazil\textsuperscript{13} is not supportive of the Land-Soligo hypothesis:

We find that variations in the distribution of income that one might expect to occur in a functioning market do not cause a significant variation in the structure of growth. Increasing regressivity does raise the growth rate... but only by a small amount.

The results of this study are not conclusive, however, because the agricultural sector was not included.

\textsuperscript{11} Tuncay Sunman has observed a similar tendency in Turkey. Using a definition of consumption that includes both market expenditures and an imputed value for housing, he found that the labor-expenditure ratio tends to decrease with increases in family income and the capital-expenditure ratio tends to increase with increases in family income. Sunman is currently working on his Ph.D. dissertation at Rice University to be entitled: \textit{Short-run Effects of Income Distribution on some Macro Economic Variables: The Case of Turkey}.

\textsuperscript{12} Gustavo Jiménez, \textit{The Capital, Labor and Import Content of Urban Consumption Patterns in Colombia} (Houston, June 1972), p. 35.

In summary, several trends are suggested by the Colombia and U.S. results. As the economy moves from the primitive to the developing stage, the consumption expenditures of the low income-classes tend to use low levels of capital relative to labor and the consumption patterns of the high income-classes tend to use high levels of capital relative to labor. It is generally agreed that capital is the scarce resource in underdeveloped countries. As an economy moves to a developed stage, the market consumption of the middle income-classes tend to use high levels of capital relative to labor and the market consumption expenditures of the high income-classes tend to use low amounts of capital relative to labor. Labor is generally thought to be the scarce resource in developed countries.

B. Industrial Structure

The results of this study have implications for the industrial structure of the United States. The pattern of consumer demand at a point in time is an indication of aggregate demand at a future point in time when the level and distribution of national income may differ. Economists believe that the pattern of consumer demands does affect industrial organization. Clopper Almon, who worked with the problem of predicting future U.S. industrial growth reports that:

---

14 In this section on industrial structure the data is put to its least reliable use since it is assumed that changes over time can be predicted by looking at cross-section data for a point in time.

Whiter the consumer's dollar leads, the American economy follows, and where our consumption projections go the rest of the model trails along.

Given that the industrial description of the economy used in this thesis is representative of the future, the indication is that the relative amount of capital (not including housing) to labor may decline as national income grows. The history of the U.S. economy, however, suggests that the industrial structure will change to modify this prediction. The study directed by Anne Carter demonstrated that the U.S. economy has acted to conserve the use of labor.\textsuperscript{16} Using input-output tables and estimates of the capital and labor requirements of production, Carter\textsuperscript{17} concludes that:

\begin{quote}

technological change...has made it possible for the American economy to produce a given bill of final demand with appreciably less labor and somewhat smaller quantities of fixed capital stock. The net decrease in labor requirements was achieved by means of decreasing direct labor requirements, along with changes in the relative importance of specific intermediate inputs required to deliver a given final demand.
\end{quote}

The results of the Carter study and this thesis suggest that in the future as the level of national income increases consumers will demand relatively more goods that are now produced with high amounts of labor relative to capital, but that the economy will act (through changes in the input-output structure and through changes in direct capital and labor requirements) to reduce the labor content of these goods.\textsuperscript{18}


\textsuperscript{17} \textit{Ibid.}, p. 43.

\textsuperscript{18} Carter's study suggests that if past trends continue both the capital-expenditure and labor-expenditure ratios for consumption will decline, but the labor-expenditure ratio will decline faster.
C. Public Finance

The results of this paper apply to the tax discussions now going on in public finance. The simple redistribution simulation presented in Appendix II indicates that the demand for primary factors will change with changes in the distribution of income. It should also be noted, that in a more general approach than the one taken here the distribution of income may be a function of the demand for primary factors. The following discussion relates in general terms how the estimates derived here relate to the discussions of the effects of taxes.

A recent review article by Peter M. Mieszkowski will be relied upon in describing how the approach taken here is consistent with questions currently being discussed in the area of public finance. Mieszkowski argues that the study of the effects of taxes must be complex, and in doing so illustrates the need for the type of empirical estimates made in this thesis:

While general taxes have no effect on the allocation of resources and relative commodity prices...commodity taxes imposed at differential rates on different commodities and taxes on wages and/or profits in particular sectors affect consumption choice and the demand for factors of production. The incidence of these taxes depends on a complicated interaction between the use of income (demand) factors and the source of income (production) factors. A commodity tax or a tax on factor earning in industry


20 Ibid., pp. 252-253.
X will increase the price of this good and be relatively more burdensome to the group which spends a high proportion of its income on this commodity. Furthermore, as the demand for X (industry Y) will fall (increase) as a result of the tax, the relative factor intensities of the two sectors will affect the distribution of after-tax income... Incidence, then depends on three separate effects: the source of income (demand) effect; the output (factor intensity) effect, and the factor substitution effect.

The results of this paper bear on the source of income and output effects because it provides insight into how various groups allocate their expenditures and which industries are labor intensive and which are capital intensive.\textsuperscript{21}

In summary, the results of this study seem to help in the estimation of the effects of a tax which is biased toward a group, a commodity or a primary factor. This thesis does not provide answers to tax questions, but it does indicate that the further development of a general equilibrium tax model designed to deal with tax issues is important because the factor intensities of consumption do differ.

\textsuperscript{21} It should be noted that the definition of capital may depend on the institutional arrangements in a country. For example, the U.S. corporate income tax is usually considered to be a tax on capital. The housing stock which is privately owned would not be subject to this tax on capital.
EXTENSIONS

It is the purpose of this chapter to assist the reader in judging the value of this study. The chapter contains discussions of possible variants of the formulation presented here; the importance of the capital concept; and the confidence that can be placed in the conclusions.

A. Variants

If the direction of the model is a useful one, several variants of the formulation presented here might be interesting:

1) consider other primary factors of production. We in the United States are now finding out that there may be other primary factors; energy and land.

2) use a finer division of commodity categories. The 38 sector input-output table might not have captured enough detail. For example, both rich and poor demand clothing, but the rich demand tailor-made clothing while the poor demand the mass-produced variety.

3) try other definitions of capital. Other results might be obtained if financial capital and human capital were considered.

4) add the government sector.

5) use a model that allows for variations in the input mixture.

6) consider variations in family size.
B. Capital

It was pointed out in Chapter II that the distinction between a capital and a current input is an arbitrary one. This realization raises the question: Why is capital an important concept? It would be fair to assert that economists have been struggling with this question since the day of Smith and Ricardo. I believe that capital is an important concept for the following reasons:

1) the existence of capital indicates a need and a willingness of the population to postpone consumption. We have long recognized that the creation of capital requires savings. The returns to saving and the amount of savings are related to the type of investment opportunities available, which seems (by the conclusions of this thesis) related to the level and distribution of income.

2) the size and nature of the capital stock reflects technology and the organization of production activities.

C. Methodology

The model developed here is very dependent upon economics, and the general approach that the discipline has taken is assumed to be assumed to be correct. Even taking for granted that the thrust of economics is proper there are many problems which remain and have been alluded to as the arguments were presented. The conclusions should be regarded as tendencies which will be modified by the forces ignored by the model.
Some of the persisting problems in economics show up in this paper. We need predictions to deal with big changes - yet our models are sometimes designed to deal with small changes. The questions we ask are important - but we have little confidence in our answers. We need to communicate our ideas more efficiently - yet our conclusions are dependent upon mathematical models and our sometimes unrealistic assumptions.
CAPITAL-LABOR RATIOS GENERATED BY CONSUMPTION EXPENDITURES

At any point in time it can be observed how the economy is combining factor inputs to produce goods and services. We can observe how much capital is being used relative to the labor input. The following example illustrates how decisions of producers and consumers determine the aggregate capital-labor ratio.

Assume:

1) there are two families (or groups) in the economy. Call them 1 and 2.

2) there are two industries in the economy which buy no inputs except capital and labor. Call them the durables (d) and services (s) industries. The average amount of capital used in the production of services (durables) is \( k_s (k_d) \). The average amount of labor used in the production of services (durables) is \( l_s (l_d) \). The capital-output and labor-output ratios do not change with changes in the scale of operations.

3) \[ \frac{k_s}{l_s} \frac{k_d}{l_d} \]

\[ k_s = \frac{\text{total value of capital stock in the services industry}}{\text{total output in services industry}} \]

\[ l_s = \frac{\text{total man-years used in the services industry}}{\text{total output in services industry}} \]
4) Family 1 (2) demands $c_{s,1}$ dollars of output from the services industry and $c_{d,1}$ dollars of output from the durables industry ($c_{s,2}$ and $d_{s,2}$).

The following equation defines the aggregate capital to labor ratio for consumption expenditures:

$$\left( \frac{k}{l} \right)_{\text{aggregate}} = \frac{(c_{s,1} + c_{s,2})k_s + (c_{d,1} + c_{d,2})k_d}{(c_{s,1} + c_{s,2})l_s + (c_{d,1} + c_{d,2})l_d}$$

The definitional identity simply states that the aggregate capital-labor ratio is equal to total capital divided by total labor.

The relative amount of capital to labor used in the production of goods and services for a family can also be computed. Because of the assumptions about production, a capital-labor ratio (for a family, group or economy) can be computed using consumption expenditures expressed in either percentage or dollar terms. By putting consumption expenditures into percentage terms, consumption patterns can be easily compared. Given the assumptions about production, it is the pattern of consumption expenditures that determines a capital-labor ratio. In a sense, the assumptions about production isolate the effect of consumption decisions on capital-labor ratios.
A REDISTRIBUTION SIMULATION

In order to estimate the effects on the aggregate capital-labor ratio of a redistribution of income, a simulation was carried out in which the question was posed: What will happen to the aggregate demands for capital and labor if $100 is taken from the representative family in one income-class, \( f \), and given to a family in another income-class, \( j \)? It was assumed that only the consumption patterns and the total expenditures of the families involved in the redistribution would be affected. The aggregate capital-labor ratio can change if the aggregate pattern of consumption expenditures changes even though the capital-labor ratios of the various industries do not change.*

To estimate the effects of a redistribution the following consumption functions were postulated:

\[
C_j^+ = C_j + \frac{100}{Y_{j+1} - Y_j} (C_{j+1} - C_j)
\]

\[
C_f^- = C_f + \frac{100}{Y_f - Y_{f-1}} (C_{f-1} - C_f),
\]

where \( C_j^+ \) and \( C_f^- \) are the new consumption patterns of \( j \) (whose income was increased) and \( f \) (whose income was reduced), and where \( C_{j+1} \) and \( C_{j-1} \)

---

* The market definition of consumption is used in this simulation.
is the vector which describes the consumption expenditures of the representative family in the next higher (lower) income class (and $C_{f+1}$ and $C_{f-1}$ are defined analogously). The first equation demonstrates the assumed effect on consumption of a $100 increase in the jth family income. The second equation demonstrates the effect of a $100 reduction in income.

The relative amounts of capital and labor required to produce the new family demand patterns were computed. In this simulation it is assumed that the economy is composed of an equal number of representative families in each income-class. In order to determine the effect of a redistribution of income on the aggregate capital-labor ratio the initial aggregate ratio (before redistribution) is compared with the new aggregate ratio (after redistribution).

The results of the redistribution simulation are shown in the table on the next page. One conclusion derived from the simulation is that a redistribution from poor to rich will lower the aggregate capital-labor ratio. In other words, as the income distribution is made more unequal, the aggregate capital-labor ratio will decrease. If the redistribution is made from high to low income-classes, the aggregate ratio will increase.
The initial aggregate capital-labor ratio is 8676.6. By comparing the initial ratio with the ratio after the redistribution, it can be determined whether a redistribution will raise or lower the aggregate ratio. For example, the first redistribution from families 8, 9 and 10 to families 2, 3 and 4 will raise the aggregate ratio. The last column of the table shows whether or not the redistribution raised or lowered the aggregate ratio. It should be noted that an income redistribution has a small effect on aggregate capital-labor ratios.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Aggregate Ratio</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,9,10</td>
<td>2,3,4</td>
<td>8677.5</td>
<td>+</td>
</tr>
<tr>
<td>7,8,9</td>
<td>2,3,4</td>
<td>8679.4</td>
<td>+</td>
</tr>
<tr>
<td>7,8,9,10</td>
<td>2,3,4,5</td>
<td>8677.3</td>
<td>+</td>
</tr>
<tr>
<td>7,8,9</td>
<td>3,4,5</td>
<td>8677.9</td>
<td>+</td>
</tr>
<tr>
<td>3,4,5</td>
<td>7,8,9</td>
<td>8673.8</td>
<td>-</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY


Jiménez, Gustavo. The Capital, Labor and Import Content of Urban Consumption Patterns in Colombia, a Master's Thesis at Rice University. Houston, June 1972.


