MEASURING THE CONTRIBUTIONS OF NATURAL RESOURCES TO THE NATIONAL OUTPUTS OF THE UNITED STATES AND JAPAN

by

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CHAPTER I

INTRODUCTION

The attempt of this study is to appraise the importance of some factors which explain the difference in productivity of the Japanese and U.S. economies. The explanation is attempted in fairly narrow economic terms; that is, the historical and institutional patterns lying behind the economic situation are not discussed except incidentally. Rather we picture the output of Japan and of the United States as being the result of employment of different factors of production available. In particular we are interested in distinguishing the agricultural and non-agricultural contributions to differences in incomes, and in assessing for each sector, the importance of materials, labor, and capital equipment in causing the differences in observable incomes. Naturally we have not finished this task, but some steps have been taken.

Suppose then we picture the output of Japan as composed of agricultural output and non-agricultural output, each being produced by labor, capital equipment, and raw materials. We picture the output of the United States in the same way. What is the importance of each of the three factors within the two broad sectors in determining the relative output of the two countries? It is assumed for the purpose of this study that economies of scale, technological knowledge, enterprise, and willingness of laborers to work hard are not explanations of the difference in per capita production. These assumptions are no doubt false. It is presumed however, that progress in understanding all forces in operation will best be made by concentrating on a few. Thus this study is concerned only with output and the three factors of production mentioned.

The plan of the study is this. In the first part of this study the existing studies of others on productivity will be considered. In the second chapter some general characteristics of postwar Japan's economy in comparison with that of the United States are presented. Economic growth, i.e., output growth, per capita income growth, the structural change of industry and the structure of foreign trade will be dealt with mainly. In chapter III, production levels and factors employed in the agricultural sectors of the United States and Japan will be considered. In chapter IV, production levels and raw materials used in non-agricultural sectors of the United States and Japan in 1951 will be discussed. In chapter V, the role of each factors of production, including capital equipment will be summarized.

The Production Function Approach

In order to reduce the problem to manageable proportions, the assumption has been made that in each of the two sectors in each country, we can write a production function in the form

Output = function (labor, capital equipment, resources);

and that the nature of the function in the two countries for each sector is the same. Provisionally, however, that is in Chapter III and IV we eliminate capital equipment, and assume that natural resources alone explain the difference in output per worker. This makes it possible to deal with only two factors, and to study the effect of resources in isolation. In particular, we seek to determine how far diminishing returns explain the observable differences in productivity of labor.

The basic method used (which will be explained more fully later) is to use price and income data to obtain equilibrium values, which will determine the shape of the production functions. It is then possible to assign importance to the role of resources, if the proportions of factors were altered to be the same in the two countries. Thus the basic problem encountered, after making the particular assumptions about the nature of the production function just mentioned, was to state the production function in a form which permitted the uses of the statistical data available. This was done differently in the two sectors.

In the agricultural sector, it was possible to obtain more sensible estimates of aggregate incomes of the two sectors, than of price per unit of land and labor. Thus it was desirable to assume a form of production function which gave values of shares of income of factors of production. This could be done by the Cobb-Douglas production function,

$$P = b\, X^{k} Y^{1-k}$$

where P is output, b constant, k constant, X and Y factors. The total income of factor X is then k.P and for Y is (1-k).P. In terms of isoquants, that is relation of X and Y when P constant we have

$$\frac{\partial Y}{\partial X} = \text{constant}.X^{\frac{1}{k-1}}$$

This slope of isoquant expression is not readily usable however, because price data are not available. The slope of the isoquant in the case k = 1/2, is readily seen to be such that the slope of marginal rate of technical substitution changes with X roughly in the manner of the rectangular hyperbola.

In the case of the non-agricultural sector, the slope of the isoquant itself has been assumed, that is

$$\frac{\partial Y}{\partial X} = a X + b$$

This may be considered a linear approximation of the slope of the isoquant of Cobb-Douglas production or any other production function.

Other Studies

Two major concepts regarding measurements of productive efficiency are developed in existing economic theories. One is partial measurement of productive efficiency, and the other is total measurement of productive efficiency. The partial measurement is defined as the total output divided by quantities of each input; such as labor, land, materials, machine and buildings. Above all, the concept of labor productivity has been used as a measurement of productive efficiency for a long time. The concept of total productivity is defined as net value of total output, divided by total inputs; i.e., the summation of value of labor input and capital input. In this method, the total output and the value of inputs must be obtained by using weights of a base country. The results are called indices of efficiency. A difficulty in this approach is to run into the troubles of price indexes. In order to avoid this defect of indices of efficiency, the total inputs coefficients approach as the concept of total productive efficiency was developed. The concept of input coefficients is defined in terms of production isoquants of economic theory. That is, productive efficiency is determined by maximum output with the least input. Total measurement of productive efficiency is a recent development of productivity study. The indices of efficiency have been developed in National Bureau of Economic Research since the end of the World War II. The input coefficients approach was used by Farrel, 1957.

L. Rostas, Colin Clark, and Marvin Frankel have made international comparative studies of productivity by using the method of partial measurement. Rostas made a comparison of output and employment in thirty-one industries of the United States and England in the prewar periods, 1935-1939. Comparisons were made in terms of physical output per worker and per man-hour. Rostas distinguished the different concepts between physical output per man and per man-hour as follows:[1]

> When measuring changes in productivity of labor in the purely technical sense or measuring costs of production, the output per man-hour concept is the relevant one. For many other purposes, e.g., estimating man-power requirements, or future national incomes, comparing real incomes in different countries, etc., the output per man concept is more appropriate.

His measurements were concentrated in the average labor productivity and expressed in terms of the physical output per man and man-hour.

Colin Clark made broad studies of international comparative productivity in order to estimate the trend of economic growth over a long-range period in the different countries in his book entitled, The Conditions of Economic Progress. In chapter V of this book, he indicates the various measurements of productivity in primary industry such as output per man, output per man-hour and output per acre. He also paid attention to the "diminishing returns" relation in primary industry by calculating the average labor productivity. He expresses the labor

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[1]Rostas, L., Comparative Productivity in British and American Industry, Cambridge, English University Press, 1948, p. 25.

productivity at national product level in terms of the international monetary unit in symbols as follows:[1]

$$\frac{p(M + I - E - V) + E' - I'}{\text{Number of Workers in Year}}$$

where M represents national income at market prices in national currency, including an allowance for imputation, V (which may be negative represents net investment income received from abroad, E and I represent exports and imports in national currency and E' and I' exports and imports measured in the international monetary unit: p represents purchasing power of one unit of national currency per international monetary unit (I.U). He computed the labor productivity at national product level in terms of I.U. for the various countries. His defense of labor productivity expressed in terms of money value is worth while noticing:[2]

> We can only assume that money values give an adequate measure of the trend of real values if we know that the goods are sold in the same market, which is not often the case when we are comparing industries in different countries. Even if we are comparing different firms within one industry in one country at one time, a certain amount of caution is still necessary. The market may be imperfect, and the same goods may in fact be being sold at lower prices by the more successful firms, and at higher prices by the less successful.

Not only the different national currency but also the different market system in the different countries give rise to difficulties for the international comparative study of productivity in terms of money value. This is the main problem with which the student of international comparative study is faced. This problem is dealt with in later in this

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[1]Clark, Colin: The Conditions of Economic Progress, London, Macmillan Co., 1957, p. 89.

[2]*Ibid.*, p. 86.

chapter in greater detail.

Marvin Frankel studied the international comparative labor productivity in the manufacturing industry of England and the United States. His measurements of labor productivity are expressed by the value of output per man-hour between two countries. The value of output is expressed in terms of dollars by using the exchange rate (or the official fixed exchange rate). He applied this method of measurement of labor productivity in his article entitled "Anglo-American Productivity Differences: Their Magnitude and Some Causes",[1] and in his book entitled, British and American Manufacturing Productivity, A Comparison and Interpretation.[2] He further states the necessity of measurement of labor productivity by a formula such as V/L, where V denotes value added and L, number of workers, in his recent article:[3]

> It is a common and plausible notion that the proportions in which productive factors are combined depend, given the limits of prevailing technology, on relative factor prices. A corollary of this notion is that should the price of one factor rise, its use will be economized and other factors substituted for it. Since the development process typically is associated with rising incomes and wage rates, it is reasonable to expect this process to be accompanied by rising output per worker and by an observable relationship between the movement of output per worker and the movement of the wage rate.

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[1]Frankel, Marvin: "Anglo-American Productivity Differences: Their Magnitude and Some Causes" American Economic Review, May, 1955.

[2]Frankel, Marvin: British and American Manufacturing Productivity, A Comparison and Interpretation, University of Illinois, 1957.

[3]Frankel, Marvin: "Methodology For an International Comparison of Productivity Levels and Wage Rates" Memorandum Number C-9, Department of Economics, Stanford University, August 1958. p. 1.

He thinks the measurement, value added divided by number of workers, is desirable. In the economic development process, we cannot ignore the relative factor prices because, it affects substitution for factors and productive efficiency.

As for measurements of total productivity, we have not had any statistical works based upon an international comparison. However, as far as the idea of indices of efficiencies is concerned, it has been developed in the intertemporal comparative basis within a country by Jacob Schmookler,[1] George Stigler,[2] Solomon Fabricant[3] and John Kendrick[4] since the end of World War II. John Kendrick has computed the total national productivity over the long-range periods. Labor input is measured by man-hours worked, by type, weighted by base periods average hourly earnings; and input of capital (including natural resources) is measured in terms of the real net stocks employed in the various industries weighted by the base period of rates of return. His total productivity is expressed in the formula as follows:

$$\frac{\text{Output}}{\text{Labor input} + \text{Capital input}}.$$

He further constructed a model for the purpose of interspatial comparison

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[1]Schmookler, Jacob: "The Changing Efficiency of the American Economy," 1869-1938, Review of Economics and Statistics, Vol. XXXIV, August, 1952.

[2]Stigler, George: Trends in Output and Employment, New York, National Bureau of Economic Research, 1947, pp. 42-43.

[3]Fabricant, Solomon: Summary of Proceedings of Conference on Productivity, Bulletin No. 913 (Washington: Government Printing Office, 1946), U.S. Department of Labor, pp. 2-3.

[4]Kendrick, John: The Meaning and Measurement of National Productivity. Dissertation, The George Washington University, June 8, 1955.

of national productivity. He has chosen two hypothetical countries, Y and Z; and obtained the homogeneous products weighted by country Y or country Z. He divided labor input into the skilled labor and unskilled labor and obtained the hourly wage rate weighted by country Y or Z. He found that the wage compensation of each skilled and unskilled labor could be measured by way of multiplying the weighted hourly wage rate. Stock of capital and rate of return are also weighted by country Y or Z. Compensation of capital is obtained by multiplying stock of capital and the rate of return weighted by country Y or Z. Total productivity is obtained from the value of homogeneous products divided by the summation of labor input compensation and capital input compensation.[1] Although he made the model for the interspatial comparative study of productivity, he did not apply it in practice.

Finally, the input coefficients approach by Farrell[2] is introduced below. He examines the agricultural productivity in the forty-eight States of the United States. Denoting output as (a), he takes cash receipts from farming plus values of home consumption in millions of dollars. Denoting land as (b), he takes land in farms minus woodland and other land not pastured, in thousands of acres. Denoting labor as (c), he takes men on farms, including farmers, farm managers, and unpaid family workers. Denoting materials as (d), he takes expenditure on feed, livestock and seed purchased in thousands of dollars. Denoting capital as (e), value of implements and machinery on farms in 1950 in

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[1]Kendrick, John: Op. cit., p. 125.

[2]Farrell, J. M.: "The Measurement of Productive Efficiency", Journal of Royal Statistical Society, Series A (General) Vol. 120, Part 3, London, March, 1957.

thousands of dollars, then, four input coefficients are expressed as follows:

x_1 = b/a (Land)

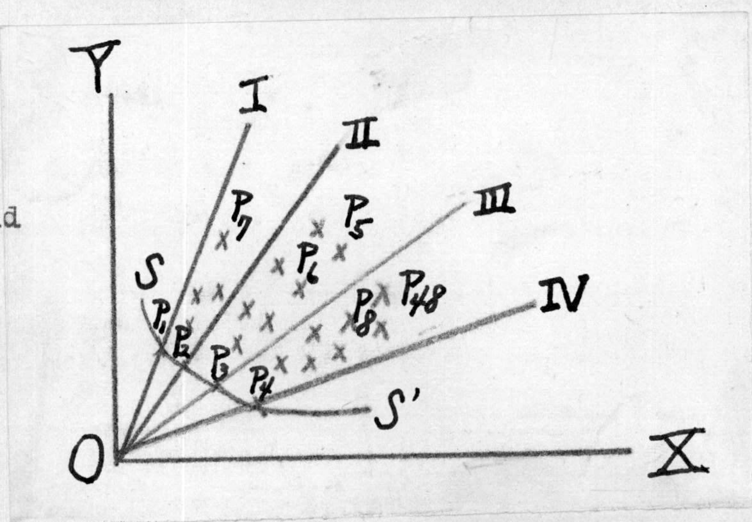
x_2 = c/a (Labor)

x_3 = d/a (Materials)

x_4 = e/a (Capital)

For the convenience of illustration, two input coefficients are assumed, land input coefficient and labor input coefficient. If we take land input coefficients on vertical line, Y axis, and labor input coefficient on horizontal line, X axis, then we can obtain 48 points (or P_1 ....P48) which represent the points of combination of two input coefficients for forty-eight States. We will be able to find the closest points to OX and OY, then we will link together these closest points; we can call this line the highest efficient isoquant observable, say, 100 per cent of efficiency. The efficiency of the rest of points will be calculated from the standpoint of 100 per cent of efficiency. This is illustrated geometrically as follows:

Land



Labor
Chart I

Four States, P_1, P_2, P_3, and P_4 have the highest efficiency, 100 per cent of efficiency. The rest of States will be estimated in relation to 100 percent of efficiency, i. e., using isoquant S - S'. The points which belong to the boundary line, I and II will be based upon P_1 - P_2, the points which belong to the boundary line II and III will be based upon P_2 and P_3, and points which belong to the boundary line, III and IV will be based upon P_3 and P_4 for the estimate of relative efficiency. Algebraically, the efficiency of the rest of States, 44 States, is expressed as follows:

$$\frac{1}{\lambda_1 + \lambda_2}$$

where λ stands for scalar multiple of vector P.) In case of four variables, the efficiency can be expressed as follows:

$$\frac{1}{\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4}$$

λ_1, λ_2, λ_3, and λ_4 will be solved by the determinants as follows:

$$\lambda_1 = \frac{|A_1|}{|A|}, \qquad \lambda_2 = \frac{|A_2|}{|A|},$$

$$\lambda_3 = \frac{|A_3|}{|A|}, \qquad \lambda_4 = \frac{|A_4|}{|A|}$$

where A stands for the determinants of coefficient matrix.

Farrell's new method of measurement of productive efficiency is technically excellent. However, prices of factors of production are completely ignored for the estimate of productive efficiency. Although he may be able to estimate the technical efficiency, he cannot estimate the economic efficiency. In the application of isoquants, the relative price of production factor is a key to determine the economic efficiency, i.e., the iso-cost and isoquant determines the maximum economic efficiency. As in the case of Kendrick's total productivity approach, the role of each factor of production is not explicitly expressed because of the process of aggregation. The total productivity approach is inadequate for the present study, because it only states that a country's per capita income is low because of low productive efficiency. Our main concern here is to seek the causes of low productivity due to the role of each factor of production. Therefore, we will apply the partial measurement of productive efficiency.

As was shown, the development of partial measurement of productive efficiency in the international comparison was very slow. No one has worked out the role of scarcity of resource factor in the productivity of other factors of production empirically using the marginal productivity concept. Unless we measure the marginal productivity of factors of production, we will not be able to explain the principle of "diminishing returns" in country A relative to that of Country B.

For the purpose of measuring the relative diminishing returns of factor of production in a country A to that of a country B, we need the relative prices of factors of production. Even in Farrell's total input coefficient approach, we cannot eliminate the value concept, e.g., value of output, expenditure of feed, livestock and seed purchased, and value of implements and machinery. This problem leads one to convert the national currency into the same denominator, such as the U.S. dollar for the sake of the international comparative study.

Measuring the value of output in various countries, as estimated in terms of national currency, into a common currency unit, usually the dollar, by means of prevailing exchange rates has been done by several students. The international comparisons of national products are in constant need for some quantitative measure of the relative economic strength of countries. However, Gilbert and Kravis[1] pointed out that international comparison of income based on conversions by exchange rates must be suspect and improbable. Many reasons which they raised are summarized as follows:

(a) In view of the severity of present day exchange controls and the existence of quantitative restrictions to trade, it would be necessary for a long-term equilibrium in exchange rates to exist. An attempt is often made to overcome this difficulty by starting with the exchange rate in a period which appears closer to a free market equilibrium and computing the purchasing power parity to the period required on the basis of relative changes in the price indexes of the countries being compared. However, it does not help to establish the appropriate purchasing power relationship of currencies owing to the more fundamental objections indicated below.

(b) The equivalence, still for internationally traded goods, between the relationship of internal prices and exchange rates, is prevented by barriers to trade in the form of tariffs and transportation costs.

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[1]Gilbert, Milton and Kravis, B. Irving, An International Comparison Of National Products and the Purchasing Power of Currencies. A study of the U.S.A., the United Kingdom, France, Germany and Italy, O.E.E.C., 1954. pp. 15-16.

(c) Even if the relation of prices of internationally traded goods were approximately the same as exchange rates, the final prices to domestic buyers would certainly differ widely because of differences in the margin added for net indirect taxes, domestic processing, internal transportation and distribution costs. For a comparison of final products, it is only the price of quantities purchased by the consumer that is significant for the purpose of converting the national product of one country to the currency units of the other.

(d) This difficulty is considerably magnified by the fact that the bulk of the final goods and services included in the gross national products are not traded internationally, and that the relationship of the prices of such goods to exchange rates become very tenuous. Hence, to convert the value of this domestically produced and consumed bulk of the national product by exchange rates introduces serious distortions in the comparisons of the total national products.

(e) Since countries differ in the relative amounts of goods and services of different kinds that they utilize, and since their relative internal price structures differ, there need not in fact be a unique answer such as exchange rates.

Thus, in comparing the national products of the United States and Japan, the quantities of the various goods and services utilized in the two countries can be combined either on the basis of the United States prices or Japanese prices. As in customary index number formulation, the following two expressions are available for this purpose.

$$(1)\qquad I_p = \frac{\sum P^J \; Q^J}{\sum P^U \; Q^J} = \frac{\sum W^J}{\sum W^J \left(\frac{P^U}{P^J}\right)}$$

$$(2)\qquad I_L = \frac{\sum P^J \; Q^U}{\sum P^U \; Q^U} = \frac{\sum W^U \left(\frac{P^J}{P^U}\right)}{\sum W^U}$$

Where P and Q indicate respectively for retail prices and quantities, and W equals P.Q. J and U stand for Japan and U.S. equation. (1) indicates the Paache index formula and (2) the Laspeyeres one.

There must be two answers unless there is great similarity in the relative price structures. An average of these two results will be used for the practical purpose. Watanabe and Komiya[1] made price comparisons for 1952 between Japan and U.S. by method similar to that which Gilbert and Kravis made for European countries, the United Kingdom, France, Germany and Italy, comparing their prices with the United States in 1950. The results of Watanabe and Komiya will be adjusted for particular years by using the implicit price deflators for the gross national products.[2]

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[1]Watanabe, T., Komiya, R., "Findings From Price Comparisons Principally Japan VS. The United States", Memorandum Number C-5, Department of Economics, Stanford, September, 1957. Mimeographed Report was Published in Japanese in 1955 by the Ministry of Finance, Japan.

[2]See Appendix p. 177 for the estimated exchange rate adjusted for the postwar periods by this writer.

CHAPTER II

SOME GENERAL CHARACTERISTICS OF THE POSTWAR JAPAN'S ECONOMY IN COMPARISON WITH THE UNITED STATES

As is well known, the greater scarcity of natural resources relative to population is a fundamental characteristic of the Japanese economy in comparison with the United States. Other differences are in amounts of capital, foreign trade and industrial structure. Some of the differences will become more clear if we examine the Japanese postwar economy. The following topics will be considered.

I. Output growth in postwar decade.

II. Per capita income as compared to other countries.

III. Industrial breakdown in comparison with the U.S.A.

IV. Structure of foreign trade compared to the U.S.A.

Although the topics listed above cannot cover everything regarding the important characteristics of her economy, the reader will be able to understand the most important general characteristics of the Japanese economy which are the prerequisite of understanding the comparative productivity in the agricultural sectors and non-agricultural sectors for the U.S.A. and Japan.

I. Output Growth in The Postwar Japan

This section deals with the nature of the gross national products, net national products and national income in the U.S.A. and Japan, rate of growth of real products in comparison with other countries and breakdown of the gross national products among consumption, investment and government in Japan compared with the United States. The main reasons for Japan's high rate of output growth will be considered also.

Measurements of Income

The Japanese Economic Planning Board in the postwar period has used concepts of gross national product, net national product and national income exactly the same as the concepts which the United States Department of Commerce employs.[1] Thus in general structure, the national accounts for the two countries are the same.

Gross national product is the value of all production in a nation in a time period. National income is the cost incurred in producing this output. The former is the product approach and the latter is the income approach. Valuation basis for gross national products is mainly the present market prices and for national income the cost of factors of production. The relation between the gross national product and national income is given as gross national products, less capital consumption allowances, less indirect business taxes and related liabilities, less business transfer payments plus subsidies, less current surplus of government enterprises equals national income. National income is the identity of the net national products.[2]

The constant-dollar or Yen gross national product is a comprehensive measure of the real volume of national production, including not only the

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[1]Rosovsky, Henry, "Statistical Measurement of Japanese Economic Growth", Economic Development and Cultural Change, Vol. VII, No. 1. October, 1958.

[2]Simpson, Paul, "Approaches to National Output Measurement." Journal of the American Statistical Association, Vol. 53, Dec. 1958.

manufacturing industries, but also the extractive industries, construction, distribution, services, and government. The best measure of the output growth is obtained from the net national product in constant prices.[1] The constant-dollar or - Yen net national products are obtained from the implicit price deflator for gross national products. The implicit price deflator for gross national products is derived from the weighting process of applying a price indexes for the various consumer goods, producer's goods and export goods. The implicit price deflators for gross national products in the United States and Japan are given in Appendix of this thesis.[2]

Measurements of Rate of Real Income Growth in Postwar Japan, 1946-55

The growth rates of real products are defined as the relative change of real output in the time period 2 to the real output in the time period 1. The rate of growth of real output is expressed in symbols as follows:[3]

$$G = \frac{Y_i - Y_{i-1}}{Y_{i-1}} \qquad (1)$$

where G stands for the growth rate of real income, Y stands for the real national income, or the net national products in constant prices, and

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[1]Cohen, B. Jerome, Japan's Postwar Economy, Indiana University, 1958, p. 43.

[2]See Appendix p. 177, This Thesis.

[3]Tsuru, S. and Ohkawa, K., "Concept of Growth Rate and Its Application to the Japanese Economy" Analysis of the Japan's Economy (Nihon Keizai No Bunseki), Tokyo, Keiso-Shobo, 1953. p. 6.

subscriptions i and i-1 respectively indicate i th of year and base year.

The real output growth in the postwar Japan can be computed by the equation (1). Statistical results of real output growth from 1946 to 1955 in base years, 1934-1936, are shown in Table I.

TABLE I

Output Growth in Constant Price, 1946-1955, Japan

(1934-1936 = 100)
(Unit: Billions of Yen)

	(1) Real Output (= Y)	(2) Change of Real Output relative to Previous Year. ($Y_i - Y_{i-1}$)	(3) Change of Real Output Relative to year of 1946. ($Y_i - Y_{1946}$)	(4) Rate of Growth to previous year. ((2)/Y_{i-1}) (= G)%	(5) Rate of Growth to Year of 1946 (3)/ Y_{1946} (= g) %
1934-36	14.4				
1946	8.2				
1947	8.7	0.5	0.5	6.1	6.1
1948	10.2	1.5	2.0	17.2	24.4
1949	11.8	1.6	3.1	15.7	37.9
1950	13.9	2.1	5.7	17.8	69.5
1951	15.2	1.3	7.0	9.4	85.5
1952	16.8	1.6	8.6	10.5	105.0
1953	18.1	1.3	9.9	7.6	110.0
1954	18.6	0.5	10.4	2.7	127.0
1955	20.2	1.6	12.0	7.9	146.5

Source: National Income and National Economic Accounts of Japan, 1930-1955, National Income Section, Research Division, Economic Planning Board, Tokyo, November, 1956.

The above table shows that the recovery in Japanese income and output in the postwar decade has been impressive. Continuous and remarkable output growth has been achieved from 1946 to 1955. National income or net national products rose from 1946 to 1955 by 148.5%. A rough annual average rate of output growth was 10.1 per cent over nine years, although the rate varied considerably from year to year. By the end of 1955, real national income was 40.2% higher than the 1932-36 average and 45.5 per cent higher than for 1950.

International Comparisons of the Rate of Output Growth

The rapid output growth of the postwar Japanese economy will be more clearly visualized if we present an international comparison of the rate of output growth. This comparison has been made by Economic Planning Agency, Japanese Government, in Economic Survey of Japan, 1957-58.[1] The average annual rates of output growth from 1950 to 1957 in Netherlands, West Germany, France, the United Kingdom, the United States and Japan are shown in Chart 2. Chart 2 shows that Japan led the world by a large margin in the rate of output growth and it was much higher than that of West Germany. This was termed a "miracle" of the world economy, and compared favorably with those of socialist countries.[2] The annual average rates of output growth in Japan over this period was roughly 11 per cent, for West Germany roughly 9.7 per cent, for France 6.6 per cent, for Netherlands 5.5 per cent, for the United States 4.6

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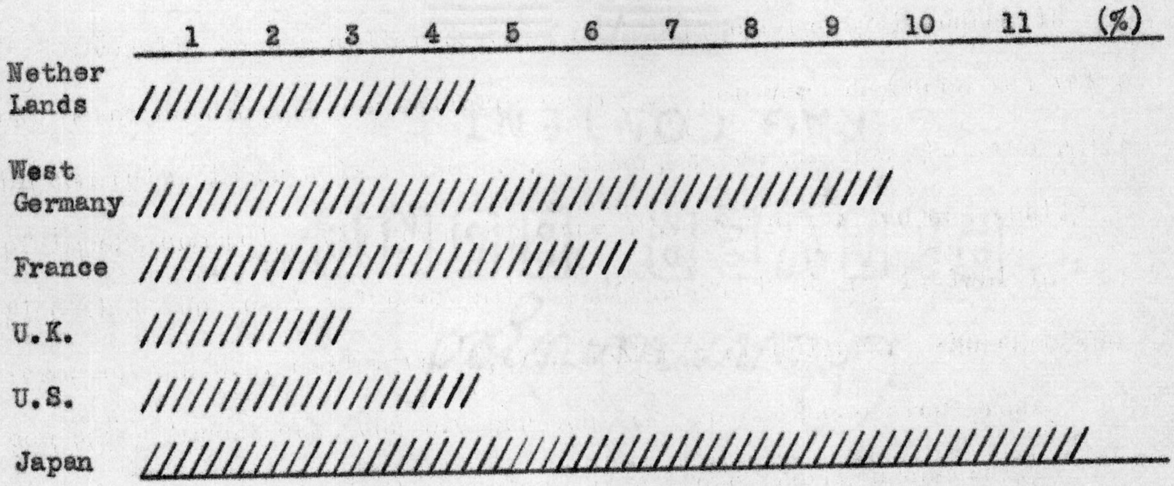
[1]Economic Planning Agency, Economic Survey of Japan, 1957-58, Japanese Government, Tokyo, 1958, pp. 42-43.

[2]Ibid., p. 43.

per cent, and for the United Kingdom 2.8 per cent.

CHART 2

POSTWAR OUTPUT GROWTH RATES, 1950-57
(Percent per Year)



Remarks: Based on National Income Statistics Compiled by Economic Planning Agency, Japanese Government.

The nature of the output growth is best seen by comparing the breakdown of the gross national products (including such components as personal consumption, gross private domestic investment, net exports of goods and services and government purchase of goods and services) of Japan with that of the United States in the postwar periods.

Comparisons of Breakdown of the Gross National Products for the United States and Japan in the Postwar Periods

The breakdown of gross national product by relative importance of components for the United States and Japan from 1946 to 1955 is shown in Table II. We notice that the ratios of consumption to the gross national products in Japan are relatively small compared to those for the United States in the postwar periods, except in 1946. On the other hand, the ratio of investment to the gross national product in Japan was much

TABLE II

<u>Comparisons of Ratio of Component of Gross National Products for U.S. and Japan</u>

	Consumption	Investment	Net Exports	Gov't Purchase
1946				
U.S.	69.8	13.4	2.3	14.5
Japan	70.3	16.0	-4.1	17.8
1947				
U.S.	70.6	13.4	3.9	12.1
Japan	69.9	15.2	-4.1	19.0
1948				
U.S.	68.7	16.6	1.3	13.3
Japan	65.3	18.5	-4.1	20.3
1949				
U.S.	70.20	12.8	1.5	15.6
Japan	67.0	15.8	-3.3	20.5
1950				
U.S.	68.5	17.6	0.2	13.7
Japan	61.6	20.1	2.6	15.7
1951				
U.S.	63.8	17.1	0.7	18.4
Japan	56.4	24.6	3.0	16.0
1952				
U.S.	63.3	14.4	0.4	21.9
Japan	59.8	19.3	2.3	18.6
1953				
U.S.	63.7	13.8	0.1	22.7
Japan	61.7	19.6	0.2	18.5
1954				
U.S.	65.6	13.5	0.3	20.7
Japan	63.4	17.0	1.0	18.6
1955				
U.S.	64.6	16.1	0.3	19.0
Japan	62.1	16.5	1.7	19.5

Sources: (1) <u>U.S. Income and Output</u>, A Supplement to the Survey of Current Business, United States Department of Commerce, Office of Business Economics, 1958.

(2) <u>National Income and National Economic Accounts of Japan</u>, 1930-1955, November, 1956, National Income Section, Research Division, Economic Planning Board.

greater compared to that of the United States in the postwar period. As for the ratio of net exports to the gross national product, Japan's figures were much greater than those of the United States of 1950. This means that Japan exported capital after 1950 several times more than did the United States.

The higher rates of output growth in the postwar Japan compared to those of the United States were, indeed, dependent upon the Japan's higher ratios of the private domestic investment and the favorable world trade right after the Korean War for Japan. The reasons of Japan's high growth rate in the postwar periods will be elaborated in detail below.

The Main Reasons For Japan's High Rate of Output Growth in the Postwar Periods

a) Investment

First, the private domestic investment is one of most important factors in growth. Output growth rate requires more capital investment and the additional investment requires personal and business savings. Further, increased savings require higher productivity, i.e., higher real income. In order to express this relation in s imple terms, let us denote the marginal capital coefficients by b and the rate of savings by a: then,

$$(2)\quad a = \frac{K_i - K_i - 1}{Y_{i-1}}$$ (where K stands for the stock of Gross Private Domestic Investment.)

$$= \frac{\Delta K}{Y_{i-1}}$$

$$(3)\quad b = \frac{K_i - K_{i-1}}{Y_i - Y_{i-1}}$$

$$= \frac{\Delta K}{\Delta Y}$$

Divide (2) by (3), we can obtain the equation (1) in page 18.

$$(4)\quad G = \frac{Y_i - Y_{i-1}}{Y_{i-1}} = \frac{a}{b}$$

i.e., the rate of output growth is a function of the rate of savings and the marginal capital coefficients.[1] The higher rate of savings and lower marginal capital coefficients cause the higher rate of output growth. The rate of savings and marginal investment coefficients for

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[1]Harrod, R. F., Towards a Dynamic Economics, London, Macmillan Co., 1954, p. 80.

the U.S.A. and Japan in the postwar periods are shown in Table III.

TABLE III

Comparisons of rate of savings (a) and marginal investment coefficients (b) for U.S. and Japan, 1946-1955

	(1) Rate of Savings (a) %	(2) Marginal Investment Coefficients (b) %	(3) Rate of Output Growth (G) % (a) / (b)
1947			
Japan	1.2%	20.%	6.%
U.S.	-0.032%	450.%	- 0.007%
J/U	37.5	4.4%	
1948			
Japan	9.1%	50%	18.%
U.S.	0.294%	76.8%	0.38%
J/U	30.9	65.1%	
1949			
Japan	-2.9%	-20%	14.5%
U.S.	-0.386%	2,825.%	-0.013%
J/U	7.7	0.7%	
1950			
Japan	8.5%	48%	17.7%
U.S.	0.594%	68.5%	0.87%
J/U	14.3	70.0%	
1951			
Japan	7.9%	85.0%	9.2%
U.S.	-0.088%	-12 %	0.7%
J/U	90.	700 %	
1952			
Japan	-3.9%	-38 %	10.2%
U.S.	-0.214%	-62 %	0.34%
J/U			
1953			
Japan	3.0%	38%	7.8%
U.S.	0.006%	1.3%	0.46%
J/U	500.	2923 %	
1954			
Japan	-2.8%	-100 %	2.8%
U.S.	0.046%	-28.8%	-0.16%
J/U			
1955			
Japan	1.1%	13 %	8.4%
U.S.	0.375%	45.9%	0.08%
J/U	2.9	28.3%	

Sources: The same as Table II.

The above table seems to support the hypothesis which we made. The rates of savings in the postwar Japan were much higher than those of the U.S.A. and the marginal investment coefficients in the postwar Japan were lower than those of the United States except in the years of 1951, 1953 and 1954. It should be noted that the rates of output growth in years of 1951, 1953 and 1954 for Japan were lower than the rates of output growth in the postwar Japan generally; however, Japan's higher rates of savings made her rates of output growth higher than the rates of output growth in these years in the United States.

Extremely high rates of savings in the postwar Japan may be explained by the high corporation savings, and the high rate of corporation profits owing to lower wage rates relative to the U.S.A. The lower marginal investment coefficients in the postwar Japan may be explained by the technological improvements, based on the desire to modernize Japan's outdated industrial equipment. The technological improvements caused the higher efficiency in Japan's industries, which created the lower marginal investment coefficients.

b) Foreign Trade and the U.S. Aids

Private domestic investment in Japan depends upon the import costs because of her scarce natural resources. The increased volume of imports need an expansion of exports. This is a significant problem with which she was faced not only in the postwar period but also in the prewar period. Although this problem will be dealt with in later section, we will point up the favorable world trade and the U.S. aids for one of the important reasons of her high rates of output growth in the postwar period.

This period was a decade of expanding world recovery and prosperity characterized by a high and rapidly growing level of world trade. The volume of world exports rose only 1.4 per cent between 1938 and 1948. It increased 77 per cent between 1948 and 1957.[1] That Japan was able to share and benefit from this trade growth is not surprising.

Further, the six billion dollars of U.S. funds poured into Japan during the postwar decade[2] were important. This injection of dollars helped to rehabilitate industry, control inflation, balance Japan's payments for the decade, create purchasing power, and build a foreign exchange reserve. This was very helpful, because services in Japan were exchanged for foreign funds which could be used to buy raw materials.

When the U.S. aid and the increased volume of imports owing to the favorable world trade climate were given to Japan, investment, consumption, employment and productivity levels were boosted owing to "supply multiplier effects."[3] We must consider theoretically the import effect of the raw materials under the unemployment situation due to shortage of raw materials. Of the manufactured goods of the first stage, some will be directly consumed for the immediate consumption goods, other will be exported, and the remaining part will be utilized in the next stage of production as intermediary goods, thereby, labor and other

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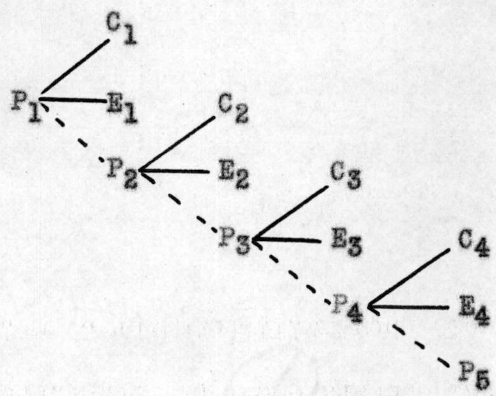
[1]Cohen, B. Jerome, Op. cit., p. 19.

[2]Ibid., p. 18.

[3]Akamatsu, Kaname, "The Theory of Supply-Multiplier, In Reference to the Postwar Economic Situation in Japan." Annals of the Hitosubashi Academy. No. 1. October, 1950.

factors are again employed to produce some more complicated manufactured goods. This process is repeated in the second stage of production induced by production as intermediary goods. This process can be depicted as follows: We indicate the original import raw materials as P_1, successive intermediary products as P_2, P_3, P_4. . . . and part of the products which disappear as direct consumption goods as C_1, C_2. . . . and those which disappear as export goods as E_1, E_2. . .



The above illustration suggests that the import raw materials P_1 will increase the gross national product by more than that of the pre-import period. Keynes' multiplier theory indicates overproduction in the advanced countries under the particular conditions, while underproduction owing to the shortage of raw-materials in the under-developed countries may be called the "supply multiplier theory", as shown in the present illustration.[1] This is one of the peculiarities of the economy of Japan which was due to the fundamental characteristic of her economy, i.e., the scarcity of natural resources relative to

[1]Akamatsu, Kaname, Op. cit., pp. 5-7.

population.

c) The Level of Consumption and Distribution of Income.

A feature of the Japanese economy during the postwar period was the increase of the income of masses of people as a share of total income. It is clear that the increase of personal income creates the additional consumption, which favors output growth in a demand and market sense, though interferring perhaps with high savings ratio. The wage earners' share of distributed national income rose from a prewar average of 38 per cent to 48 per cent in recent years.[1] The liberation of tenant lands sharply decreased land rentals from the very high rate of prewar days, which then amounted to 30 per cent of the total agrarian spending, to less than one per cent.[2] Such land reform may not have decreased total land incomes but it certainly dispersed themmore widely.

As a result of democratization policies in the postwar Japan, namely the dissolution of the "Zaibatsu" (the giant financial family groups in the prewar Japan), land reform, and the encouragement of the trade union movement; a redistribution of national products, adverse to the high-income, low-consumption, monied groups, and favorable to the low-income, high-consumption, wage-earning and farm groups, with their heightened propensity to spend on consumer goods, has enormously increased the absorptive capacity of the domestic market in Japan.[3]

The marked rise in consumer's purchasing power is shown in the

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[1]Economic Planning Agency, National Income White Paper, Tokyo, 1957.

[2]Economic Survey of Japan, 1958, p. 45.

[3]Cohen, B. Jerome, Op. cit., p. 22.

contents of consumption changed together with the improvement of the consumption level. In the immediate postwar period, foodstuff purchases comprised the largest proportion, but with an increase in incomes, the purchasing power shifted from foodstuff to textiles. Recently the trend has been from textiles to housing, durable consumer goods and service demand.

If we compare the change of consumer's pattern together with increase of compensation of employees in the postwar Japan with that of the U.S.A., the characteristic of consumption level will become much more clear in her postwar period. The statistical results are shown in Table IV.

TABLE IV

Comparisons of Consumption Patterns and Compensation of Employees for U.S. and Japan, 1934-1955

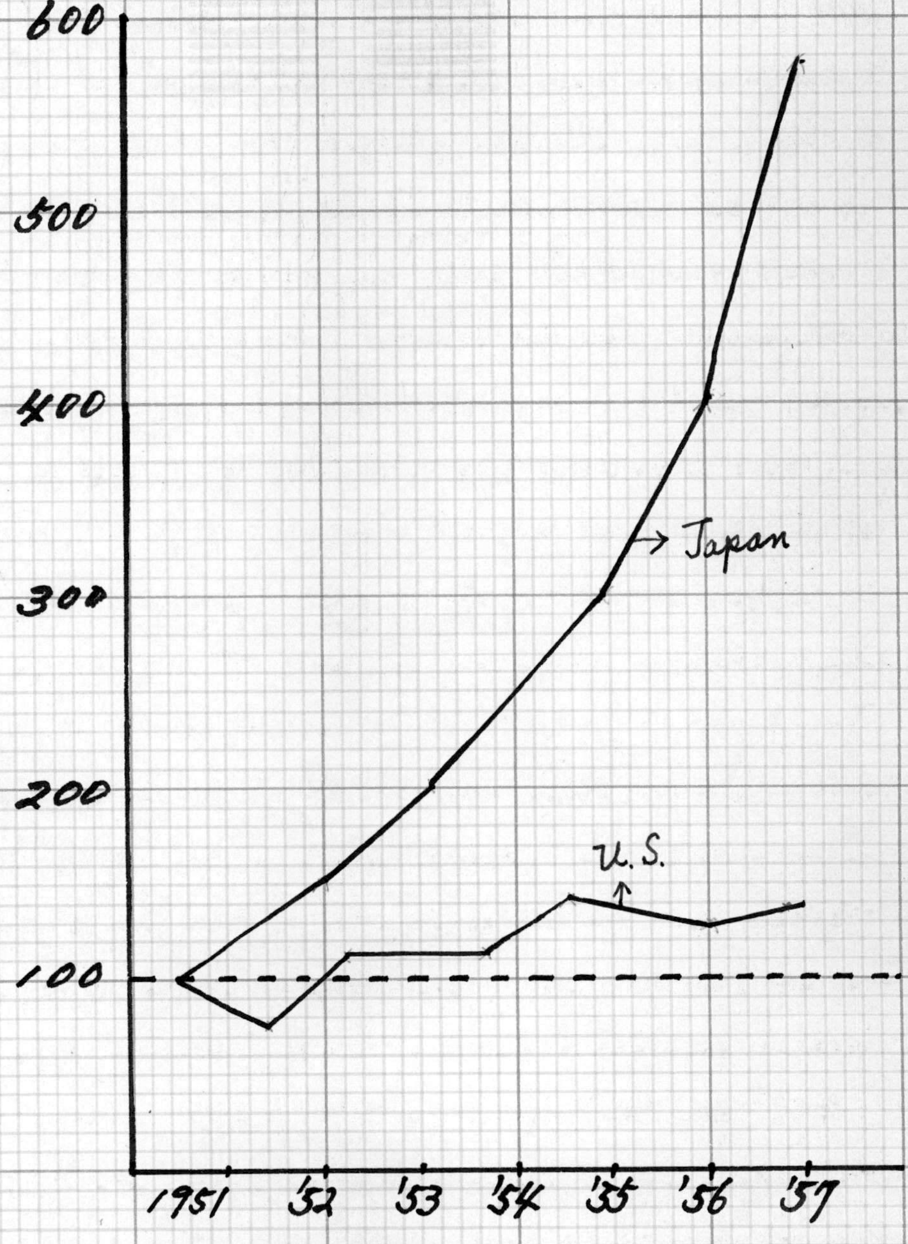
	(1) The Ratio of Compensation of Employees to National Income	(2) The Ratio of Foods Consumption to Personal Consumption Expenditures
	%	%
1934-36		
Japan	38.9	40.0
U.S.	67.	31.
1946		
Japan	30.8	70.3
U.S.	65	35.
1947		
Japan	32.6	69.9
U.S.	65	35
1948		
Japan	42.2	65.3
U.S.	63	34
1949		
Japan	41.8	67.0
U.S.	65	32
1950		
Japan	42.4	61.6
U.S.	64	30.5
1951		
Japan	42.5	56.4
U.S.	64	32
1952		
Japan	46.1	59.8
U.S.	67	32
1953		
Japan	46.7	61.7
U.S.	68	30
1954		
Japan	48.2	63.4
U.S.	69	30
1955		
Japan	47.6	62.1
U.S.	68	28.

Sources: (1) Business Statistics, 1959 Edition, A Supplement to Survey of Current Business, U.S. Department of Commerce, Office of Business Economics.
(2) The same sources as Table II.

The above table shows that a ratio of food consumption to personal consumption expenditures in Japan have decreased from 70.3 per cent in 1946 to 56.4 per cent in 1951 while the ratio of compensations of employees to national income have increased from 30.8 per cent in 1946 to 48.2 per cent in 1954 and that the U.S. ratios of foods consumption to personal consumption expenditures have decreased slightly from 35 per cent in 1946 to 28 per cent while the ratio of compensations of employees to national income have been almost stable between about 63 per cent in 1948 to 69 per cent in 1954. Comparing the U.S. ratio of compensations of employees to national income with those of Japan, we find that the U.S. figures were greater by a factor as large as two in 1946 and 1947, and by lower factors in other years, as low as 1.4 in 1954 and 1955. As for the ratio of foods consumption to personal consumption expenditures, the Japanese figures were consistently two times those of the United States.

The sharp decrease in the ratio of food consumption in postwar Japan compared to that of the U.S.A. indicates the rapid change of consumer's pattern away from foods to clothing, housing, consumers' durable goods and services. Accordingly, the expansion rate of production of durable consumer goods in the postwar Japan was a surprising factor in the Japanese output growth in the post war period as compared to that of the U.S.A. A comparison of rates of growth in the production of durable consumer's goods between the United States and Japan has been made by Japanese Economic Planning Agency. This is shown in Chart 3. Japan's production of durable consumers' goods in the year of 1957 was 580 per cent of the 1951 level, whereas the U.S. index in the same year was only 138 per cent.

(Chart 3) Expansion of Production of Consumer's Durable Goods., U.S. & Japan.
(1951 = 100)



Remarks: Expansion rates represent rates of growth in the production of consumer's durable goods computed by the Research Department of Economic Planning Agency, Japanese Government.

(d) The Role of Government

Finally the Japanese government played a vital role in the rapid output growth in the postwar decade. The government furnished funds to industry to step up the recovery and to modernize equipment and also manipulated the taxation system to encourage these developments. For instance, the amount of funds furnished to industry since the termination of the war is estimated to reach ¥ 1,300,000. million in terms of present currency value, or 30 per cent of the total funds for private equipment investment obtained from external sources.[1] The counter-cyclical policies, i.e., anti-inflationary control policies in the immediate postwar periods from 1946 to 1949 and anti-recession policies after the termination of Korean War contributed to economic growth.

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[1] Economic Survey of Japan, 1958, p. 48.

II. Japan's Per Capita Income Compared to Other Countries

The economy of Japan in the postwar decade was characterized by a high and rapid rate of output growth, the highest perhaps in the world, though it was not the highest rate of per capita income growth compared to other countries in per capita income growth. This section will deal with population growth, per capita income growth and international comparisons of per capita income.

Population Growth

Population growth tends to make per capita income and rate of per capita income growth low. This is best seen in symbols below. Denoting the rate of population growth as x and the rate of per capita income as y, we can state in symbols as follows:

4) $$G = \frac{Y_i - Y_{i-1}}{Y_{i-1}} = \frac{a}{b}$$ (see page 24)

5) $$x = \frac{N_i - N_{i-1}}{N_{i-1}}$$ (where N stands for number of populations)

6) $$y = \frac{\frac{Y_i}{N_i} - \frac{Y_{i-1}}{N_{i-1}}}{\frac{Y_{i-1}}{N_{i-1}}}$$

Let Y_i / Y_{i-1} equals m, and N_i / N_{i-1} equals n.

7) G equals m-1

8) x equals n-1

9) y equals m/n-1

Multiply (8) to (9),

10) $(x + 1)(y + 1) = m$

(7) minus (10),

(11) $G = x + y + x.y$

Since x and y are small figures of percentage, x.y. will be negligible. Therefore,

12) $\underline{G = x + y}$ [1] (or in more exact terms, $G = x + y + x.y$)

13) $\underline{y = G - x}$ (or in more exact terms, $\underline{y = G - x / 1 + x}$)

i.e., the rate of per capita income depends upon the rate of output growth and population growth. In other words, the rate of per capita income growth tends to be lower than the rate of output growth if the rate of population growth is positive. On the other hand, the rate of per capita income growth tends to be larger than the rate of output growth if the rate of population growth is negative.

Comparisons of rates of population growth in the postwar Japan with the U.S.A., U.K., France, Germany, Italy, Netherlands and India are shown in Table V.

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[1] Tsuru, S. and Ohkawa, K., Op. cit., pp. 6-9.

TABLE V

International Comparisons of Population Growth
(per cent per year)

	Japan	India	Italy	Germany	U.K.	U.S.	Netherland	France
1947	2.2%	1.3%	0.83%	2.18%	0.72%	1.93%	2.1%	0.89%
1948	2.6%	1.3%	0.74%	2.89%	0.99%	1.74%	1.7%	0.98%
1949	2.3%	1.3%	0.66%	1.94%	0.59%	1.74%	1.6%	0.87%
1950	2.0%	1.3%	0.64%	1.61%	-0.07%	1.67%	1.6%	0.81%
1951	1.6%	1.3%	0.84%	1.09%	-0.05%	1.76%	1.48%	0.77%
1952	1.5%	1.3%	0.69%	0.65%	0.28%	1.73%	1.15%	0.72%
1953	1.4%	1.3%	0.45%	0.98%	0.33%	1.66%	1.07%	0.69%
1954	1.5%	1.3%	0.56%	1.08%	0.34%	1.74%	1.16%	0.70%
1955	1.1%	1.4%	0.56%	0.98%	0.36%	1.76%	1.28%	0.76%
1956	1.1%	1.3%	0.45%	1.20%	0.47%	1.76%	1.36%	0.85%
1957	1.0%	1.3%	0.42%	1.34%	0.48%	1.80%	1.21%	1.01%
1958	0.7%	1.3%	0.31%	--	0.44%	1.68%	1.38%	0.93%
Average Annual rate of growth (47-58)	1.58%	1.3%	0.6%	1.46%	0.5%	1.75%	1.55%	0.96%

Source: Demographic Yearbook, United Nations, New York, 1958.

The above table shows that the average annual rate of population growth in postwar Japan was relatively lower than those in the U.S.A., but, relatively higher than in West Germany, Netherlands, India, France, Italy and U.K. Another characteristic of rate of population growth in the postwar Japan has been a continuous decline from 2.2 per cent, 1946-47, to 0.7 per cent, 1957-58. This rapid declining rate of population growth especially from 1955 to 1958 was one of the distinguishing characteristics of postwar Japan compared to other countries.

The importance of Japan's rate of population growth is best seen in the relation between population and natural resources. For example as regards, hectares of arable land per capita in 1955; the figure for Japan was only 0.055, for Italy 0.31, for India 0.48, for West Germany 0.15, for Netherlands 0.959, for France 0.48, for U.K. 0.48 and for U.S. 1.1.[1] Japan was poor in land to the extent of having only about 5 per cent of the land per capita of the U.S. and 10 per cent of the United Kingdom. This topic will be elaborated in Chapter III and Chapter IV.

Per Capita Income Growth Rates

The rate of per capita income growth is a better measurement of economic growth in a national economy than the rate of output growth, because this rate indicates the economic growth rate in real terms after eliminating the population growth rate as illustrated in equation (13). The rate of per capita income is estimated by the equation (6) given on page 35. Per capita products at constant prices from 1950 to 1957 are taken from Statistical Yearbook, United Nations, 1958. The statistical results of the international comparisons of rate of per capita income growth are shown in Table VI.

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[1]Calculation is based upon Yearbook of Food and Agricultural Statistics Production, 1957, F.A.O., United Nations, Rome and Demographic Yearbook, 1956, United Nations, New York.

TABLE VI

International Comparisons of Per Capita Income Growth
(Per cent growth per year)

	Japan	India	Italy	Germany	U.K.	U.S.	Netherland	France
1951	7.7%	1.04%	6.00%	10.0%	4.0%	5.0%	1.02%	2.0%
1952	9.9%	3.09%	1.89%	7.27%	0%	0.7%	1.01%	1.96%
1953	4.0%	4.00%	7.41%	5.93%	2.9%	3.7%	7.0%	2.88%
1954	0.96%	0.96%	4.31%	6.4%	4.7%	-3.6%	6.54%	4.67%
1955	6.7%	0.95%	6.61%	9.77%	2.7%	6.6%	5.26%	5.36%
1956	9.8%	2.83%	3.87%	5.48%	0.87%	0%	2.5%	4.24%
1957	7.3%		5.97%	3.90%	1.72%	0%	2.44%	5.69%
Annual Rate	6.62%	2.14%	5.15%	6.96%	2.41%	1.77%	3.68%	3.83%

Remarks: Figures are based upon "Index Numbers of Per Capita Products at Constant Prices", Statistical Yearbook, United Nations, 1958.

The above table shows that West Germany, Japan, and Italy had high annual average growth rates of per capita income relative to other countries and that the United States, India and U.K. had low rates. Moreover, the United States was lowest in the average annual rate of per capita income growth, i.e., lower than even India. Very low figures of the United States may be explained by her very high population growth rates in this decade and the lowest growth rate in the year 1954 due to the termination of Korean War as well as by the high base from which the growth starts. Although France and Netherlands showed the almost same position on the basis of average annual growth rate, France had a continuous, gradual trend as compared to

Netherlands.

Although Japan was top on the basis of output growth rates, West Germany led the world on the basis of international comparison of growth rates of per capita income. Japan's rate of per capita income growth from 1950 to 1957 was still very high relative to most other countries. In the years of 1952, 1956 and 1957, Japan led the world, but in the year of 1954 Japan's figure was the lowest in the post war decade and lower than for any other country except the United States. Japan occupied the second position among the countries listed above, because of her rather high rate of population growth and a low product figure in 1954 owing to the termination of the Korean War. This is evident that cyclical fluctuations were of importance during this period.

Comparing the national income in the postwar and prewar Japan, we find that the real national income in 1951 rose slightly above the prewar level of real national income and three years later in 1954, a per capita income passed the prewar level. It is clear that population increase absorbed much of the remarkable output growth gains in the postwar decade. The movement of per capita income in the post-war Japan compared to that of the prewar Japan, is shown as follows:

1934-1936	1946	1948	1950	1952	1953	1954	1955	
210.	109	128	167	197	207	212	227	(Unit: Yen)

Indeed, as shown in Table V for population growth, Japan's population pressure was serious until the year of 1954, as the rate of population growth was more than 1.5 per cent up to that year.

International Comparisons of Per Capita Income

Japan's economic strength in terms of per capita income will be compared with other countries in this section. Combining Watanabe and Komiya's results with those of Gilbert and Kravis, we find the exchange rate of various currencies in terms of the real purchasing power of one dollar to be:[1]

Dollar's Worth of Each Currency

	Official Exchange Rate (U.S. $ 1)	Dollar's Worth Estimated
U.K. (1950)	.357 £	$ 1.59
France (1950)	350. Fr.	$ 1.59
Germany (1950)	4.20 DM	$ 1.60
Italy (1950)	625. Li	$ 1.91
Japan (1952)	360 ¥	$ 1.91

The international comparisons of per capita income will be made with the above estimated dollar's worth of currencies. The results are shown in VII.

[1]Watanabe T., and Komiya R., Op. cit., p. 3.

TABLE VII

International Comparisons of Per Capita Income in Dollars

	National Income at market price (Billions)	Population in Thousands	Per Capita Income at National Currency	Per Capita $ Income at Official Rate of Exchange	Per Capita $ Income in Estimated real terms
U.S.	$ 241.9	151,683.	$1,594.77	$1,594.77	$1,594.77
U.K.	£ 10.675 (unit: Millions)	50,325.	£ 212.12	594.15	944.70
France	7,520. Fr.	41,736.	Fr. 180.18	514.80	818.53
Germany	74.5 DM	47,847.	DM. 1,557.04	370.72	593.15
Italy	337.9 Lire	46,603.	7,250.60	116.00	221.56
Japan ¥	4,959.	85,500.	58,000.	161.11	307.72
India	98.2 Rupees	367,530.	267.19	56.20	N.A.
Netherlands (Unit: Millions of guilders)	17,739.	10,382.	1,708.63	424.	N.A.

Sources: 1. Statistical Yearbook, United Nations, 1958.
2. Demographic Yearbook, United Nations, 1958.

Real per capita income in the United States in 1950 was 1,594.77 dollars, in the United Kingdom 944.70 dollars, in France 818.53 dollars, in Germany 593.15 dollars, in Italy 221.56 dollars in 1950, and in Japan 307.72 dollars in 1952. Using the index numbers of per capita products at constant prices from 1950 to 1957 of the Statistical Yearbook, United Nations, 1958, we may compare the international per capita real incomes from 1950 to 1957. The statistical results are shown in Table VIII.

TABLE VIII

International Comparisons of per Capita Income, 1950-1957

	Japan	Italy	Germany	France	U. K.	U.S.
1950	260.02	221.56	593.15	818.53	944.70	1,594.77
1951	280.02	234.85	652.47	834.90	982.48	1,674.51
1952	307.72	239.28	699.17	851.27	982.48	1,690.57
1953	320.02	257.01	741.44	875.83	1,010.83	1,754.25
1954	323.10	268.12	788.89	916.75	1,058.64	1,690.46
1955	344.65	285.81	865.99	965.87	1,086.41	1,802.90
1956	378.50	296.89	913.45	1,006.79	1,095.85	1,802.90
1957	406.19	314.62	949.02	1,064.09	1,114.75	1,802.90

The per capita income in each country relative to the United States in 1951 and 1957 is as follows:

	Japan	Italy	Germany	France	U.K.	U.S.
1951	16.7	14.0	39.0	50.0	59.0	100.0
1957	22.5	17.5	52.6	59.0	61.8	100.0

Japan's per capita income was only 16.7 per cent of that of the United States, 28 per cent of United Kingdom, 33.4 per cent of France, 42.8 per cent of Germany and 119 per cent of Italy in 1951. In the year of 1957, Japan's per capita income was 22.5 per cent of the United States, 36.4 per cent of United Kingdom, 38.2 per cent of France, 42.7 per cent of West Germany and 118.5 per cent of Italy. Although Japan's rates of output growth were very high relative to other countries in the postwar decade, Japan's poverty relative to the Germany, France, U.K. and U.S. is exposed in comparisons of per capita income.

III. Industrial Breakdown In Comparison With U.S.

This section deals with the structural difference in the industry of Japan and the U.S.A. in the prewar and postwar decade. The degree of industrialization between two countries is measured by the ratio of national income originating by industry to national income and the ratio of labor forces engaged in each industry to total labor forces. The causes of structural change between the two periods and the two countries will be examined.

Classification of Industry

The whole of economic activity may be divided into the three fields of activity; primary, secondary and tertiary industry.[1] Primary industry is defined to include agriculture, livestock farming of all kinds, hunting and trapping, fisheries and forestry. Secondary industry is defined to cover manufacturing production, building and public works construction, mining and electric power production. Mining and electric power production are the exploitation of natural resources as well as primary industry, however, the operation of these industries resembles that of manufacturing industry more than that of primary industry; therefore, Clark classifies mining and electric power production as secondary industry. The building and constructional industry sometimes might be included in the service industry in the case that a large part of its output which consists of repair and maintenance work which is conducted on a small scale. Manufacturing is not easy to define, in

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[1]Clark, Colin, The Conditions of Economic Progress, London, Macmillan & Co., 1940, pp. 337-338.

countries and epochs where the work of individual craftsmen is as substantial importance. Generally it refers to producing of materials into new forms. Tertiary industry includes commerce and distribution, transportation, public administration, domestic, personal and professional services.

Characteristics of each industry are explained by Colin Clark.[1] In the first place, the output of primary and secondary industries is (with the exception of building and structural work) always transportable, while the output of tertiary industries is not. There can be no international trade in tertiary products, with the exception of certain forms of transport itself, or of financial services such as banking and insurance. The next consideration of fundamental importance is that the output of primary processing industries consists largely of necessities of life. Finally, the basic difference between primary and secondary types of production has always been that the former is subject to conditions of "diminishing returns" and the latter to conditions of "increasing returns" to scale. Movement of population and labor forces among three fields of industry will never cease until the equilibrium is obtained.

Ratio of National Income of Primary, of Secondary and of Tertiary Industry to National Income For U.S. and Japan, 1935, 1946 and 1955.

Statistical results are shown in Table IX. In prewar periods, the ratio of national income of primary industry to national income in Japan was 19.8 per cent, for the secondary industry it was 31.0

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[1]Clark, Colin, Op. cit., pp. 337-338.

TABLE IX

Ratio of Primary, Secondary and Tertiary Industry to Domestic National Income

	1935	1946	1955
1. Primary Industry			
The U.S.A.	11.3%	10.2%	4.9%
Japan	19.8%	38.8%	22.1%
2. Secondary Industry			
The U.S.A.	29.7%	32.2%	39.1%
Japan	31.0%	26.3%	29.7%
3. Tertiary Industry			
The U.S.A.	59.0%	57.6%	56 %
Japan	49.2%	34.9%	48.2%
4. Domestic National Income			
The U.S.A. (billion $)	56.690	180.308	328.523
Japan (billion Yen)	14.4	360.9	6,650.2

Remarks: Based on the Survey of Current Business, United States Department of Commerce, Office of Business Economics and National Income and National Economic Accounts of Japan, 1930-1955, Economic Planning Board, Japan.

per cent and for tertiary industry it was 49.2 per cent; whereas in the United States in 1935, for primary industry it was 11.3 per cent, for secondary industry it was 29.7 per cent and for tertiary industry it was 59.0 per cent.

Primary and secondary industry were relatively more important in Japan than in the United States in the prewar periods. On the other hand, tertiary industry in the United States exceeded by 10 per cent of all output that of Japan. One of the distinguishing characteristics of this table was that the ratio of primary industry in Japan was higher by 1.8 times that of the United States. The degree of industrialization between two countries in the prewar can best be seen by this table.

In the year of 1946, or right after the end of World War II, the ratio of primary industry income to national income in Japan was 38.8 per cent, for secondary industry it was 26.3 per cent and for tertiary industry it was 34.9 per cent. Due to the breakdown of industrial life after the war, the relative importance of primary industry income to national income became two times greater than in 1935. Japan again became a country of primary industry.

The structure of industry in the United States in 1946 was not much different than before the war. The movement of secondary industry in the United States was one of the postwar characteristic of the United States.

In the year of 1955, the percentage figures in two countries show considerable change. Roughly speaking, Japan's structure of industry has become very close to that of prewar level. Primary industry was still a little higher by 2.3 per cent than that of 1935. Secondary and tertiary industry were still slightly less by 1.3 per cent and 1.0 per cent compared to those of prewar level. On the other hand, the structural change of the U.S. industry showed the declining of the importance of primary industry, i.e., 11.3 per cent in 1935, 10.2 per cent in 1946 and 4.9 per cent in 1955. In contrast to the declining importance of primary industry in the United States, importance of secondary industry has been increasing compared to that of the prewar level. As for tertiary industry, the role of this industry has declined very slowly but is still the most important component of national income. Comparing the structural change of industry in Japan with that of the United States in 1955, we notice that Japan was a country of primary industry relative to the United States, i.e., the ratio of primary industry income to national income in 1955, Japan was 4.4 times that of the United States.

The breakdown of primary, of secondary and of tertiary industry reveals structural changes in industry between periods and the two countries in more detail. Primary industry in the United States comprises agriculture, agricultural services, forestry, and fisheries; whereas in Japan, it is agriculture, forestry and fisheries. The ratios of the agricultural income to national income in the United States and Japan are shown in Table X.

TABLE X

Breakdown of Primary Industry, (1935, 1946 and 1955)

	1935	1946	1955
a) Agriculture			
The U.S.	11.0%	9.2%	4.5%
Japan	16.7%	31.1%	17.2%
b) Agricultural services, forestry and fisheries			
The U.S.A.	0.3%	1.0%	0.4%
c) Forestry			
Japan	1.6%	5.0%	2.3%
d) Fisheries			
Japan	1.5%	2.7%	2.6%

That is to say, the ratios of national income in the agricultural services, forestry, and fisheries included to the total national income in the United States are negligible, and the ratio of agricultural income to primary industry income in the United States in 1935, 1946 and 1955 was more than 90 per cent. In Japan, forestry and fisheries are relatively more important to those of the United States; i.e., the ratio of income in fisheries and forest to primary industry income shows more than 20 per cent in 1955. The trend of the relative importance of fisheries and forestry to primary industry income in Japan has been gradually increasing; i.e., 15.0 per cent in 1935, 19.0 per cent in 1946 and 22.0 per cent in 1955.

Components of secondary industry, as described before, are mining, contract construction and manufacturing. The statistical results of structural change of secondary industry are shown in Table XI.

TABLE XI

Breakdown of Secondary Industry

Ratio of Components to Domestic National Income

	1935	1946	1955
a) Mining			
The U.S.	2.1%	1.6%	1.7%
Japan	2.3%	3.0%	2.1%
b) Contract Construction			
The U.S.	2.3%	3.5%	4.9%
Japan	3.2%	6.9%	4.6%
c) Manufacturing			
The U.S.	25.3%	27.1%	32.5%
Japan	25.5%	16.4%	23.0%

In 1935, the structure of secondary industry in the U.S.A. and Japan was almost the same and the percentage figures of three fields in Japan were only slightly larger than those of the United States. In 1946, the ratio of manufacturing income to national income in the United States was higher by some 11.0 per cent than for Japan. On the other hand, the Japanese figures for mining and construction were greater than those of the United States in 1935 and 1946. The percentage of construction in Japan was 3.4 per cent higher in 1946 than in the U.S.A. It reflects high activity in construction following destruction of the housing during the World War II. In 1955, the pattern of mining, construction and manufacturing in Japan became roughly similar to prewar level, except the slight low figure of manufacturing industry; whereas the U.S. figures showed a boost in manufacturing industry, i.e., 25.3 per cent in 1935 to 32.5 per cent in 1955.

The trend of structural change in the fields of tertiary industry between two periods and two countries can be seen in Table XII.

TABLE XII

Breakdown of Tertiary Industry

Ratio of Components to Domestic National Income

	1935	1946	1955
a) Wholesale and Retail trade			
The U.S.	16.2%	18.8%	15.4%
Japan	13.5%	10.7%	17.3%

TABLE XII (Continued)

Breakdown of Tertiary Industry

Ratio of Components to Domestic National Income

	1935	1946	1955
b) Finance, Insurance & Real Estate			
The U.S.	10.4%	7.9%	9.7%
Japan	10.6%	2.5%	5.0%
c) Transportation, Communication and other public utilities			
The U.S.	10.5%	8.2%	8.5%
Japan	10.5%	4.4%	9.1%
d) Services, Government services, other and unknown			
The U.S.	21.9%	22.7%	22.4%
Japan	14.7%	17.3%	17.2%

One of the most important changes in Japan was that the ratio of finance, insurance and real estate to national income in 1946 and 1955 was some 50 per cent less than that of prewar periods, or 1935; i.e., it dropped from 10.6 per cent in 1935 to 2.5 per cent in 1946 and 5.0 per cent in 1955. The structural change of tertiary industry in the U.S.A. was not different in the postwar periods from the prewar periods. On the other hand, the pattern of tertiary industry in Japan between two periods changed not only in finance, insurance and real estate but also in other tertiary industry. That is to say, the ratio of national income originated in wholesale and retail trade in Japan increased from 13.5 per cent in 1935 to 10.7 per cent in 1946 and 17.3 per cent in 1955;

the ratio of transportation, communication and other public utilities to national income decreased from 10.5 per cent in 1935 to 4.4 per cent in 1946 and 9.1 per cent in 1955; the ratio of services, government services and other unknown services to national income in Japan increased from 14.7 per cent in 1935 to 17.3 per cent in 1946 and 17.2 per cent in 1955. The decline of finance, insurance and real estate in postwar Japan probably resulted from the dissolution of the Zaibatsu and decline of the international financial position.

The Ratio of Labor Forces Employed by Industry to The Total Labor Forces

The developments which have been sketched in the previous section are reflected in labor force developments. Generally these developments have been a large growth in output in postwar Japan achieved by reestablishment of manufacturing industries. The flow of labor to manufacturing has increased output; on the other hand, the flow has not been fast enough and large enough to prevent an overpopulation on farms and a general lowering of income levels. Statistical data in labor force are taken from the U.S. income and output, 1958 and the U.S. National income, 1954 and Nihon Keizai Tokeishu, 1958. Statistical results are shown in Table XIII.

TABLE XIII

Ratio of Labor Force to Total Labor Force by Industry
(Per cent of Total)

	1930	1947	1955
I. Primary Industry			
U.S.	20.3%	12.2%	8.9%
Japan	49.3%	53.4%	41.0%
a) Agriculture			
U.S.	19.8%	11.7%	
Japan	46.8%	49.9%	37.9%
b) Forest & Fisheries			
U.S.	0.5%	0.5%	
Japan	2.5%	3.5%	3.1%
II. Secondary Industry			
U.S.	28.51%	33.38%	33.27%
Japan	20.4%	22.3%	23.8%
a) Mining			
U.S.	2.16%	1.68%	1.27%
Japan	1.1%	2.0%	1.4%
b) Construction			
U.S.	4.95%	5.2%	6.2%
Japan	3.3%	4.0%	4.6%
c) Manufacturing,			
U.S.	21.4%	26.7%	25.8%
Japan	16.0%	16.3%	17.8%
III. Tertiary Industry			
U.S.	50.9%	53.5%	57.9%
Japan	30.2%	24.2%	35.2%
a) Wholesale & Retail Trade			
U.S.	17.0%	19.1%	19.3%
Japan	14.0%	6.3%	13.8%
b) Finance, Insurance & Real Estate			
U.S.	3.5%	3.2%	3.9%
Japan	0.7%	0.8%	1.6%
c) Transportation, Communication, & other Public Utilities			
U.S.	8.5%	7.4%	6.6%
Japan	4.4%	5.1%	5.2%
d) Services, Government Services, Other & Unknown			
U.S.	21.9%	23.8%	28.1%
Japan	11.1%	12.0%	14.6%

Sources: U.S. Output and Income, 1958 and National Income, 1954
Nihon Keizai Tokei Shu, 1958.

The proportion of labor forces in primary industry in Japan was no less than 41 per cent in 1955, and was even higher in earlier years. By contrast it was only about 9 per cent in the United States in 1955. A breakdown analysis of tertiary industry in the postwar decade for two countries showed that the ratio of labor forces of each industry in tertiary industry to total labor forces was inclined to increase except for the U.S. transportation, communication and other public utilities. In 1955, the Japanese figures showed a little higher, in comparison to those of her prewar periods. Comparing the United States with Japan in 1955, the U.S. figure was 1.6 times greater than that of Japan.

Breakdown Analysis of Manufacturing Industries

The foregoing analysis suggests that Japan's surplus labor forces in primary industry (mainly agriculture) has been only partly absorbed by manufacturing industry. Manufacturing industry is the key to the economic development of Japan. First, a breakdown analysis of manufacturing industry between prewar and postwar periods in Japan will be made for the purpose of finding the structural change of manufacturing industries. The ratio of the average value of products of each class of industries to the added value of total manufacturing industry and ratio of labor forces of each industry to total labor forces of manufacturing industries will be calculated. The average value is taken from 1934 to 1936 for the prewar level. The statistical results are shown in Table XIV.

TABLE XIV (a)

Breakdown of Manufacturing Industries, Japan

Manufacturing Industries. Total equal 100	1934-1936 Ratio of Average value of products of each industry to total manufacturing industry.	Ratio of Labor Forces	1955 Ratio of Added value of each industry to manufacturing total.	Ratio of Labor Forces
1) Food and Kindred Products	10.6%	6.9%	11.4%	11.0%
2) Textile Mill Products	34.0%	40.3%	13.5%	19.5%
3) Apparel and other finished products	--		1.2%	2.5%
4) Lumber and Wood products	2.3%	3.7%	3.5%	6.4%
5) Furniture & Fixtures	--		1.7%	2.1%
6) Paper & Allied products			4.3%	3.3%
7) Printing, Publishing & allied products	2.1%	2.7%	5.6%	4.5%
8) Chemical and related industries	16.7%	10.3%	13.8%	7.1%
9) Products of Petroleum and Coal			1.4%	0.56%
10) Rubber products			1.8%	1.5%
11) Leather & Leather products			0.47%	0.56%
12) Stone, Clay, and glass products	2.7%	3.96%	5.3%	5.3%
13) Metal products	17.2%	9.4%		
14) Primary Metal Industries			11.8%	7.5%
15) Fabricated Metal Industries			3.7%	4.8%
16) Ordinance & Accessories			0.2%	0.23%
17) Machinery	13.3%	16.7%	6.3%	7.3%
18) Gas & Electric Power	0.2%	4.2%		
19) Electric Machinery Equipment & Supplies			5.3%	4.6%
20) Transportation equipment			5.6%	6.3%
21) Professional, Scientific & Controlling instruments, Photographical & Opitcal goods			0.1%	1.5%
22) Miscellaneous				

Sources for Table XIV (a): Statistical Abstract of the U.S.A., 1936 and 1956 based on U.S. Census of Manufacture and Annual Survey of Manufacture. A Supplement to the Survey of Current Business, National Income, 1954 and 1958.

Economic Statistics of Japan, 1956, the Bank of Japan based on Census of Manufactures by Ministry of International Trade and Industry. Nihon Keizai Tokei Shu, 1958, Nihon Hyoron Sha. (in Japanese language)

Remarks: i) The figures up to 1936 represent figures for establishment having 5 or more employees, while the figures after 1953 represent figures for establishment having 4 or more employees for Japan. The U.S. figures represent for establishments having 4 or more employees.

ii) The amount of added value is an amount obtained by subtracting from the total value of shipments, the total cost of material, fuel, electric energy consumed, and of contract works, as well as the amounts of excise taxes.

iii) The number of employees includes regularly employed office workers, labors, and individual proprietors as well as their family workers.

The ratio of the average added value of products of textile industry in prewar periods (1934-1936) to the total added value of manufacturing industry was 34.0 per cent, whereas the ratio of labor forces of textile industry to total labor forces of manufacturing industries in the prewar periods was 40.3 per cent. Japan was a country of textile industry in the prewar periods. In 1955, the ratio of added value of textile mill products to that of total manufacturing industry was 14.7 per cent; whereas the ratio of labor forces of textile industry to those of total manufacturing industry was 22.0 per cent. This is a surprising structural change of manufacturing industry in Japan between prewar and postwar periods. The main reason for this structural change was, of course, a decline of Japan's silk industry owing to the development of synthetic fibers throughout the world in the postwar decade.

The second largest industry in prewar Japan was the metal industry. The ratio of average added value of metal industry to that of total manufacturing industry in prewar Japan was 17.2 per cent. In the postwar Japan, metal products declined slightly to 15.7 per cent. The reason for a decline of metal products was the disappearance of weapons due to the disarmament declaration in the postwar Japanese Constitution. The third largest industry in prewar Japan was the chemical and related industries group. The ratio of the average added value of chemical and related industries to that of total manufacturing industry was 16.7 per cent, whereas the ratio of labor forces of chemical and related industries to total manufacturing industry was 10.3 per cent. In the postwar, the ratio of added value of chemical and related industries to the added value of total manufacturing industry was almost the same, or 17.0 per cent, whereas the ratio of labor forces of chemical and related industries to total labor forces of manufacturing was 9.2 per cent. It suggests the improvement of labor efficiency in the chemical and related industries in the postwar Japan relative to prewar periods. The fourth largest industry in the prewar Japan was the machinery industry. The ratio of value added of machinery industry to value added of total manufacturing industry was 13.3 per cent, whereas the ratio of labor forces of machinery industry to total labor forces of manufacturing industry was 16.7 per cent. In the postwar Japan, the ratio of value added of machinery industry to value added of manufacturing industry was 17.2 per cent; whereas the ratio of labor forces of machinery industry to total labor forces of manufacturing industry was 18.2 per cent. This suggests an improvement of labor efficiency in the machinery industry in the postwar relative to prewar. It should be noted that the machinery industry in the postwar Japan has become the most important industry, in the place of textile industry in the prewar Japan.

In the postwar Japan, the most important industry was machinery, second was chemicals, third was metal products and fourth was textiles. By contrast, in the prewar Japan, first was textile, second was a metal industry, third was chemical and fourth was machinery as described above. This entire change may be described as a structural change from light industry in prewar to heavy industry in the postwar period.

The statistical results of the United States are shown in Table XIV (b). In prewar U.S., the ratio of value added of each industry to value added of manufacturing industry indicates that the United States had already become a country of heavy industry. The ratio of value added of metal products to value added of manufacturing industry was 12.7 per cent and the metal products were the most important industry. For the machinery industry, it was 11.8 per cent, then the second most important industry.

TABLE XIV (b)

Breakdown of Manufacturing Industries in U.S.

	1935		1955	
	The ratio of value added by each industry to total manu.	The ratio of labor forces in each ind. to total.	The ratio of value added by each industry to total manu.	The ratio of labor forces
1. Food and kindred products	3.3%	12.4%	10.9%	10.2
2. Tobacco manu.			0.8	0.5
3. Textile prod.	7.5%	22.0%		
4. Textile mill prod.		(13.5%)	4.0%	6.5
5. Apparel & related products		(8.5%)	4.1%	7.6
6. Forest products	4.5%			
7. Lumber & wood prod.		7.7%	2.8	4.2
8. Furniture & Fixtures		4.1%	1.7	2.2
9. Paper & Allied Prod.	3.2%	3.2%	3.8	3.3
10. Printing, Publishing & allied prod.	8.0%	5.7%	5.1	5.0
11. Chemicals & allied industries	7.1	4.2	8.3	4.6
12. Petro. & coal prod.	3.5%	1.4	2.1	1.1
13. Rubber prod.	1.6%	1.5	1.7	1.6
14. Leather & leather goods	2.8%	4.0	1.3	2.2
15. Stone, clay & glass prod.	3.0%	3.2	3.4	3.2
16. Primary metal		16.5	9.8	7.9
17. Iron & steel & their prod. not inc. mach.	9.7%			
18. Non-ferrous metals & their prod.	3.0%			
19. Fabricated metal prod.			6.4	6.7
20. Mach., not including transp. equipment	11.8%			
21. Machinery except elec.		6.5	9.9	9.8
22. Electrical machinery		3.8	5.6	6.1
23. Transp. equip. air, land & water	6.8	6.4	12.7	11.1
24. Railroad repair shop	1.2%			
25. Instruments & related products		6.3	1.7	1.7
26. Miscellaneous				

Sources: Same as Table XIV (a)

IV Importance of Foreign Trade and Structure of Foreign Trade, Japan and U.S.

We have already discussed the role of natural resources in per capita income and structural change of industry in the economy of Japan and the United States. It follows that foreign trade is a very important key to solve the bottleneck of Japan's output growth, per capita income and industrialization. This section will deal with the role of natural resources in the foreign trade of Japan in comparison with the United States as follows:

(i) Role of natural resources as a determinant of the dependence of foreign trade in the national economy.

(ii) Role of natural resources as a determinant of structure of foreign trade.

The Dependence on Foreign Trade in the Economy of Japan and the U.S.A.

The dependence on foreign trade, first is measured by the ratio of the commodity import costs and export value to the gross national products. The statistical results are shown in Table XV. In the prewar Japan, the ratio of commodity import cost to the gross national product was 14.8 per cent; whereas, in the prewar United States, it was 3.4 per cent. The Japanese ratio was 4.3 times that of the United States. This indicates that the degree of dependence on foreign trade in the economy of Japan was very high compared to that of the United States in the prewar period. This difference is partly due to the greater size of the United States economy, since the amount of trade naturally decreases the larger the economic unit involved.

TABLE XV

The Percentage of Commodity Imports Cost and Export Value to G.N.P.

	The U.S.A.[1]		Japan[2]	
	% of Export to G.N.P.	% of Import to G.N.P.	% of Export to G.N.P.	% of Import to G.N.P.
1935	3.2	3.4	15	14.8
1946	4.5	2.3	4.8	8.6
1947	6.6	2.5	0.78	1.55
1948	4.9	2.8	1.95	2.3
1949	4.7	2.6	5.0	8.5
1950	3.6	3.2	7.5	8.8
1951	4.6	3.4	8.9	14.3
1952	4.4	3.1	7.9	12.4
1953	4.3	3.0	6.7	12.7
1954	4.2	2.8	8.0	11.7
1955	3.9	2.9	9.1	11.1

Sources: 1) Yearbook of International Trade Statistics, 1957, United Nations, and U.S. Income and Output, 1958.

2) Yearbook of International Trade Statistics, 1957, United Nations, and National Income and National Economic Accounts of Japan, 1930-1955. November 1956.

In postwar Japan, the ratio of commodity imports cost to the gross national products was lower than in prewar period. Above all, in the periods of abnormal inflation, from 1946 to 1948, it became extremely low; i.e., it was 8.6 per cent for 1946, for 1947 it was 1.5 per cent and it was 2.3 per cent in 1948. The ratios of import costs to the gross national products in years of 1947 and 1948 in Japan were much lower than those of the United States. There is no doubt that this low figure was a factor in the per capita income in Japan.

In 1949, the ratio of commodity import costs to the gross national products in Japan increased to 8.5 per cent as compared to 2.3 per cent in the previous year. The figure of 1949 was still lower than that of 1935 but greater by some 3.3 times than that of the United States. The high import values in this year was due to 550 millions of dollars of the United States net grants to Japan, which was 58 per cent of total import costs.[1] Japan's abnormal inflation started to stabilize in this year. The year of 1949 was the turning point from inflation to higher output and economic stabilization.

In 1950, the outbreak of the Korean War brought income to Japan which made still larger imports possible. In 1951, the ratio of commodity import costs to the gross national products in Japan was 14.3 per cent which was the highest in the postwar periods and slightly less than prewar periods by 0.5 per cent. It was 4.2 times greater than that of the United States. This was the year in which Japan's real national income slightly exceeded that of the prewar period. Foreign trade in Japan affected her business cycle and output growth. Since 1951, the trend of the ratio of import cost to the gross national products in Japan had been declining gradually every year.

In postwar Japan, the deficit balance of payments was the most distinguishing feature of foreign trade compared to that of the prewar. The difference between the ratio of export value and import value to the gross national products in the postwar Japan is shown as follows.

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[1] Statistical Abstract of the United States, 1956, p. 894. Economic Statistics of Japan, 1951, p. 329.

1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1935
-3.8%	-0.8%	-0.4%	-3.5%	-1.3%	-5.4%	-4.5%	-6.0%	-3.7%	-2.0%	+0.2%

These deficit balance of payments in export and import by merchandises in the postwar Japan were made possible by the United States grants and special procurements. That is, up to 1950, some 2 billion dollars of U.S. grants made up the deficit balance of foreign trade and after the Korean War the deficit balance was made up by some 4 billion dollars of the U.S. special procurement program.

The trend of the deficit since 1951 was a declining one except for the year of 1953. The end of the Korean War clearly indicated Japan's maladjustments of import and exports; i.e., Japan's export sharply declined in 1953. After 1954, the trend of increase of exports and decrease of imports cost can be seen in Table XV.

The Dependence on Foreign Trade By Commodities

Japan's dependence on foreign trade for materials can be measured by the ratio of commodity imports to total supply. Such data together with similar data for the United States are shown in Table XVI.

TABLE XVI

Imports Of Resources As Percent[1] Of Total Supply In 1955

	Japan	U.S.A.
Food:		
rice	9.5%	
wheat	60.9%	
barley	39.4%	
soybeans	61.4%	
sugar	96.0%	63%
Beet & Cane sugar, not refined		
coffee	100.0%	100.0%
Industrial Materials:		
phosphate rock	100.0%	3.0%
raw cotton	100.0%	
wool	100.0%	
forest products	5.1% (1951)	12.6%
rayon pulp	22.7%	
iron ore	78.3%	18.0%
coal	6.5%	0.8%
coking coal	26.1%	1.1%
crude oil	96.0%	10.0%
tin ore	100.0%	100.0%
copper ore	1.9%	10.0%
bauxite ore		26.4%
lead ore	14.2% (1951)	36.5%
zinc ore	15.9% (1951)	30.0%
magnese ore		2.0%
chromium ore		97.5%
tungsten ore		59.2%
crude rubber	100.0%	100.0%
salt	78.2%	0.5%
abaca	100.0%	

[1]Calculated by dividing the volume of imports by the sum of imports and domestic production.

Sources: Ministry of International Trade and Industry, Tokyo. Year Book of International Trade Statistics, 1957, Volume 1. United Nations. Year Book of Forest Products Statistics, 1957, Food and Agriculture Organization of the United Nations, Rome, Italy. 1957.

In agricultural products, the ratio of quantity imported of rice to total supply was 9.5 per cent, for wheat it was 60.9 per cent, for barley it was 39.4 per cent, for soybeans it was 61.4 per cent and for sugar it was 96.0 per cent. The ratio of imports cost of foods to total import cost in Japan in 1955 was 29.1 per cent. On the other hand, the United States was independent of foreign imports of foods except for coffee and sugar. This great reliance on imports in food creates a serious economic effect in Japan. Importation of food does not contribute to re-export manufactured goods to foreign countries. It does not contribute to employment of additional workers and output growth. This heavy reliance on foods of foreign trade was the chief reason why Japan's balance of trade in import and export account was always in the red in the postwar decade.

Japan's scarcity of resources was not only food but also the industrial materials. In the raw materials of textile industry, the ratio of imported quantity of raw cotton to total supply was 100.0 per cent, for wool it was also 100.0 per cent and for rayon pulp it was 22.7 per cent. That is, the raw materials of textile industry in Japan were heavily dependent upon the foreign trade. The import cost of raw materials in textile industries in Japan in 1955 was 24 per cent of total import cost. On the other hand, the United States was entirely independent of import and exported the raw materials of textile industry to the rest of the world.

Japan's dependence on imports in other industrial materials was investigated as follows: For phosphate rock, tin ore, crude rubber and abaca, they were 100.0 per cent of total supply. For crude oil, it was 96.0 per cent, for iron ore it was 68.3 per cent, for salt it was 78.2 per cent, for coking coal it was 26.1 per cent and for coal it was 6.5 per cent. Most of the important raw materials for heavy industry are very scarce in Japan, except for coal. On the other hand, the United States had a relative abundance of natural resources except non-ferrous metal and forest products. That is, for tin ore it was 100.0 per cent, for chromium ore it was 97.5 per cent, for tangsten ore it was 59.2 per cent, for lead ore it was 36.5 per cent, for zinc ore it was 30.0 per cent and for bauxite ore it was 26.4 per cent. For forest products, it was 12.6 per cent.

The structure of Japan's imports can be measured by the ratio of each commodity cost imported to total imports cost. The statistical results are shown in Table XVII (a). The ratio of food and beverage to the total imports cost in Japan in 1955 was 29.1 per cent, for the raw materials of textile industry, it was 24.4 per cent.

We may now compare these figures of the postwar period with those of prewar, although the lack of prewar data embarrasses us. We notice two main differences between the two periods. One was a surprising increase of food and beverage import in the postwar period compared to that of the prewar period. That is, it increased from 7.5 per cent in 1935 to 29.1 per cent in 1955. This indicates Japan's relative scarcity of agricultural lands relative to population in the postwar decade. The other was a sharp decline of imports of raw cotton in 1955, or 15.5 per cent compared to 29.0 per in 1935. In prewar Japan, the textile industry dominated Japan's industry because of her position with regard to raw silk, cotton and other products of textile industry

TABLE XVII (a)

Imports by Principal Commodity

	1935	1952	1955
Total Value (Millions of Yen)	2,472	730,352	889,715
Food & Beverage	7.5%	30.4%	29.1%
a) Rice	0.12%	9.1%	8.0%
b) Barley	0%	4.15%	1.61%
c) Wheat	1.74%	7.7%	7.1%
d) Sugar	0.53%	5.5%	4.7%
Textile Materials		30.3%	24.4%
a) Rayon pulp		0.75%	
b) Wool	7.7%	6.85%	6.7%
c) Raw Cotton	29.0%	21.20%	15.5%
d) Hard & Bast Fibres	1.1%	1.1%	0.9%
Metal Ores		7.2%	7.5%
a) Iron ore	1.37%	4.5%	2.18%
b) Non-ferrous Metal Ores		1.03%	1.35%
Non-Metalic Minerals		1.07%	4.1%
a) Phosphates Rock	0.8%	1.2%	1.46%
b) Salt	0.6%	1.2%	0.89%
Mineral Fuels		11.5%	11.7%
a) Coal	1.98%	4.6%	2.3%
b) Crude Oil & Petroleum products	6.15%	6.95%	9.1%
Other Materials		6.8%	13.4%
a) Raw skins	0.85%	0.93%	0.91%
b) Soy Beans	2.18%	1.10%	4.03%
c) Crude Rubber	2.19%	0.92%	2.68%
d) Wood	2.01%	.69%	2.5%
Chemicals		2.8%	3.14%
Machinery		4.6%	6.5%
a) Passenger Motor cars		1.05%	2.64%
b) Vessels		0.74%	0.15%
Others		3.7%	4.8%

Source: Ministry of Finance, Economic Statistics of Japan, 1956.

in the world markets. However, in the postwar periods, the development of synthetic fiber and the industrialization of underdeveloped countries made it impossible for Japan to dominate the world markets; because, the underdeveloped countries have started to give priority to development of light industry in their growth program.

Evaluation of Japan's Import Costs in terms of the U.S. Dollar, 1951.

We seek to measure the value of Japanese imports in terms of dollar costs in the United States. This will enable us to find Japan's Yen value in units of commodity imports per the United States dollar. The conversion of Yen value in units of import commodity into the U.S. dollar will be made in symbols as follows:

$$\text{Yen per Dollar (import goods)} = \frac{\sum P^J Q^J}{\sum P^U Q^U}$$

where P, and Q stand for wholesale price and quantity of imports and J and U denote Japan and the United States.

Japan's import values and quantity data are taken from Quantity Table For the Japanese Interindustry Table, 1951. In this Table, we can find Japan's fifty-six commodities imported. Wholesale prices of Japan's import commodities are taken from Wholesale Price Index by the U.S. Department of Labor. The difference of quality and classification of fifty-six commodities imported into Japan made the statistical decision difficult. The wholesale prices of twenty-six commodities are used in our present study. The ratio of the value of twenty-six commodities used to total import cost was 70. per cent. This indicates the high importation of raw materials in all Japanese imports. It should be noted that food imports are included.

Statistical results are shown in Table XVIII.

The Japanese national currency Yen per one dollar of units of agricultural foods products such as rice, wheat and barley is estimated as 307 Yen per dollar. This estimate is much higher than 219 Yen per dollar in 1952 estimated by Watanabe and Komiya,[1] because their calculation was based upon the total available quantity of agricultural products, not just imports. Our figure is still lower than the official exchange rate of 360 Yen per dollar in 1952. However, the raw materials for textiles such as cotton and wool are estimated as 378 Yen per dollar of unit of raw material of textile industry. This is slightly higher than the official exchange rate in 1952 and lower than Watanabe and Komiya estimate, 401.2 per dollar. The difference between Watanabe and Komiya and our estimate is due to the exclusion of rayon pulp and hard and bast fibres from our estimate. For anthracite it was 556 Yen per dollar, and for bituminus it was 1,292. Yen per dollar. For coking coal, it was 750 Yen per dollar and this was the largest volume of coal imported into Japan in 1951. For coal as a whole, it was 714 Yen per dollar. It was much higher than the official fixed exchange rate and much lower than Watanabe and Komiya estimate of 924.1 Yen per dollar of unit of coal. The main difference of our estimate from Watanabe and Komiya is presumably due to the higher price of coal in the Japanese domestic products of coal. For crude petroleum it is estimated as 544 Yen per dollar. It is slightly less than 599.5 Yen per dollar of Watanabe and Komiya. For iron ores, pig iron and cold finished and

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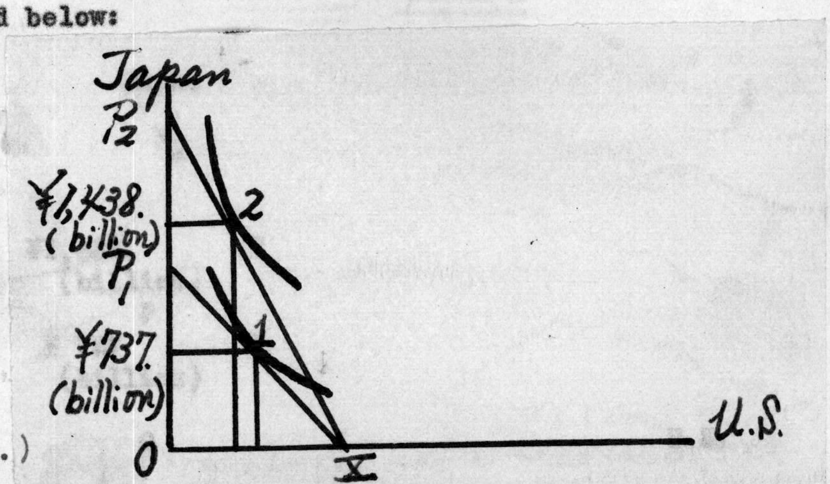
[1]Watanabe and Komiya: Op, cit., pp. 3-6.

coated steel, it is estimated as 815 Yen per dollar, whereas Watanabe and Komiya estimate was 446.8 Yen per dollar of unit of iron and steel. The difference between the two figures is due to the exclusion of iron ores from the Watanabe and Komiya estimate.

Overall Yen per dollar of unit of import commodity in Japan is estimated as 373 Yen per dollar. We may now convert Japanese Yen value of commodity imports into the U.S. dollar, since we know that the ratio of import commodity (26 commodity) was 70.0 per cent. We can easily find that the total value of commodity imports in Japan in 1951 in terms of the U.S. dollar was 1,977. millions of dollars. The Japanese commodity import cost was 5.4 per cent of the United States gross national products in 1951, whereas the ratio of Japan's commodity import cost to the gross national products in 1951 was 14.3 per cent.

We may now compare our estimated overall Yen per dollar of unit of commodity imports with the estimated exchange rate of Watanabe and Komiya. The estimated exchange rate of Watanabe and Komiya in 1952 will be adjusted to that of 1951 by using the implicit price deflator for the gross national products, i.e., the estimated exchange rate in 1951 was 184.2 Yen per dollar. This means that if a person exchanges the U.S. dollar for 360 Yen in Tokyo and buys consumer goods, he can buy nearly twice the amount of goods in Tokyo as compared to New York. If the estimated exchange rate of 184.2 Yen per dollar were available to the Japan's commodity import cost in 1951, Japan's commodity import cost would be reduced from 737,241. million Yen to some 378 billion Yen which would be some 7.3 per cent of the gross national products. Hence, the Japanese balance of payment in import and export account would be much improved. To put this problem differently, Japan could import some 1.95 times greater an amount of raw materials than the existing amounts of imports commodity in 1951. Diagramatically it will be illustrated below:



(Chart 4.)

The above isoquants map clearly shows that if the Japan's present official fixed exchange rate (360 Yen per Dollar) changes to Watanabe and Komiya estimated rate (184.2 Yen per dollar), price line 1 will change to price line 2. This means that the Japanese value of imports will be raised up from 737 billion Yen to 1,438. billion Yen if we assume the same slope of isoquant at price line 2 as that of price line 1. In the place of increase of Japan's value of imports, the United States imports from Japan will be decreased as illustrated in the above isoquants map. In other words, Japan's value of exports will be decreased due to the change of exchange rate.

The loss inherent in Japan's economy due to her scarcity of natural resources will be created in not only productivity level but also foreign trade; i.e., Japan has to import foods and industrial raw materials. Transportation cost and imports cost will be a large item of loss of Japanese national economy. In addition to these, the present official exchange rate will serve somewhat to limit her volume of imports. As for the effect on productivity, we will suggest more detail in the following chapters.

TABLE XVIII

Evaluation of Japan's Import Costs in U.S. Dollar, 1951

	(1) $P.^J Q.^J$	(2) $P.^U Q.^J$	(3) Yen per $ (1) / (2)
	(Unit:	Thousands)	
1. Rice	37,890,582	187,460.	202
2. Wheat	58,421,372	148,500.	394
3. Barley	30,923,153	69,300.	446
4. Soybeans	17,330,929	35,800.	482
5. Cotton	168,916,938	322,000.	525
6. Wool	70,991,578	313,000.	252
7. Sugar	33,126,882	665,500.	505
8. Salt	12,335,807	38,000.	325
9. Anthracite	1,160,143	2,080.	556
10. Bituminus	86,330.	67.	1,292.
11. Coking Coal	16,360,561.	22,630.	750.
12. Crude Petroleum	24,000,649.	44,200.	544.
13. Gasoline	296,080.	343.	865.
14. Kerosene	2,949,107.	7,500.	390.
15. Heavy Fuel Oil (A. B.)	12,133,325.	86,500.	140.
16. Heavy Fuel Oil, C.	587,757	805.	730.
17. Copper Ore	191,205	402.	475.
18. Iron Ore	20,917,562	23,400.	895.
19. Pig Iron	801,524	2,020	398.
20. Cold Finished and Coated Steel	922,651	2,400.	388.

TABLE XVIII (Continued)

21.	Copper	978.	1.5	650.
22.	Lead	1,546,275.	2,770.	560.
23.	Zinc	3,316,437.	5,040.	658.
24.	Vinylon and Nylon	3,097.	3.7	835.
25.	Sodium hydroxide	1,587.	1.68	945.
26.	Cotton Yarn	72,237.	328.	220.
	Total	$\sum P._{J} Q._{J}$	$\sum P._{U} Q._{J}$	$\sum P^J Q^J / \sum P^U Q^J$
		515,284,746.	1,380,051.68	373

Sources: (1) Wholesale Price Index, 1958, U.S. Department of Labor.

(2) Quantity Table For the Japanese Interindustry Table, 1951, Ministry of International Trade & Industry.

Remarks: 1) Price of Japanese commodity is producer's price.

2) Price of coking coal in U.S. is producer's price.

3) See Appendix p. 178 for the U.S. wholesale prices.

CHAPTER III

PRODUCTION LEVELS AND CROP-LAND USED IN THE AGRICULTURAL SECTORS, JAPAN AND U.S., 1951

The purpose of this chapter is to attempt an explanation of the difference in output per worker in the United States and Japan arising from the differences in the availability of farm-land. It is clear that the scarcity of the Japanese farm-land relative to population causes higher prices of farm-land and higher average rate of rent than in countries such as the United States where more land is available. The problem is to determine how great a handicap to production are the higher land prices and lower labor incomes inherent in Japan's position as a country of low resource endowment relative to population.

Various influences affect the difference in output per worker in agricultural sectors of the U.S.A. and Japan. Among these are number of persons per hectare of land working on farms, adaptability to large scale methods (= technology), different demands for food relative to other goods, weather conditions, quality of land, and scarcity of other factors such as fertilizer, fuel, machinery and the like. To reduce this problem to simple terms, farm income is divided into two major parts; farm income due to the land factor and farm income due to other production factors. The agricultural income difference between the two countries is explained by the differences in proportions of these production factors and of the over-all productivity of factors in the two countries.

It is clear that the scarcity of one production factor, that is, farm-land in Japan tends to keep the marginal productivity of labor low due to the sharp "diminishing returns" relations. In a general way, it can be observed that an approximation of this loss resulting from the law of "diminishing returns" maybe assessed by using the observable data on rents, wages and quantities of factors in the two countries in the year of 1951, and this is what is attempted.

I. The Cobb-Douglas Production Function

The Cobb-Douglas production function is a useful theoretical tool for the present analytical purpose. Before the application of the Cobb-Douglas production function to the present statistical analysis, the theory of the Cobb-Douglas production function will be illustrated. Professor Douglas's first investigations,[1] published in 1926, measured the amount of fixed capital used in manufacturing industries in the U.S.A. between 1899 and 1922. He measured the "quantity" of labor employed by these industries over the same period (taking into account changes in the average length of the working week and in the relative proportions of clerical and administrative to manual labor) and compared these with index numbers of the physical volume of product obtained. He also made computation over a similar period for the State of Massachusetts and for the two Australian States of New South Wales and Victoria.

Describing output as P and the quantities of labor and capital

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[1]Douglas, Paul, The Theory of Wages, The Macmillan Co., New York, 1926.

as L and C, Professor Douglas, working in association with Professor Cobb, sought to obtain a functional relation:

$$P = f(L, C)$$

assuming that $mP = f(mL, mC)$

where m is any constant.[1]

Thus in effect he assumed that the productivity function must be a homogeneous linear function of the first order. He thus assumed away the possibility of general increasing returns or general diminishing returns to scale. Professor Cobb after numerous experiments, suggested a suitable type of function, satisfying the above condition, and also satisfying the condition that when either L or C is zero, the product P must also be zero. This function is:

$$P = f(L, C) = b\,L^{k}\,C^{1-k}$$

where k and b are constants.[2] The meaning of exponents will be explained in the numerical terms below. Suppose k equals 0.75. Such an exponent has been estimated for manufacturing in a country indicating that a one per cent increase in labor will increase the output by 0.75 per cent (actually $1.01^{0.75} - 1$)[4], while a one per cent increase in capital will lead to approximately 0.25 per cent increase in production.

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[1]Douglas, Paul, The Theory of Wages, The Macmillan Co. New York, 1934, pp. 131 ff.

[2]Clark, Colin, The Conditions of Economic Progress, Macmillan and Co. Limited St. Martin's Street, London, 1940, p. 378.

[3]Belshaw, H., Population Growth and Levels of Consumption, George Allen and Unwin, London, 1956. Chapter IV.

[4]The figure is derived: $P = b\,L^{0.75}C^{0.25}$

$$P' = b\,(1.01\,L)^{0.75}\,C^{0.25}$$

$$P'/P = 1.01^{0.75}$$

By Taylor's Theorem,

$$\frac{P' - P}{P} = 1.01^{0.75} - 1 \doteq 0.01 \times 0.75 = 0.75\%$$

Among the many uses of the function, a recent application to growth problems may be mentioned.[1] The formula has the merit of making explicit a number of variables which are lost in the Harrod-Domar formula, first the productivity of labor; second, the existence of increasing, constant, or decreasing returns. The formula further calls attention to an asymmetry in much of the discussion of development, which discusses the quality of labor and the quantity of capital. The quantity of labor should not be neglected, nor the quality of capital.[2]

II. Our Approach To the Cobb-Douglas Production Function

First of all, we assume constant returns to scale; i.e., the summation of exponents equal 1. The reasons we assume constant returns to scale are that economies of scale between countries can be ignored so far as coefficients are concerned since the constants k will reflect such economies. Within each country, it is clear that individual farms tend to grow as a result of increasing returns to scale. Thus the full efficiencies of economies of scale within farms should be achieved in equilibrium, and not exist on a country basis. Thus we do not have to worry about increasing returns within countries since the force of competition tends to remove them. As between countries the effects of external or general size economies are measured by general output levels as measured by the constant.

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[1]Kindleberger, P. Charles, Economic Development, The McGraw-Hill Book Co. Inc., New York, Toronto, London, 1958. pp. 47-48.

[2]Ibid., p. 48.

As Doublas shows,[1] the marginal productivity of capital is related to the exponent, for the partial differentiation of P with respect to C will give the increment of output consequential upon an increment of capital:

$$P = b\, C^{1-k}\, L^{k}$$

$$\frac{\partial P}{\partial C} = (1 - k)\, b\, C^{-k}\, L^{k} = (1 - k)\, \frac{P}{C}$$

In other words, the marginal productivity of capital is inversely proportional to the amount of capital at present in use per unit of output and also to the exponent of capital (1 - k) in the above formula.

Denoting agricultural output as A, quantities of land in farm as M and all other factors of production as L, our formulation of the Cobb-Douglas production function is written in symbols:

(1) $$A = b\, L^{k}\, M^{1-k}$$

where b and k are constants. The exponent of land (1-k) can be estimated from national income distribution data, because the ratio of farm income due to land (or net rent) to farm income is equal to (1-k). In symbols:

(2) $$\frac{R}{P_a\, A} = (1-k)$$

where R stands for farm income due to all farm land and Pa.A stands for agricultural income.

The equation (2) is easily obtained from the equation (1) by using the marginal productivity theory of income distribution. Net rent

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[1]Clark, Colin, Op. cit., p. 385.

is in general determined by marginal productivity of land. Thus, R is stated in symbols as follows:

$$(3) \qquad R = P_a \cdot \frac{\partial A}{\partial M} M$$

where P_a is the price of agricultural product. The partial derivative of the equation (1) with respect to M is stated:

$$(4) \qquad \frac{\partial A}{\partial M} = (1-k) \; b \, M^{-k} L^{k}$$

Multiply (4) to P_a in order to obtain the farm income due to land.

$$(5) \qquad P_a \, M \, \frac{\partial A}{\partial M} = P_a \; M \, (1-k) \, b \, M^{-k} \, L^{k}$$

Multiply (1) to P_a in order to obtain the farm income.

$$(6) \qquad P_a \cdot A = P_a \, b \, L^{k} M^{1-k}$$

Hence, the ratio of farm income due to land to farm income is:

$$(7) \qquad \frac{R}{P_a \; A} = \frac{P_a \, (\, 1-k \,) \, b \, M^{-k} \, L^{k} \, M}{P_a \, b \, L^{k} \, M^{1-k}}$$

$$= \underline{1 - k}$$

Under these assumptions, the exponents of factors of production can be estimated from income data. This will be done below.

The exponents of factors of production are called the elasticity of factor of production. The elasticity of land or other factors of production will be written in symbols as follows:

$$(8) \qquad 1-k = \frac{M}{A} \cdot \frac{\partial A}{\partial M}$$

$$(9) \qquad k = \frac{L}{A} \quad \frac{\partial A}{\partial L}$$

The elasticity of factor of production is determined by the factor coefficients and marginal productivity of production factors. This suggests that we will be able to measure the relative "diminishing returns" relations of factors of production from equations (8) and (9). That is the marginal productivity of land or all other production factor can be estimated as follows:

(10) $$\frac{\partial A}{\partial M} = (1 - k).\frac{A}{M}$$

(11) $$\frac{\partial A}{\partial L} = k.\frac{A}{L}$$

That is, the marginal productivity of land is determined by average land productivity and the elasticity of land factor, whereas marginal productivity of all other factors of production is determined by average productivity of all other factors of production and the elasticity of other factors of production.

The constant term b reflects the general productivity of agriculture. Since M and L are variables (= denoting L as workers), we will be able to estimate b; the extent to which b in one country is larger than in another reflects the effectiveness of given land and labor. Our version of the Cobb-Douglas production function is restated as follows:

$$A = b\, L^{k}\, M^{1-k}$$

The constant b will depend on capital and non-agricultural supplies in such case as well as technology. The constant for the U.S., (b), and that of Japan, (B), will reflect the effects of such influences as capital, non-agricultural supplies, scale, and technology.

We have suggested that the estimate of elasticities of production factors, land and all other factors of production may be obtained if we know the ratio of farm income due to all farm land to farm income. The problem now becomes the measuring of the farm income due to all farm land. The farm income due to all farm land will be derived from the net rent paid to landlords. Some recent economic literature[1] has stressed that land is a production factor distinct from labor and capital. The distributive share of land (rent) is determined in theory by the marginal value product of land independent of wages to labor and interest to capital. However, observable rent payments are not restricted statistically to the physical productivity of the land but often include the return for various amounts of risk and uncertainty by the landlords, depending upon the nature of the lease and on other circumstances.[2] This very much complicates the statistical problem.

As for measuring farm income due to all farm land in the U.S.A., Barton and Cooper made a suggestive contribution in the article entitled, "Relation of Agricultural Production to Inputs" in the Review of Economics and Statistics (May, 1948). Barton and Cooper, agricultural economists at the Department of Agriculture, state that "Estimates of the cost of total net rent on all farm real estate each year

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[1]Scitovsky, Tibor, Welfare and Competition, Chicago, Illinois, Richard D. Irwin, Inc., 1951, pp. 227-228.

Johnson, D. G., "Resource Allocation Under Share Contracts", Journal of Political Economy, Vol. LVIII, April, 1950.

Heady, O. Earl, Economics of Agricultural Production and Resource Use. Prentice-Hall, Inc., New York, 1952, p. 623.

[2]Heady, O. Earl, Ibid., pp. 623-631.

were made by dividing the total of net rent on rented real estate by the percentage that the value of rented real estate was of the value of all real estate".[1] Restatement of their measurement in symbols will be made thus:

The Cost of Net Rent on All Farm Real Estate equals

$$\frac{\text{Total of Net Rent on Rented Real Estate}}{\dfrac{\text{Value of Rented Real Estate}}{\text{Value of All Real Estate}}}$$

$$= \frac{\text{Total of Net Rent on Rented Real Estate}}{\text{Value of Rented Real Estate}} \times \text{Value of All Real Estate.}$$

$$= (\text{Average rate of rent per dollar of rented real estate}) \times (\text{Value of all real estate})$$

According to the statistics of the Bureau of Agricultural Economics, the real estate contains the farm-land and buildings.

For the purpose of present comparative studies, the percentage of hectares of rented farm land against the total hectares of land in place of percentage of the value of real estate will be applied, simply because of lack of Japanese value data. The estimate of cost of total net rent on all farm land given above can be expressed alternatively in a formula as follows:

Total net rent on all farm land

$$= \text{Total of Net Rent on Rented Farm Land} \div \frac{\text{Hectares of Rented Farm Land}}{\text{Hectares of Total Farm Land.}}$$

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[1] Barton, T. Glen, and Cooper, R. Martin, "Relation of Agricultural Production to Inputs", The Review of Economics and Statistics, May, 1948, p. 123.

$$= \frac{\text{Total of Net Rent on Rented Farm Land}}{\text{Acres of Rented Farm Land}} \times \text{Acres of Total Farm Land}$$

= Average rate of Rent per acre X Acres of Total Farm Land

That is, the cost of total net rent on all farm land is derived from the average rate of rent per acre multiplying by acres of total farm land.

III. The Statistical Measures Used

In order to apply the ideas outlined above, numerical measures are required of "labor" used, land used, price of "labor," price of land or average rate of rent and total outputs of agricultural sectors in each country. Any one of these may be computed if the others are known. In practice the wage of "labor" has been computed from the other data. Some information on wages on farms are given below, but these have not been used statistically. Japan's statistical data are taken from National Income Statistics of Japan, October, 1953, National Income and National Economic Accounts of Japan, 1930-1955, December, 1956, Interindustry Analysis of the Japanese Economy, 1958, Economic Statistics of Japan, 1955, Statistical Yearbook of Japan, 1958, Inter-industry Table, Japan, 1951, (182 sectors), 1958, and Nihon Keizai Tokeishu (Japanese Statistical Collection of Economics) edited by Ouchi, 1958. The U.S. statistical data are taken from Census of Agriculture, Agriculture Statistics, and U.S. Income and Output, (A Supplement to the Survey of Current Business) 1958. Statistical Yearbook, U.N. and Report on the 1950 World Census of Agriculture, F.A.O., U.N. serve for the supplemental data.

1) Comparisons of Farm Income of the U.S.A. and Japan, 1951

The farm income of the U.S.A. in 1951 was 20,285. millions of dollars and that of Japan in 1951 was 881.6 billions of Yen. We may not compare the farm income in real terms of Japan with that of the U.S.A. If we use the estimate of Watanabe and Komiya for the value of the Yen in 1952 and adjust this to 1951 prices, we find an estimated exchange value of 184.2 Yen in Japan.[1] Converting our figure of 881.6 billions of Yen into dollars, we obtain 4,786. millions of dollars. Japanese farm income in 1951 was only 23.6 per cent of the U.S. farm income. This compares with a ratio between national income of Japan to national income of U.S., of an estimated 8.5 per cent. This indicates that agricultural output in Japan is large relative to all output as compared to that of the United States.

(2) Comparisons of Crop-land For the United States and Japan, 1951.

In the U.S. Department of Agriculture usage, cropland is defined as land harvested, failure, fallow, and idle, exclusive of land used only for pasture. In the Japanese Ministry of Agriculture and Forestry, the cropland is defined as cropland harvested. The rate of utilization of arable land in Japan in 1951 was 152 per cent and the arable land was 5,048,499 hectares. Areas of cropland in Japan, 1951 were 7,691,722 hectares,[2] whereas areas of the U.S. cropland were 165,514,120 hectares.[3]

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[1]See Appendix, p. 177.

[2]Statistical Yearbook, 1958, Bureau of Statistics Office of the Prime Minister, Tokyo. Source: Crop Statistical Section.

[3]Source: The U.S. Department of Agriculture, 1953.
*(1 acre is 0.407 hectare.)

Japanese areas of cropland in 1951 were only 4.6 per cent of the U.S. areas of cropland. This large difference of areas in cropland between two countries influences the size of farm operation, productivity of farm-land and of all other production factors in agricultural sectors, prices of agricultural land, of products and so on in the economy of the U.S.A. and Japan.

(3) <u>Comparisons of Number of Workers in the Agricultural Sectors for the U.S.A. and Japan, 1951.</u>

The number of workers is defined as persons engaged in production who include the unpaid family workers, proprietors of unincorporated enterprises and the workers for wage and salary. This definition is given by both U.S. Department of Commerce and Japanese Ministry of International Trade and Industry. Number of workers in the Japanese agricultural sector, 1951 was 15,208. thousands and that of the U.S.A. was 5,804. thousands. i.e., the number of workers in Japanese agriculture was 262 per cent greater than that of the U.S.A. Many agricultural workers on the scarce agricultural land of Japan creates low income per worker as compared with that of the U.S.A. This will be elaborated in a later section.

(4) <u>Total Rental Value of Land in Japan and in the U.S.A., 1951</u>

The value of land can be computed theoretically by multiplying total area of land by the rent per unit area. In addition to the problems of quality of land involved in this procedure, other problems of a more pressing nature arise in the case of estimating rent in Japan. This is because the land reform program in postwar Japan has placed some 90 per cent of all land in private ownership. Moreover the rent on the 10 per cent still leased is controlled officially by the government and at prices unrealistically low.[1] Thus it becomes necessary to use some alternative means than quoted rent value for estimating the return to land.

The means finally decided upon was to use prewar rental value as a basis. The rental price in this period was that of a free market and was realistic. Moreover it was quoted in terms of real commodities, notably rice, and thus can be realistically converted into prewar prices. There is no means of knowing that the value of land in the postwar period was the same as prewar Japan, but all information available suggests the land is more valuable in the postwar period because, in addition to the high rate of population growth in this period, many people returned to Japan's proper land (the four islands of Hokkaido, Honshu, Shikoku and Kyushu) from China, Manchuria, Karafuto, Korea and Formosa right after the termination of World War II. Hence the value of land is certainly not less than the estimate based on the prewar rent value.

The total of net rent on rented farm land in 1951 was reported in National Income Statistics of Japan, October, 1953, Economic Counsel

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[1]"Farm Status", The Oriental Economist, No. 538, Tokyo, August, 1955.

"Japan's Land Reform", Fuji Bank Bulletin, Tokyo, May 1953.

Williamson, B. Mark, "Land Reform in Japan", Journal of Farm Economics, May, 1951.

Raper, F. Arthur, "Some Effects of Land Reform in Thirteen Villages", Op. cit. May, 1951.

Hewes, I. Lawrence, Jr., "The Japanese Land Reform Program--Its Significance to Rural Asia" Proceedings, Thirteenth Annual National Farm Institute, February, 1951.

Board, as follows:

a) Tenant Paddy-Field Rent 1,403. (Millions of Yen)

b) Up-land Rent 602. (Millions of Yen)

Total of Net Rent of Rented Farm Land 2,005. (Millions of Yen)

This total of net rent figure on rented farm land was based upon the official controlled rate of rent, which was a result of Japan's Land Reform in 1945. The official controlled rate of rent was 600 Yen per Tan of rice-field, which was the maximum rate of rent. (A Tan is 0.245 acres) We may now compare this maximum official controlled rate of rent with the rate of rent in the free markets of Japan in 1936.

According to the information of the Branch of Ministry of Agriculture and Forestry in Yamagata Prefecture in Japan,[1] "In prewar periods, the Japanese tenants had to pay to their landlords 2.5 bags of rice or one Koku (A Koku is 5.119 bushels) per Tan out of 8 bags of rice production or 3.2 Koku." The rent rate in Yen in prewar Japan may be roughly estimated using the 1951 price of rice. One Koku of rice in 1951 in Tokyo wholesale prices was worth 7,860 Yen.[2] If we assume that Japan's black market rate of rent in 1951 was the same in terms of rice as the prewar rent, it was 13.1 times (7,860/600) higher than the official controlled rate of rent. This was, indeed, a result of land reform in postwar Japan. Now, we will be able to estimate total of net rent of rented farm land in terms of black market rate by multiplying 2,005. millions of Yen to 13.1. The estimate of total of net

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[1]Ministry of Agriculture and Forestry, Norin Tokei Chosa, Tokyo, Japanese Government Printing Office, August, 1953, p. 6: and also, Allen, George Cyrill; Japan's Economic Recovery, London, New York, Oxford University Press, 1958.

[2]Ouchi and et al., Nihon Keizai Tokeishu, Nihon Hyoronsha, 1958.

rent of rented farm land was some 26,265. millions of Yen.

To find the average rate of rent, the figure of area of rented farm land in 1951 is required. Since 1951 figure of the rented farm land in Japan was not available, we will use the figure in 1950 for Japan available from the Report on the 1950 World Census of Agriculture,[1] or 724,652. hectares. The average rate of rent per hectare in 1951 was 36,245 Yen (26,265./724,652). We may now convert this average rate of rent in Yen, 1951 into the U.S. dollars. The average rate of rent in 1951 in Japan in dollars was 196.8 dollars if an estimated exchange value of 184.2 Yen in Japan per U.S. dollar is applied. Finally we can obtain the Japanese farm income due to farm land by multiplying the average rate of rent to total of cropland in Japan; i.e., the cost of total net rent on all farm land in 1951 Japan was 278,786,463,890 Yen. Converted in dollars the rental income is 1,513. millions of dollars.

The total of net rent on rented farm land in 1951 in the U.S. was 1,981,121. thousands of dollars.[2] The per cent of rented farm land to all land in farms was 42 per cent.[3] This per cent was derived from the summation of land rented to others by farm operators and land rented from others by farm operators divided by the total land in

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[1]Report on the 1950 World Census of Agriculture, Vol. 1, Census Results by Countries, Food and Agriculture Organization of the United Nations, Rome, Italy, 1955.

[2]Agricultural Statistics, 1953, U.S. Department of Agriculture.

[3]Census of Agriculture, Vol. II, General Report, Statistics by Subjects, U.S. Department of Commerce.

farms. The total cost of net rent of all farm land can be obtained from the total of net rent on rented farm land by dividing the percentage of rented area to total farm land (or 1,981. millions of dollars / 0.42), or 4,716,954. thousands of dollars. The average rate of rent in 1951 U.S. was derived from the total cost of net rent of all farm land (or 4,716,954. thousands of dollars) dividing by total croplands (or 165,514,120 hectares), i.e., some 29 dollars per hectares. If we compare this U.S. average rate of rent per hectare with that of Japan in 1951, the Japanese average rate of rent was 678.6 per cent higher than that of the U.S.A. It is clear that the scarcity of Japan's cropland reflected the higher average rate of rent.

(5) Comparisons of Wage Rate in the Agricultural Workers for the U.S.A. and Japan, 1951

The average wage rates per day in the agricultural sectors of two countries are given in the Production Year Book, Vol. 12, by the Food and Agriculture Organization of the United Nation, Rome, 1958. The workers are defined as only male workers. Wage rates mean the cash portion of remuneration (where received partly in cash and partly in kind). Payments in kind included in figures are shown: a) Value of board; (b) Value of lodging.). The wage rate per day in the Japanese agriculture was 209 Yen and that of the U.S.A. was 5 dollars in 1951. Converting the wage rate of Japan's agricultural sectors into the U.S. dollars, we can obtain some one dollar, thirteen cents; i.e., the Japanese agricultural worker's wage rate per day in 1951 was 22.6 per cent of that of the U.S. The statistical results are shown in Table XIX.

TABLE XIX

The Important Statistical Data of Agriculture
U.S. & Japan, 1951

	(1) Japan	(2) U.S.	(3) Percentage, Japan of U.S. (1)/(2)	(4) Symbols for Japan [Column (1)]
1) National Income (Billions)	4,353.2 Yen ($23.633)	277.041	8.5%	Y
2) Farm Income (Billions)	881.6 Yen ($4.786)	20.285	23.6%	$p_a A$
3) Crop-Land (Hectare)	7,691,722	165,514,120	4.6%	M
4) Number of Workers (Thousands)	15,208.	5,804	262.0%	L
5) Average Rate of Rent per Hectare	36,245 ($196.8)	$29	678.6%	$r = p_m$
6) Net Rent on all Farm Land. (Millions)	278,786 ($1,513)	4,717	32.1%	R
7) Wage Rate per Day for Male Worker	209 Yen ($1.13)	5.	22.6%	p_ℓ

I V Application of the Present Statistical Data to the Cobb-Douglas Production Function

1) Measuring the "diminishing returns" on all other production factors by computing the elasticity of production factors.

We have already known in the previous analysis of the Cobb-Douglas production function that the elasticities of production factor may be computed from national income data. Let be the elasticity of land factor for Japan (1-k) and for U.S. (1 - k'), then, (1-k) and (1 - k') can be computed from the ratio of net rent on all farm land to farm income in each country; i.e., from equation (2) above as follows:

$$1-k = \frac{278,786}{881,600}$$

$$= 0.31$$

$$k = 0.69$$

$$1 - k' = \frac{\$4,717}{\$20,285}$$

$$= 0.23$$

$$k' = 0.77$$

Since the law of "diminishing returns" may be expressed in terms of the marginal productivity of a production factor, we shall estimate the marginal productivity of land, and all other production factors in the agricultural sectors in the economy of Japan and U.S. from the elasticities of production factors. For Japan we find the marginal productivity of land to be:

$$\frac{\partial A}{\partial M} = (1-k)(A/M)$$

$$= 0.31 \times \left(\frac{\$\ 4,786,000,000.}{1,691,722}\right)$$

$$= 0.31 \times 622$$

$$= \underline{192.82}$$

where A/M represents the Japanese average value productivity of 1 hectare land. On the other hand, for the U.S. marginal productivity of land we obtain:

$$\frac{\partial a}{\partial m} = (1 - k')(a / m)$$

$$= 0.23 \times (20,285,000,000 / 165,514,120)$$

$$= 0.23 \times 122.5$$

$$= \underline{28.18}$$

i.e., the marginal productivity of one hectare land in Japan, 1951 was 192.82 dollars and that of the U.S.A. was 28.18 dollars. The marginal productivity of land in Japan was 6.8 times greater than that of the U.S.A. It is clear that the scarcity of land in Japan relative to the U.S.A. is reflected in larger returns of the Japanese crop-land as compared to the U.S.A.

The marginal productivity of all other production factors in the agricultural sectors of the U.S. and Japan in 1951 may be estimated in the same way as follows:

$$\frac{\partial A}{\partial L} = k(A/L)$$

$$= 0.69 \times (\$\ 4,786,000,000/15,208,000)$$

$= 0.69 \times 314.7$

$= \underline{217.1}$

where A/L represents the average value of labor productivity for Japan, or$314.7 per agricultural worker in 1951.

For the U.S.A.,

$$\frac{\partial a}{\partial \ell} = \underline{k'} \ (a / \ell)$$

$$= 0.77 \times (20,285,000,000/5,804,000)$$

$$= 0.77 \times \$ \ 3,495$$

$$= \underline{2,691.15}$$

where a/ℓ represents the average value of labor productivity in the U.S.A. in 1951, or $3,495 per agricultural worker.

That is, the marginal productivity of labor in Japan in 1951 was 217.1 dollars, whereas that of the U.S.A. was 2,691.15 dollars, the marginal productivity of labor in Japan was 8.1 per cent of that of the U.S.A. This shows the sharp diminishing returns of labor factor in Japan relative to that of the U.S.A. due to the scarcity of Japan's agricultural land resource factor. This figure differs considerably from the ratio of wages given in Table XIX. It is a more likely estimate of the ratio of wage ratio in the two countries and is more consistent with per capita income relations.

(2) <u>Estimate of the Constant (b) for Japan and U.S. For Measurement of Capital, Technology and Other Factors</u>

Let the constant for Japan's production function be B, and for U.S. b, then we can estimate B and b.

For Japan,

$$A = B. L^{k} M^{1-k}$$

$$\log A = \log B + k \log L + (1-k) \text{Log } M$$

$$\log 4{,}786. = \log B + 0.69 \log 15.2 + 0.31 \log 7.69$$

$$3.67997 = \log B + 0.69 \times 1.181 + 0.31 \times 0.886$$

$$\log B = 2.59042$$

$$B = 389.4$$

i.e., Japan's constant is estimated 389.4.

For the U.S.A.,

$$a = b\, \ell^{k'} m^{1-k'}$$

$$\log a = \log b + k' \log \ell + (1-k') \log m$$

$$\log 20{,}285. = \log b + 0.77 \log 5.804 + 0.23 \log 165.514$$

$$4.307 = \log b + 0{,}77 \times 0.76373 + 0.23 \times 2.2188$$

$$\log b = 3.2086$$

$$b = \underline{1{,}617}$$

The ratio, B/b = 389.4/1,617 = 24%, measure the most important differences in the production functions for agriculture in Japan and the U.S. The factors labor and land are less effective in Japan because other factors such as machinery, fertilizers and agricultural implements, technologies and scale of operations favor production in the U.S.A. The difference of farm income between U.S. and Japan, i.e., Japan's farm income in 1951 was 24 per cent of that of the U.S., partly comes from the less Japan's position of capital and technology relatively to that of the U.S.A. It should be noted that the adaptability of capital and technology to the Japanese agriculture is also limited by her scarcity of crop-land.

We shall now represent some of these results graphically. For this purpose we put the ratio of Japan's farm income (A) to the U.S.A.'s farm income (a) into the simplest terms, namely:

i) $$A/a = \frac{B\,L^{k}\,M^{1-k}}{b\,\ell^{k'}\,m^{1-k'}}$$

$$L^{k}M^{1-k} = (L/M)^{k}M$$

$$\ell^{k'}\,m^{1-k'} = (\ell/m)^{k'}m$$

ii) Hence, it can be restated as follows:

$$A/a = \frac{B\left(\frac{L}{M}\right)^{k} M}{b\left(\frac{\ell}{m}\right)^{k'} m}$$

iii) It will be expressed in terms of logarithms as follows:

$$\log A = \log(B.M) + k \log(L/M)$$

$$\log a = \log(b.m) + k' \log(\ell/m)$$

i.e., the ratio of Japanese farm income to the U.S. farm income depends upon (1) the ratio of Japan's capital and technological position (B) to that of the U.S.A. (b), (2) the ratio of the Japanese quantities of crop-land (M) to that of the U.S.A. (m), (3) the ratio of the Japanese agricultural workers per hectare of crop-land (L/M) to that of the U.S.A. (ℓ/m), and finally, (4) the ratio of elasticity of all other production factors in Japan (k) to that of the U.S.A. (k'). The elasticity of all other production factors (k and k') determines the slope of straight lines in the logarithmic graph.

We take log A and log a on the vertical line, Y axis, and log (L/M) and log (ℓ /m) on the horizontal line, X axis; then, log B.M and log b.m show the constants and k and k' show the slope of straight line for Japan and for the U.S.A. respectively. The figures obtained for this analysis in 1951 were as below:

$\log A = \log 4,786. = 3.67997$

$\log a = \log 20,285. = 4.30707$

$\log B.M = \log (389.4 \times 7.692)$

$= \log 2,995.2648 = 3.4764$

$\log b.m = \log (1,617 \times 165.514)$

$= \log 268,636.138 = 5.42911$

$\log (L/M) = \log (15.208 / 7.692)$

$= \log 1.975819 = 0.29557$

$\log (\ell/m) = \log (5.804 / 165.514)$

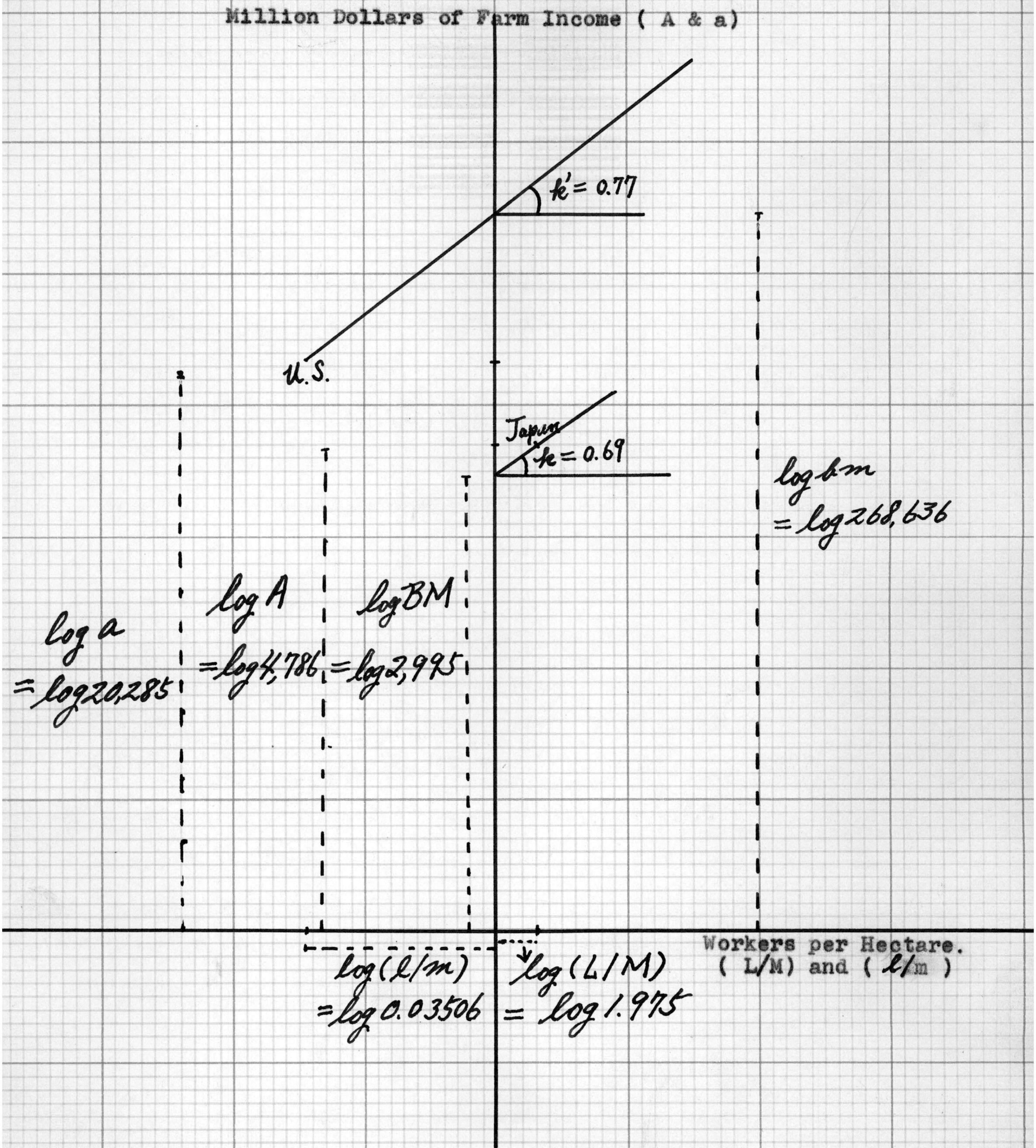
$= \log 003,506$ (per hectare) $= -1.45519$

(L/M and ℓ/m...Unit : thousand per million hectares)

$k = 0.69$ and $k' = 0.77$

Now, we can draw the Cobb-Douglas production function in agricultural sectors of the U.S.A. and Japan, in 1951 in Chart 5. It is clear from Chart 5 that Japan's more labor intensity ($L/M > \ell/m$, i.e., Japan's laborer per hectare was greater some 56.3 times than that of the U.S.A.), her lower elasticity of all other production factors ($k < k'$), her lower positions of capital and technology ($B < b$) and her scarcity of crop-land ($M < m$) all together determine Japan's lower farm income per worker relative to the U.S.A.

Chart 5. Cobb-Douglas Production Function in Agricultural Sectors for U.S. and Japan, 1951



(3) Estimate of Japan's New Farm Income under the Assumption of The Equality of Japan's Crop land per Labor to that of U.S. in 1951 under Japanese Elasticity, k

Direct appraisal of the importance of agricultural land in Japan can be measured much more clearly if we think of the agricultural land factor only; i.e., assuming that Japanese agricultural land per labor force were available to the same extent as in the U.S. while holding the elasticities of production factors and capital and technological position constant. In fact this is the pure effect of productivity due to land resources.

Our assumption is restated in symbols as follows:

i) $\frac{L}{\ell} \cdot m = M^* = 433,646,994.$ (Hectares) M^*: Japan's new crop-land.

ii) B and k are constant.

The Cobb-Douglas production function will be as follows:

$$A^* = B\,L^k\,{M^*}^{1-k}$$

$$\log A^* = \log B + k \log L + (1-k) \log M^*$$

$$= \log 389.4 + 0.69 \log 15.208 + 0.31 \log 433,646,994$$

$$= 2.59040 + 0.69 \times 1.1821 + 0.31 \times 2.63609$$

$$= 4.2226369$$

$A^* = \underline{16,700}.$ (Unit: Millions of Dollars)

That is, assuming only two factors of production, land and labor, ignoring all other determinants of the efficiency of labor such as capital equipment, agricultural implements, costs of fertilizers and economies of scale, we should expect, that if the crop land were available in Japan in 1951 as the same quantities of land per the agricultural worker, as in the United States in 1951, that Japan could have produced 16,700 million dollars of agricultural income with 433,646,994 hectares and with the Japan's existing number of agricultural workers. The ratio, 16,700/ 4,786 equals 3.5, indicating Japan's increase of farm income resulting from the increase of quantities of land. On a per worker basis this is 1,098.1 dollars per Japanese "land adjusted" workers. In the United States itself in 1951 the figure is 3,495 dollars.

In this way, we reach the conclusion that the income per worker in the agricultural sector is actually some 11.1 times (3,495. / 314.7), as large in the U.S.A. as in Japan. If we adjust the Japanese output for land deficiencies in the manner outlined, we find that U.S. output per worker is some 3.18 times as large as in Japan. This suggests that other influence than land quantities increases the U.S. output per agricultural worker by a factor of 3.18. To put this matter differently, it appears that out of the total difference in real output per the agricultural worker, some 24.6 per cent is accounted for by greater land availability in the U.S.A. and some 73.4 per cent by other factors such as the advantages of capital, technology scale, and so on.[1] Further this analysis will be carried through in greater detail in the next section.

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[1]See Appendix p. 181 for the detailed calculation.

(4) <u>Estimate of Japan's new Farm Income Under the Assumption of the Equality of Japan's Crop Land per Labor to that of U.S. with U.S. Elasticities k'.</u>

In order to isolate the effect of productivity due to capital, technologies and others from the effects due to the Japanese "land adjusted" per agricultural worker, we assume that the elasticities of Japanese agricultural land and labor factor will change to the same level as those of the U.S.A. in 1951 and that the Japanese capital and technology position will be kept constant. In symbols, the Cobb-Douglas production function will be as follows:

$$A^* = B\,L^{k'}\,M^{*\,1-k'}$$

$$\log A^* = \log B + k' \log L + (1-k')\,M^*$$

$$= \log 389.4 + 0.77 \log 15.208 + 0.23 \log 433.646994$$

$$= 2.59040 + 0.77 \times 1.1821 + 0.23 \times 2.63609$$

$$= 4.1069177$$

$$A^* = \underline{12{,}800.}$$

Assuming only two factors of production, land and labor, and that the elasticity of two production factors for Japan is raised to the level of the U.S., and ignoring all other determinants of the efficiency of labor such as capital equipment, agricultural machines, costs of fertilizers and economies of scale, we should expect, that if the crop-land were available in 1951 in the same quantities of land per the agricultural worker, as in the United States in 1951, that Japan could have produced 12,800. million dollars of agricultural income with 433,646,994 hectares and with the Japanese existing number of agricultural workers, or 15,208 thousands of workers.

The ratio, \$12,800 / 4,786 equals 2.7, indicates Japan's increase of farm income resulted from the increase of quantities of land and the change of elasticities of production factors. On a per worker basis this is 841.7 dollars per Japanese "land adjusted" workers. In the United States itself in 1951 the figure is 3,495 dollars whereas the actual figure of Japan was 314.7 dollars. In this way, we reach the conclusion that the real income per worker in the agricultural sector is actually some 11.1 times as large in the U.S.A. as in Japan. If we adjust the Japanese output for land deficiencies in the manner outlined, we find that U.S. output per worker is 4.15 times as large as in Japan. This suggests that other influence than land quantities increases U.S. output per agricultural worker by a factor of 4.15. To put the matter differently, it appears that out of the total difference in real output per the agricultural worker, some 16.6% is accounted for by greater land availability in the U.S.A. and some 84.4% by other factors, or capital and technology position of the U.S.A.[1] (greater availability of the constant b in symbols)

This suggests the importance of capital and scale in the agricultural sector, i.e., the difference between the U.S. elasticity of land and that of Japan is given as 2,772 million dollars, which indeed shows the inefficiency of labor and land as compared with that of Japan. The great difference between 53,120 under $A^* = b\,L^{k'} M^{*\,1-k'}$ and 12,800 under $A^{**} = B\,L^{k'} M^{*\,1-k'}$, or 40,320. million dollars is in considerable part due to the great difference of capital position

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[1] See Appendix p. 181 for the detailed calculation.

between two countries (and reflected in B and b). The differential position of agricultural sectors between the two countries can be seen in the following table:

TABLE XX

Expenses of Fertilizer & Agricultural Implements, U.S. & Japan, (1951)

	(1) Japan[a] (Million Yen)	(2) U.S.[b] (Million dollars)	(3) The Ratio of Japan to U.S. 1) / (2)
1. Cost of Fertilizers and Lime	66,109 ($358.898)	1,061.	33.8%
2. Operation of Motor Vehicles	3,537[(i)] ($19.2)	2,048.	0.9%
3. Maintenance or Depreciation of Buildings, Machinery and Equipment	2,575[(ii)] 13,820.[(iii)] ($89.0)	4,443.	2.0%
4) Total	86,041. ($467.1)[(iv)]	7,552.	6.2%

Remarks: i) Japanese figure denotes the cost of transportation.
ii) Japanese figure; agricultural machinery and implements.
iii) Japanese figure; construction and maintenance.
iv) Conversion rate, 184.2 Yen per dollar.

Sources: a) For Japan, Interindustry Table, Japan, 1951 (182-Sectors) Ministry of International Trade & Industry, Tokyo, 1958.
b) For the U.S.A., Agricultural Statistics, 1953. U.S. Department of Agriculture.

That is, capital position in the Japanese agricultural sector, 1951, was only 6.2 per cent of that of the U.S.A. If we eliminate Japan's transportation cost and U.S. motor vehicles, then, capital position of the Japanese agricultural sector in 1951 was 8.1 per cent of that of the U.S.A. It is clear that this great difference of capital position between the U.S. and Japan affects agricultural productivity considerably. It should be noted that agricultural machinery and implements in the Japanese agricultural sector in 1951 was only 2% of that of the U.S.A. whereas the total expenditure on fertilizer in Japanese agricultural sector was some 30.% of that of the U.S.A. This suggests that Japan's agriculture is less capital intensive relative to the U.S.A. The chief reason of this lesser capital intensive in Japan was, of course, due to the scarcity of agricultural land relative to the U.S.A. The small scale of farm operation and mountainous geographical characteristic of Japanese farm land made it impossible to mechanize the Japanese agriculture.

CHAPTER IV

PRODUCTION LEVELS AND MATERIALS USED IN THE NON-AGRICULTURAL SECTORS JAPAN AND U.S., 1951

The purpose of this chapter is to attempt an explanation of the difference in output per worker in the United States and Japan arising from the differences in the availability of crude raw materials at advantageous terms. It is clear that at high prices, Japan has all the available raw materials in the world market which she needs. The problem is to determine how great a handicap to production are the higher prices inherent in Japan's position as a country of low resource endowment relative to population.

To reduce this problem to simple terms, some extreme simplifying assumptions are required. The first of these is that production is a function of factors in a specified fashion. In particular, only two factors of production, namely, labor and resources, are assumed for the present analytical purpose. The second assumption is that the two factors of production treated are homogeneous. The third basic assumption is that the total output of the non-agricultural sectors in the two countries is homogeneous. The fourth assumption is that substitution between two factors of production is possible in the two countries. Finally, the fifth assumption is made that prices prevailing in the two countries are at equilibrium levels reflecting optimum use of resources. These assumptions will make possible meaningful comparative studies of the output of Japan and U.S., although further qualification of the results will be noted at relevant points.

Before we examine the significance and reasonableness of these assumptions, we shall present the method of analysis which they make possible in order that the reader may understand the general line of thought. In a general way, we can observe an approximation of loss involved from the law of "diminishing returns" by using the given prices and quantities of factors used in the two countries in the year 1951, and this is what is attempted.

1. Theory of the Production Function

The basic theory of the production function confronting in a firm will be briefly considered, because a general production function is obtainable from the firm's production function.

General Production Function Obtainable From Firms

Sune Carlson's presentation is typical of the conventional approach of production function as usually stated.[1] If we denote the quantity of output by Y, and the quantities of the variable productive services, n in number, by $X_1.........X_n$), we write

$$Y = f\ (X_1.........X_n)$$

This is our production function. It must be remembered that the production function is defined in relation to a given capital, or to the fixed capital coefficients in the short run and to capital as variable in the long run.

A given amount of output may frequently be produced from a number

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[1]Carlson, Sune: A Study on the Pure Theory of Production, The University of Chicago Libraries, Chicago, 1939. P. 14-15.

of different service combinations. It may also be true that the same combination of productive services gives varied amounts of output, depending upon how efficiently the productive services are organized. Carlson focuses attention on the flows of inputs and outputs because these are the variables that convey the impact of the firm in question on the markets in which it operates.[1]

The fact that there is one output in the equation quoted is fortuitous, not an essential characteristic of the conventional approach.[2] Production functions can be derived for observations measured in either physical or value units. One derived for a group of record firms can include all input and output quantities measured in value terms. Ordinally, output is measured in value terms; inputs such as capital are measured in value terms: labor and land are measured in physical units. But regardless of whether the observations are in physical or value units, the production function must correspond with the technical conditions of production. Even if all units of output and input are measured in dollars or Yen value terms, the technical relationships are the same as if observations were in physical units. This statement applies, of course, only where price is a constant, as it is in the purely competitive condition of a firm.[3]

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[1]Dorfman, Samuelson, and Solow, Linear Programming and Economic Analysis, McGraw-Hill Book Co., Inc. New York, p. 201.

[2]Dorfman, et. al., Op. cit., p. 201.

[3]Heady, Johnson, and Hardin, Resource Productivity, Returns to Scale, and Farm Size, The Iowa State College Press, Ames, Iowa, U.S.A., 1950, p. 4.

Since all units of output and input are measured in value terms in the production function, a general production function for industry will be obtainable from the firm's production function. A simple aggregation and some weighting of different products is a necessary approximation procedure. A problem now arises, as is well-known, from index numbers, and which is elaborated in the Appendix.[1] We shall use index numbers to obtain a general production function for industry from that of the industrial firm. We now consider the firm's production function.

Substitutability VS. Technical Complementarity

Production functions show different service combinations at given outputs. Generally, the different service combinations are divided in three possible ways; perfect substitution, technical complements and a service combination between these extremes.

First, perfect substitution means that one resource may be substituted entirely for the other. The isoquants are linear or the marginal rate of technical substitution is constant. The marginal product of the resource is constant; there is no limit to the quantity of the best resource to use: this is not a practical case. Geometrically, this case is illustrated as follows:[2]

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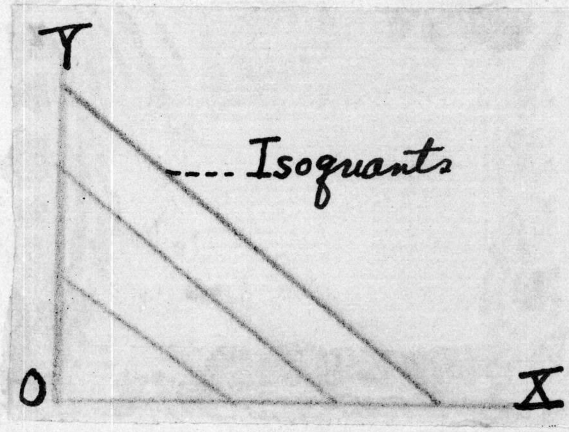
[1]See Appendix, pp. 182-183.

[2]Heady et. al., *Op. cit.*, pp. 4-5.

Resource B



Resource A

(Chart 6, Production Function with Constant Resource Returns)

The resources are perfect substitutes and as long as the marginal rate of substitution (a constant) is greater than the price ratio, profits can be increased by substituting one resource for the other.

Second, at the opposite extreme, technical complements indicate that substitution of two factors is impossible. In this case, no consideration of least cost is involved, but only the optimum quantity of the resources in fixed proportions to use. One resource alone is increased with the constant other resource at the given output, as a result, the input-output curve can represent diminishing returns. Production function is reduced to a simple relation between output and factor, A. The geometrical illustration is given as follows:[1]

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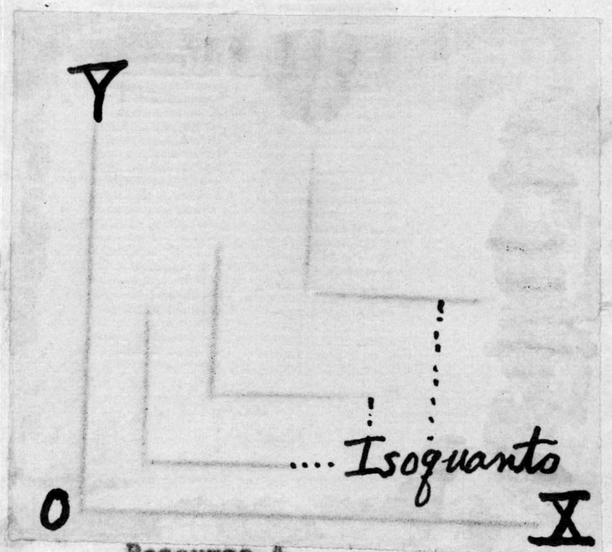
[1]Heady et. al., Op. cit., pp. 4-5.

Resource B

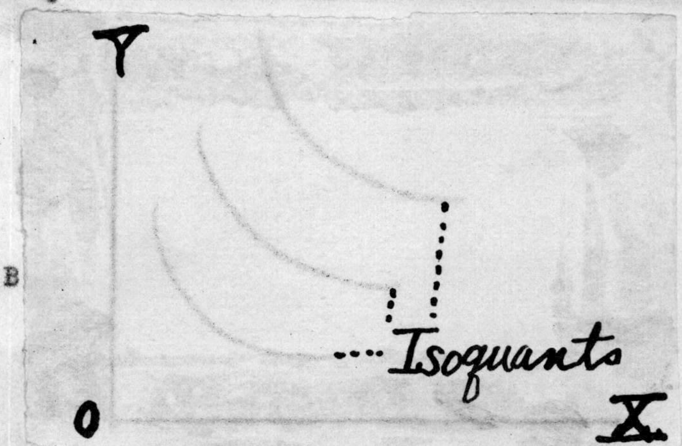


Resource A

(Chart 7, Production Function with Resources as Technical complements)

Third, there is a general type of service combination between these extremes of technical complements and perfect substitutes. The marginal rate of technical substitution is to diminish over the range in which substitution between two factors is possible and technical complements may prevail beyond the range of substitution. Geometrically, this type of production function is illustrated as follows:[1]

Resource B



Resource A

(Chart 8, Function with diminishing marginal productivity and substitution rates)

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[1]Heady, et. al., Op. cit., pp. 5-6.

In this case diminishing productivity holds true for each resource alone, or for any fixed ratio of the two resources. The following theory of the firm's production function is focused on this type of service combination. The production function represents the scope and limitations of production as determined by technical conditions. Such a function may be represented by isoquants and productivity curves.[1] The nature of isoquants and productivity curves will be illustrated.

Illustration of Production Indifference Curves or Isoquants.[2]

It is worth while to illustrate the principle of isoquants graphically. For the sake of convenience, we shall have to restrict ourselves to the firm that employs only two factors of production, labor and resource. Our second assumption is that the same output can be produced in more than one way and with more than one combination of factors but there is a limit to the possibility of substituting one factor for another. Let us take the quantity of labor as X and the quantity of material as Y. Then we can draw the production indifference curves, usually called isoquants, defined as combinations of factors yielding the same output.

The isoquant 100 in Chart 9 shows the different quantities of the two factors which can produce 100 units of the product, and so forth. Lines I and II indicate limits which further substitution becomes

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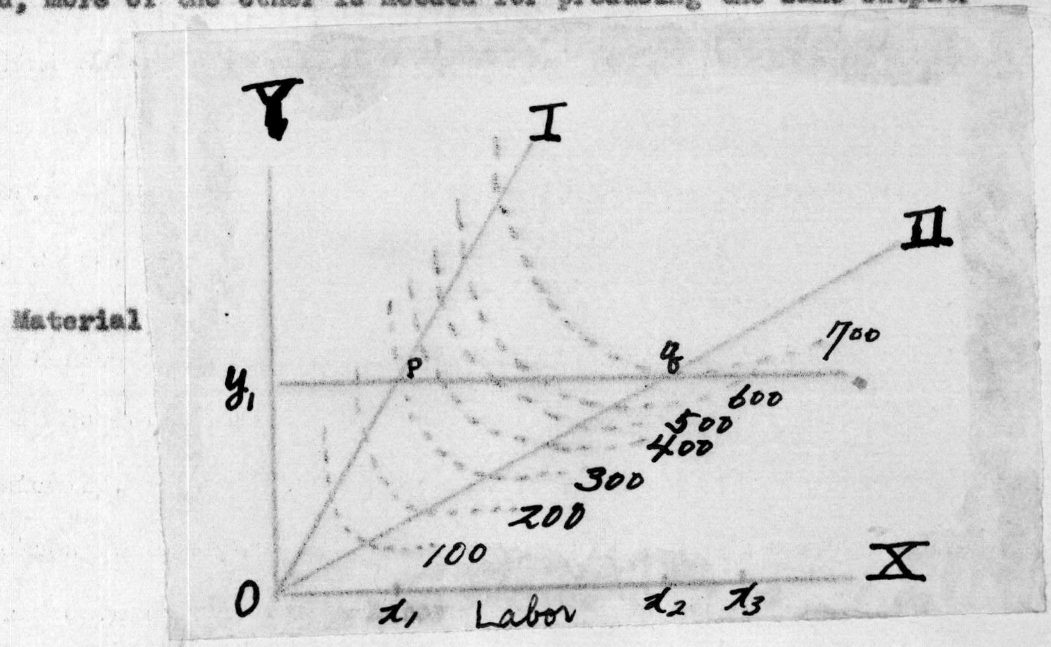
[1]Scitovsky, Tibor, Welfare and Competition, Irwin, Inc., Chicago, 1951, p. 121.

[2]Scitovsky, Tibor, Op. cit., pp. 113-117.

impossible. These two lines are usually called the boundary lines. The isoquants in Chart 9 have been drawn with a downward slope through part of their range to indicate the fact that, when less of one factor is used, more of the other is needed for producing the same output.

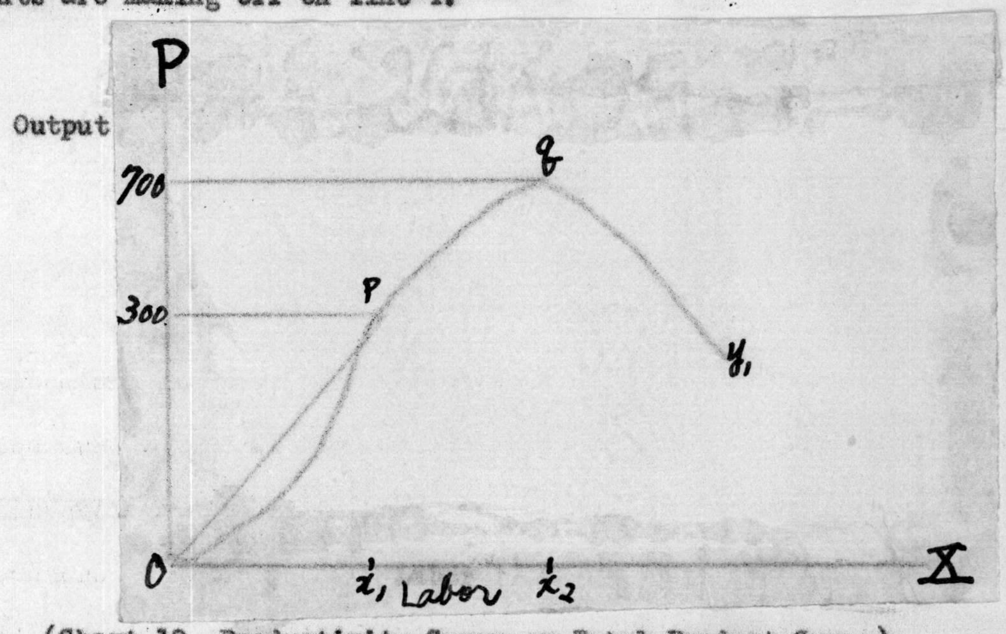


(Chart 9, Isoquants Map)

The slope of the isoquant in this range expresses the rate at which one factor can be substituted for the other without changing outputs. This is called the marginal rate of technical substitution between two factors of production. The shape of isoquants beyond the limits of substitution is parallel to the axes or veering away from the axes, showing that additional quantities of one factor alone are useless or cumbersome. If x_3 workers, or more than x_2 workers are employed with the constant materials y_1, they interfere with the smooth functioning of the factory, cause overcrowding, get into each other's way, and thereby reduce total output from 700 unit of output to 600 unit of output, as shown in Chart 9.

Productivity Curve Derived From Isoquants[1]

Production curves indicate the dependence of output on the quantity of factor of production X, while withholding other factors of production P constant. The production curve may be derived from the isoquants. The relationships between output and movement along a horizontal line in the isoquants map become clear in the productivity curve. Let us measure the factor labor on the horizontal axis and the quantity of output on the vertical axis, then draw the production curve which in the isoquants map was represented by intervals which isoquants are making off on line Y.



(Chart 10, Productivity Curve or Total Product Curve)

The position and slope of the productivity curve are most easily determined at points p and q, whose relation to the corresponding points in Chart 9 is simplest to establish. It appears from Chart 9

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[1]Scitovsky, Op. cit., pp. 117-118.

that output is highest at point q, from which it follows that the productivity curve will have its highest point at q, rising up to there and descending beyond it. To determine the slope of the productivity curve y_1 at point p, we assume that a one percent addition to the input of factor X and Y at point p would also raise output by one percent. At point p, the marginal productivity of factor Y is zero, because the additional increase of factor Y would not increase output at all. The increased input of factor X results in a proportional increase in output. Hence, the slope of the productivity curve at this point must be the same as that of a straight line going through the origin: i.e., at point p, the marginal productivity of labor is equal to the average productivity of labor; which will be illustrated later in Chart 11.[1]

From here on, it is easy to complete the drawing of the productivity curve y_1. Assuming that the curve is smooth, we must make it concave from below between points p and q. As to the range to the left of p, there the productivity curve must always have a slope that is steeper than that of a straight line through the origin. This represents the fact that in this range, increases in the input of X result in more than proportional increases in output; because in this range the marginal productivity of Y is negative. Thus, the results enable us to draw the productivity curve y_1 shown in Chart 10 from the isoquants in Chart 9.

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[1]See page 116 in <u>This Thesis</u>.

Assessing the Role of the Law of "Diminishing Returns" in Isoquants

The slope of the productivity curve shows the marginal rate of transformation of factor X into output P. This rate is also called the marginal productivity or marginal product of the factor X. Generally, the marginal product of a factor is defined as the additional unit of quantity of product due to the utilization of one additional unit of the factor. The additional quantity of the factor needed to produce an additional quantity of product is called the marginal input. The law of "diminishing returns" is set forth by the marginal concept, say, marginal product and marginal input.

The law of "diminishing returns" states that as equal increments of one input are added, the inputs of other productive services being held constant, beyond a certain point the marginal products will diminish. This law is valid under the following conditions. First, the state of technology is held constant. Second, the law does not apply when all inputs are harmoniously varied; it is necessary that there be productive services whose quantity is held constant. Third, the law answers the possibility of varying the proportions in which the various productive services combine. In this connection, we should note that the phrase "beyond an input" must also be interpreted to mean; "beyond and input that is usually reached" if the law is to be important. Under these conditions, the law embraces almost all production functions.[1]

It is worth while to illustrate the marginal productivity curve

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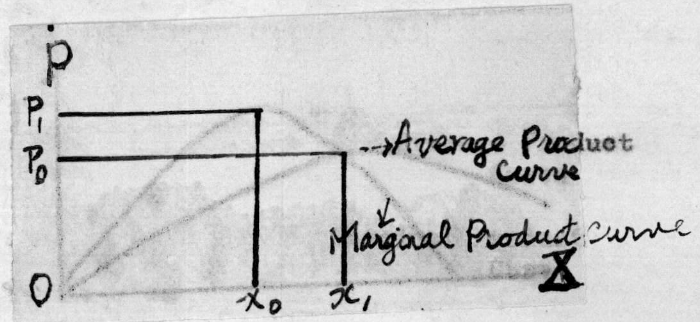
[1]Stigler, J. George, The Theory of Price, Macmillan Co., New York, 1946, pp. 111-112.

derived from the productivity curve (or Total Product curve) in Chart 10. The average productivity curve can also be derived from the productivity curve. The marginal product is equal to the slope of the total product curve, and the marginal product will increase (or decrease) with the increase (or decrease) of the angle which the tangent to the total product curve forms with the horizontal axis.

First, when the average product is increasing (or from O to p in Chart 10), the marginal product is greater than average product. Second, when average product is at maximum at the point p, the marginal product equals the average product. Third, the maximum marginal product is reached at the highest tangent below the point p. Finally, when the average product is decreasing, marginal product is less than average product (or from p to q). At the point q, as mentioned before, the marginal product will become zero.[1] Thus, we can draw the marginal and average product curve shown in Chart 11 from the total product curve in Chart 10.

Output



Labor

(Chart 11, Marginal & Average Product Curves)

[1]Stigler J. George, Op. cit., pp. 24-30.

The law of diminishing returns dominates the range beyond a labor input x_o, on the horizontal axis. Production will always take place beyond x_o, since if it pays to use labor at all, it will pay to use labor with at least the maximum marginal product. It should be noted that the marginal product and marginal input are reciprocals of each other beyond x_o. Let the marginal product of a factor X be MP_x and the marginal input of X be MI_x. The relationship between the marginal product of the factor X and its marginal input may be stated[1]

$$MI_x = \frac{1}{MP_x} \quad \ldots\ldots\ldots(1)$$

A simple and important relation exists between the marginal inputs and marginal products of two factors of production on the one hand and the marginal rate of technical substitution on the other hand. The relations can also be expressed in symbols.[2]

$$M.T.S._{xy} = \frac{MI_y}{MI_x}$$

$$= \frac{\Delta y}{\Delta x}$$

$$\frac{MI_y}{MI_x} = \frac{MP_x}{MP_y} \quad \ldots\ldots\ldots(2)$$

where $M.T.S._{xy}$ stands for the marginal rate of technical substitution between two factors, X and Y.

These relations enable us to measure the relative diminishing returns relations between two isoquants of different shape.

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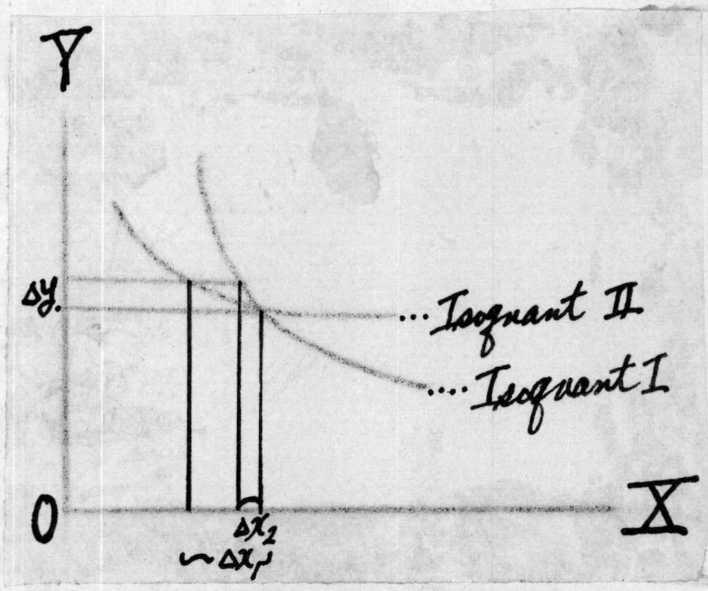
[1]Scitovsky, Tibor, Op. cit., p. 119.

[2]Ibid., p. 119.

Assuming isoquant I, for which the marginal rate of substitution is -2, and isoquant II, for which the marginal rate of technical substitution -4, and setting resources on the vertical line Y axis and labor on the X axis, we can draw the two isoquants, I and II, in the same isoquant map at the same production level.

Materials



Labor

(Chart 12, Diminishing Returns in Isoquants)

At point p, the slope of isoquant I is -2 and that of isoquant II is -4. The marginal product of labor in each isoquant can be algebraically estimated as follows:

$M.T.S._{xy}$ for isoquant I = -2

or

$$\frac{\Delta y}{\Delta x_1} = -2 \quad \ldots\ldots (3)$$

$M.T.S._{xy}$ for isoquant II = -4

or

$$\frac{\Delta y}{\Delta x_2} = -4 \quad \ldots\ldots (4)$$

Divide equation (4) by equation (3),

$$\frac{\Delta x_1}{\Delta x_2} = 2$$

$$\Delta x_1 = \frac{1}{MP_{x_1}} \quad \ldots\ldots(5)$$

$$\Delta x_2 = \frac{1}{MP_{x_2}} \quad \ldots\ldots(6)$$

Divide equation (5) by equation (6)

$$\frac{\Delta x_1}{\Delta x_2} = \frac{MP_{x_2}}{MP_{x_1}}$$

Hence, $\underline{MP_{x_2} = 2MP_{x_1}}$

That is to say, the marginal product of labor for the isoquant II is 2 times that of the isoquant I. We may say that the isoquant I indicates 50 per cent more diminishing returns than the isoquant II does. The shape of the isoquants expresses the relative diminishing returns relation.

The Equilibrium Conditions in Production Functions

Up to now, our discussion has been focused on the isoquants and productivity curves. The isoquants and productivity curves together describe a firm's or industry's production function. Next, we have to take into consideration the optimum conditions when both factors of production are allowed to vary. Under the criterion of minimum cost of production, the equilibrium conditions in production functions are,[1] first, that the marginal rate of technical substitution of two factors

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[1]Scitovsky, Tibor, Op. cit., p. 123.

of production equals the ratio of their market prices and second, that the isoquant be convex to the origin in the neighborhood of that point. The second condition is restated as the diminishing marginal rate of technical substitution. The latter condition is fulfilled when the firm produces within the range of substitutability, bounded by the boundary lines I and II in Chart 9.

The first condition is restated in symbols:

$$M.T.S._{xy} = \frac{P_x}{P_y}$$

$$\frac{MI_y}{MI_x} = \frac{P_x}{P_y}$$

$$P_y \cdot MI_y = P_x MI_x$$

$P_x \cdot MI_x$ is the market cost of the marginal input of X, or the marginal cost of an additional unit of output when this is produced by the increased utilization of factor X only. Similarly, $P_y \cdot MI_y$ is the market cost of the marginal input of Y, or the marginal cost of an additional unit of output when this is obtained by the increased utilization of factor Y only. Hence, the condition of minimum cost is written:

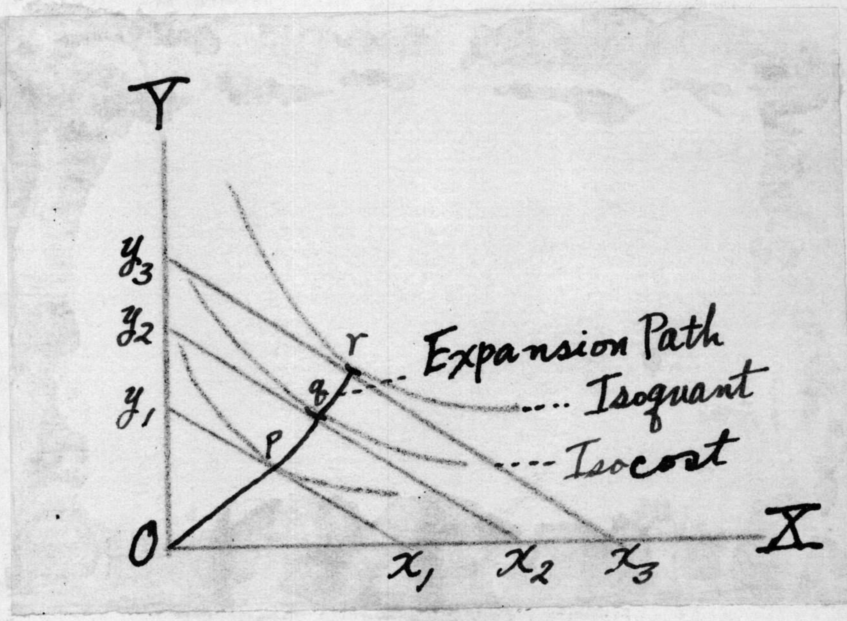
$$\underline{MC = P_x MI_x = P_y MI_y}$$

These equations state that, to minimize his costs, the producer must equate the price of each factor to the marginal cost.

The proof of these equilibrium conditions is obtained by considering any alternative situations. If the value of marginal input of a factor X is greater than the value of marginal input of a factor Y, producers tend to utilize a factor Y more than a factor X in order to achieve the minimum cost. Purchasing a factor Y in the place of a factor X is possible because a factor X is a substitute for a factor Y. As a result, a price of a factor Y will be raised until the value of marginal input of a factor X will become equal to the value of marginal input of the factor Y.

The optimum conditions of combination of two factors of production, that is, the maximum output at producer's minimum cost, can be drawn by the isoquants and isocosts which show the ratios of market prices between two factors of production.[1]

Materials



Labor

(Chart 13, Isocosts)

Each one of isocosts in Chart 13 expresses the various combinations of the two factors which can be bought at the same cost. To maximize his profit, the entrepreneur must go to a point of tangency between an isocost and an isoquant, because it is at such points that a given isocost

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[1] Scitovsky, Tibor, _Op_. _cit_., p. 123.

touches the highest isoquant (maximum output at given cost) and a given isoquant touches the lowest isocost (given output at minimum cost). A line which passes through the tangencies, p,q, and r, and through the origin O, is called the expansion path, defined as the path of the minimum costs at the different production levels.

We shall be able to use the foregoing basic theory of the production function in our studies of comparative productivity in the non-agricultural sectors of U.S. and Japan, if we can obtain the necessary statistical data and make the appropriate assumptions. In our present analysis, the value of crude raw materials, number of workers, the gross national product (or, national income) in non-agricultural sectors, the wage rates and price of unit of crude raw materials will be necessary statistical data. These variables can be drawn in the same isoquants map for two countries, although the difference of economies of scale gives us some difficulties such as problems of index numbers.[1] We will discuss in the next section appropriate assumptions which make it possible and meaningful to use the theory of a firm's or industry's production.

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[1]See Appendix in <u>This Thesis</u>, pp. 182-183.

11. Discussion of the Assumptions

In this section, the significance and reasonableness of the assumptions listed at the beginning of the chapter will be discussed. It is clear that we have had to make such assumptions in order to use available data for comparison of productivity in the U.S.A. and Japan.

The first assumption was that only two factors of production were utilized in the non-agricultural sectors in the economies of the U.S. and Japan. The two factors of production selected are labor and raw materials. Actually, as is well-known, the factors of production are not limited to two. The reason why we restrict ourselves to only two factors of production is that we wish to isolate the effects of resource scarcity. In other words, we assume provisionally that all factors other than resources are equal in productive capacity even though we strongly suspect that they are not. This permits us to analyze the importance of resources alone on the assumption made. A further useful purpose is that a simple measure of other factors can be made in terms of labor.

The second assumption was that each of the two factors of production was homogeneous. In the case of labor, capital and other factors, we assume homogeneity for analytical purpose. Although the workers in the two countries are not homogeneous, because incentive to work, degree of skill, scientific knowledge and ability to apply knowledge are different among workers within each country. If homogeneous workers are not assumed, it will be impossible to measure the number of workers in the two countries on the same production indifference (or isoquants map). In the case of materials, homogeneity raises an index problem, since materials are compounds of metals, cottons, woods and etc. of different types. (These are obtained non-homogeneity from a physical unit, because the qualitative differences of materials between two countries may be great.)

From the economic point of view, raw materials can be considered homogeneous by some type of weighting process, which is implicitly used by all economists in connection with aggregate measures such as gross national product, real income of consumers, price indexes and the like. This subject is discussed in the Appendix.[1] The two important facts are these. First of all, heterogeneous objects may be measured by a single homogeneous unit, if the proportions are constant. Thus one unit of raw material can be defined as one ton of coal plus 100 bales of cotton etc., and this unit is perfectly satisfied in so far as the proportions of raw materials in question remain constant. Although the proportion will not remain constant in time or as between countries, they will be sufficiently so, that the amount of reconciliation of one material in terms of another is greatly reduced. Only the variation in proportions must be explained in terms of some substitution or index number method. Secondly, a means of measurement of substitution between materials can be found in terms of consumer substitution of products in utilities. This is also discussed in the Appendix.[2]

The third assumption was that the total output of the non-agricultural sectors in the economy of U.S. and in that of Japan are homogeneous. In case of a theory of a firm's production function, one

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[1&2] See Appendix, pp. 182-183.

product is assumed. Here, we deal with not only one product but also the various kinds of products in the non-agricultural sectors. This also raises an index number problem of weighting the different outputs in terms of one another. The justification is similar to that just described for the factors, and will be discussed in Appendix.[1] We assume homogeneous total product in converting Japan's value of total output in the non-agricultural sector into U.S. dollar value of total output. Thus, we will be able to treat the total output in two countries, as well as we treated one product of a firm in the isoquant map.

The fourth assumption was that substitution between factors would be possible and that the marginal rate of technical substitution is diminishing over the range of possible substitution. The latter assumption will be readily granted if substitution is possible at all, as will be presently shown. The possibility of substitution requires, however, some justification. Three main reasons for believing that substitution takes place are as follows:

a) Direct Material Saving Devices

Substitution between materials and labor is possible by saving materials through employing more labor. A country like Japan which has a low resource endowment relative to population seems likely to incline to save materials by using more labor. Examples for this type of substitution are numerous. During the Pacific War, oil in Japan was so scarce that a motto of Japanese was: "A drop of oil is as precious as a drop of human blood." As was well-known in Japan's military

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[1]See Appendix in This Thesis, pp. 182-183.

strategy, "Kamikaze Suicide Pilots" illustrated materials saving. The "Kamikaze Suicide Pilots" did not prepare the gasoline for a round-trip but only for one way.

Another Japanese example during World War II was that authorities recommended that people walk on foot in the place of taking the tram-cars and driving automobiles. A Japanese motto was: "Walk on Foot! and Walk on Foot!" This clearly indicated that more additional labor forces were required for the purpose of saving the precious gasoline and electric energies which could thus be diverted to more important industrial uses.

In general, the careful use of materials requires more labor forces. For example, a careful cutting of logs under lower labor cost can be considered as saving of crude woods. The repetitive use of iron resources by re-smelting scrap and the repetitive use of paper resources by re-pulping the waste paper at the expense of more use of labor can be also considered as direct materials saving. The exploitation of mineral deposit of poor grades is a good example of saving materials at the expense of more use of labor. In fact, most of Japan's coal deposits require a shaft mining method which is more expensive relative to the open-air mining method. Volcanic formation of the geology of Japan has made as abundance of dislocational strata, which has made her shaft mining method more labor intense than otherwise.

b) <u>Choices of Techniques in Production</u>

The second type of substitution between materials and labor is that the highly developed techniques make it possible to use more material and less labor and, on the other hand, the less developed techniques require more labor and less material use. Examples for this type of substitution are also numerous, when we compare the economy of Japan and U.S. This type of substitution seems to be well explained in the comparative studies of service industries in the U.S. and Japan.

The well equipped super market in the U.S.A. with machines such as calculating machines, refrigerators and large floor space, lighting etc., makes it possible to use more materials for sale with relatively less labor services. In Japan, relatively poorly equipped super-markets require more labor and less materials for sale. The structural difference in super-market between two countries is due to the different degree of technical development.

In the fields of communication, the automatic telephone service requires fewer telephone girls but more materials for the equipment in the U.S. economy as a whole. On the other hand, the automatic telephone service in Japan is only utilized in the large cities; so that Japan's telephone service requires more labor and less materials. In the fields of transportation, the U.S. large trucks, which her good highways make possible, can load more materials per driver; on the other hand, Japan's small trucks due to her poor highways can load less materials per driver. Since the U.S. bus is highly mechanized with gadgets such as automatic doors and bus fare collectors, the bus conductors are eliminated. On the other hand, in Japan, each bus requires at least one bus conductor (or more labor requirements) due to less mechanization of the bus facility (or less material requirement).

The fields of household service are good examples of the contrasts in this type of substitution between the two countries. As is well-known, most U.S. households have refrigerators at the present time. This requires less house-wife service, i.e., she does not have to go to the grocery store to buy food everyday. In Japan, most housewives have to go to grocery stores to buy fish, fresh vegetables, fruits etc. everyday as they have no refrigerators at their houses. The refrigerators require more materials such as electric energies and steel, and less house-work. Dish-and-clothes-washing-machines which households in the U.S.A. commonly use require more materials and less labor. In Japan, most households do not have these machines at their houses. Some Japanese households hire maids in the place of these machines. The lack of these machines means that Japanese households require, without doubt, more labor (or house-wives' services) and less materials as compared to those in the U.S. These examples are numerous: vacuum-cleaners, hot water equipment and public water systems, heating systems, common use of gas and electricity for cooking etc. in the U.S.A., and, on the other hand, the comparative lack of these consumer's durable goods in Japanese households, is shown by the hand-washing of clothes and dishes, use of brooms for cleaning, boiling of hot water by crude woods or coal, drawing water out of wells, the use of stoves or foot-warmers, (heat is by charcoal), the use of charcoal for cooking etc.

In general, the large scale economy with highly developed techniques requires more materials and less labor, while the small scale economy with less developed techniques requires less materials and more labor.

c) <u>Possible Substitution in Types of Consumer Goods</u>

The third type of substitution between materials and labor is seen from the relationship between the scarcity of consumer goods and labor services. The general idea of this type of substitution is that the scarcity of consumer goods requires more labor intensity. For example, a few clothes require more tailoring and cleaning services than do more clothes. A poor quality of food requires more time to cook and prepare at homes and restaurants. Most Japanese house-wives had the bitter experience of cooking substitute food materials, such as potatoes and wheat flour for Japanese major foods, rice, during the war and right after the war, while Japan's food shortage was severe. A few shoes require more frequent repairing than more shoes. A small house relative to the size of family requires more frequent cleaning and sweeping than does a large house. Generally, we may conclude that the relative scarcity of consumer's goods requires more personal services to take care of them.

The observations which we make in the comparative studies of U.S. and Japan enable us to assume possible substitution between materials and labor. However, they do not imply perfect substitution because it is clear that no production is achieved by the labor factor operating only without materials and vice versa. Technical complementarity is only assumed for the range beyond the lines bounding possibilities of substitution.

Returning now to our fifth assumption, which was that equilibrium is achieved in actual production. In actual production, the equilibrium conditions may not obtain. However, it is desirable to assume that producers in the two countries are making efforts to maximize profits. The reason that we assume producer's maximum profit and optimum conditions ($M.T.S._{xy} = P_x / P_y$) is that we can make sensible comparative studies later, as will be seen by making use of isoquants analysis.

III. The Statistical Measures Used

To apply the ideas outlined above, we shall describe the measures, for factors of production namely, labor and resource, for the price of labor, for the price of materials and for total outputs of non-agricultural sectors in each country. For this purpose, statistical data in Japan are only available for the year 1951. Quantity Table For the Japanese Interindustry Table in 1951, published by Ministry of International Trade & Industry was a very useful one. The U.S. statistical data are taken from Census of Agriculture, Minerals Yearbook, Electric Power Statistics, Wholesale Price Index and U.S. Imports of Merchandise for Consumption and Report, No. 120. U.N. Statistical Yearbook serves for the supplemental data.

The raw materials are chosen in terms of the crudest forms in order to avoid duplication of intermediate forms and to keep the measure as purely "material" as distinct from processing values as possible. The availability of raw materials is defined as the total supply, or the domestic production plus imports. The data are available for the twelve products raw cotton, raw wool, crude woods, crude petroleum, natural gas, iron ores, anthracite, bituminus and lignite, copper ores, leads, ores, salt and hydro-electric energy. Omitted are materials such as water, cement components, sand ground, bauxite, and food products. Some of them (e.g. water and sand) are cheap, therefore, they are not important. Bauxite was omitted because data are not available from the

Japanese statistics. Foods are not important in the non-agricultural sectors. In order to isolate the non-agricultural sectors, the food products have been considered a purely agricultural product, except for the processing done.

In order to obtain a physical number of raw materials available in each country, an index number approach has been used. The materials available for Japan are evaluated in terms of U.S. dollar prices as well as in Japanese Yen. Since the Japanese data express the value of materials in terms of producer's selling price, the U.S. price data are also taken from the producer's selling price. In the case of imports, however, the import cost is used. The value of Japanese materials in terms of dollars can be easily obtained from the Japanese quantities ($=Q^J$) multiplied by the U.S. producer's selling price ($=P^U$), or ($P^U \times Q^J$). Yen per U.S. dollar of commodity is obtained as follows: Cost of Japanese materials used in U.S. is $\sum P^U Q^J$ dollars. One dollar would buy $\frac{1}{\sum P^U Q^J}$ portion of Japanese materials. The number of Yen required to buy one dollar unit of commodity in Japan is $\frac{\sum P^J Q^J}{\sum P^U Q^J}$ Yen. If $1,000,000 of U.S. output is a "material unit", then number of U.S. units is $\frac{\sum P^U Q^U}{1,000,000}$. The number of Japanese units is $\frac{\sum P^U Q^J}{1,000,000}$ or in price indexes terms $= \frac{\sum P^J Q^J}{1,000,000} \div \frac{\sum P^J Q^J}{\sum P^U Q^J}$. The statistical results are shown in Table XXI as follows:

TABLE XXI

Value of Principal Materials Used in Non-Agricultural Sectors in the U.S.A. and Japan, 1951

	(1) U.S.A. (Thousands of Dollars)	(2) Japan (Thousands of Dollars, U.S. prices)	(3) Japan (Thousands of Yen, Japanese Price)	(4) Yen per one dollar of commodity (3) ÷ (2)
1. Raw Cotton	2,911,120.	289,000.	169,572,938.	586
2. Raw Wool	408,400.	56,500.	72,165,556.	1,280
3. Crude Woods	85,749.	13,506.	15,557,813.	1,170
4. Crude Petroleum	2,655,825.	21,800.	27,738,956.	1,270.
5. Anthracite	659,818.	17,000.	5,432,889.	320.
6. Bituminus Lignite	2,627,065.	190,329.	148,808,110.	782
7. Natural Gas	542,964.	213.	933,732.	4,380
8. Iron Ores	694,249.	25,800.	24,217,711.	938
9. Copper Ores	722,000.	21,000.	9,876,550.	470
10. Lead Ores	201,500.	17,700.	9,550,654.	541
11. Salt	58,472.	15,800.	22,128,029.	1,400.
12. Hydro Electric Energy	1,360,320.	487,000.	131,000,000.	269.
13. Total	12,927,482.	1,155,642.	636,982,938.	551.
	$\sum P^U Q^U$	$\sum P^U Q^J$	$\sum P^J Q^J$	$\frac{\sum P^J Q^J}{\sum P^U Q^J}$

The relative scarcity of Japan's materials is reflected in value of Yen per dollar value of commodities. The Japanese official exchange rate in 1952 was 360 Yen per dollar. The relative scarcity of materials in Japan appears if the price in Yen of dollar value of commodities is higher than the official exchange rate, or 360 Yen per dollar. On the other hand, the abundance of materials in Japan relative to U.S. must be presumed if the price in Yen per dollar value of commodities is lower than the official exchange rate.

Only two materials available for Japan, hydro-electric energy and anthracite, were relatively abundant by this test. For hydro-electric energy, price in Yen per dollar value in 1951 was 269 Yen, and that of anthracite was 320 Yen. The rest of materials of Japan reflect the relative scarcity of materials. For natural gas, price in Yen per dollar value was extremely high, or 4,380 Yen. Salt, raw wool, crude petroleum, crude woods and iron ores were classified in the second group which price in Yen per dollar value of commodity is more than 1,000. Yen or around 1,000. Yen. The prices in Yen of dollar value of each commodity were respectively 1,400. Yen for salt, 1,280. Yen for raw wool, 1,270. Yen for crude petroleum, 1,170 Yen for crude woods and 938 Yen for iron ores. The third group consists of materials for which the price in Yen of dollar value of commodities is around 500 Yen, namely, raw cotton, copper ores, lead ores and bituminus and lignite are 586 Yen, 470 Yen, 541 Yen and 782 Yen.

The overall materials available for Japan in 1951 were 636,982,938. thousands of Yen and 1,155,642. thousands of dollars of "material units" defined above. The overall materials available for U.S. in 1951 were

12,927,482. thousands of dollars of "material units." The principal crude materials available for U.S. were 11.2 times greater than those of Japan. The relative scarcity of materials for Japan as overall commodities can be seen in the value of Yen per dollar value of overall commodities, or 551 Yen which was 1.5 times higher than the official exchange rate in 1952. As a result of relative scarcity of Japan's natural resources, this test clearly indicates that the prices of industrial materials in Japan are much higher than those of U.S. The higher prices of materials show Japan's disadvantage in production especially in fields of textile, construction, chemical and heavy industries.

IV. Application of the Present Statistical Data to Theory of Production Functions

For the sake of application of the present studies of comparative productivity for the economy of U.S. and Japan to the theory of production functions, three key statistical data in the two countries will be required. First is the value of available materials which we have already obtained. Second is number of workers in the two countries. The number of workers is defined as persons engaged in production who include the unpaid family workers, proprietors of unincorporated enterprises and the workers for wage and salary. The number of workers in the U.S. in the year of 1951 was 56,466. thousands of persons[1] and that

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[1] A Supplement To The Survey of Current Business, 1954, pp. 196-203.

of Japan was 20,752. thousands of persons.[1] Third is national income in the non-agricultural sector. Since the gross national product data in non-agricultural sector of Japan are not available, as it is more desirable as compared to national income data, the non-agricultural national income data are utilized in the present analysis. Therefore, care should be paid to the difference between the gross national products and national income. As was mentioned before, the gross national products are the final goods and services which are evaluated by the market value. The national income is the summation of distributive shares of production factors which is evaluated by cost of production. National income is derived from the gross national product as follows:

G.N.P. - Business Indirect Tax - Capital Consumption Allowance + Subsidies = Net National Product

= National Income.

The present statistical data are taken from the national income originating by industries which is based upon the cost of production. The U.S. non-agricultural national income in 1951 was $257,393. millions of dollars[2] whereas that of Japan was ¥ 3,471.6 billions of Yen.[3] Japan's

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[1] Interindustry Analysis of the Japanese Economy, Ministry of International Trade & Industry Council For Industry Planning, Tokyo, 1958, p. 20.

[2] A Supplement To The Survey of Current Business, United States Department of Commerce, 1954.

[3] National Income and (National Income) Account, Economic Planning Board, 1956.

Yen value of the non-agricultural national income is converted into dollar value to $13,847. millions of dollars,[1] which was 184.2 Yen per dollar, derived from 1952 Yen currency purchasing power per dollar value estimated by Watanabe and Komiya. The detailed calculation is shown in Appendix I.[1]

Now, we are ready to apply the Paretian type of analysis in order to explain the difference of income per non-agricultural worker in the two countries. This is the main purpose of our statistical research in this section. In fact, the income per worker in 1951 U.S. was $4,556. dollars, whereas that of Japan was $910 dollars. The U.S. income per worker was 5 times greater than that of Japan. This 5 times greater income per worker in U.S. compared to Japan will be explained by the theory of production functions.

Finding Proportion lines of Factors of Production

A proportion line of factor of production indicates increases in the two resources, labor and materials, by the same proportion. Usually it is called the "scale line."[2] The proportion lines of factors of production in U.S. and Japan can be obtained from the present statistical data. Let us take the number of workers on the horizontal line X, and the value of available principal crude materials on the vertical line Y, then, two points, U(x_u,y_u) and J (x_j, y_j), will be obtained in Chart 14. A line of the same proportion of factors of production will

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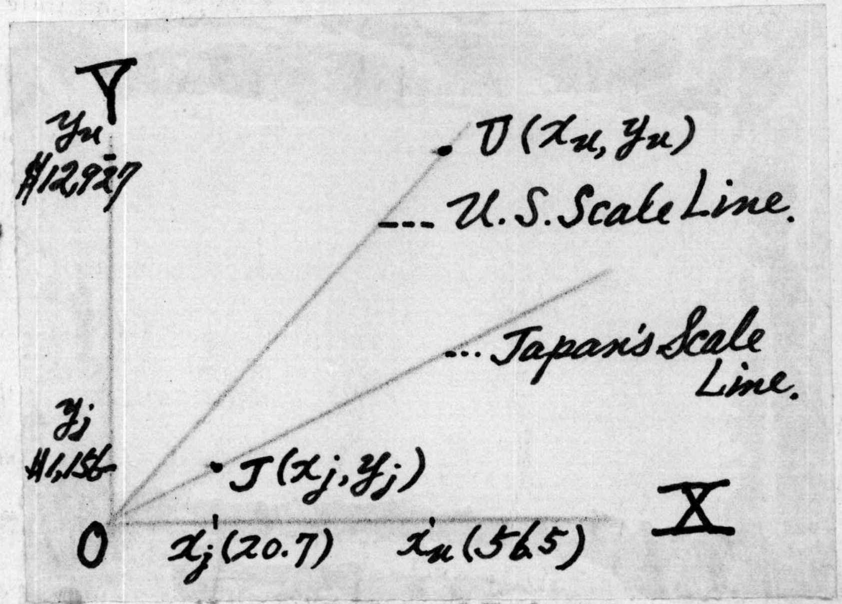
[1]See Appendix p. 182-183.

[2]Heady, et. al.: *Op. cit.*, pp. 11-12.

be drawn by connecting each two points to the origin.

Value of Materials



Number of Workers

Unit: Millions of dollars and Persons.

(Chart 14)

The constant proportion lines (or scale lines) for U.S. and Japan show the structure of production, that is, combination of two factors of production. It is clear that the Japan's constant proportion line indicates more labor intensity and less available materials relative to U.S. On the other hand, the U.S. constant proportion line shows less labor intensity and more materials relative to Japan. Japan's proportion of factors of production, dollar value of materials per worker, was $55.8 whereas that of U.S. was $228.8. These figures are obtained by y_j/x_j and y_u/x_u. Japan's less available materials in 1951 were 24.4 per cent of the U.S. materials. The requirement of workers per one million dollars of materials in U.S. was 4.4 thousands of workers, whereas that of Japan was 17.9 thousands of workers. Japan's labor intensity was 4.1 times greater than U.S.

Finding the Iso-costs

The iso-costs, as mentioned before, indicate the combination of same costs between two factors of production at the different production levels. The slopes of Iso-costs in U.S. and Japan can be obtained by the ratio of the annual wage rate to price of "unit of materials" in two countries. Japan's annual average wage rate in the non-agricultural sector in 1951 was given ¥ 146,400. from Economic Statistics of Japan, 1954, by Bank of Japan. The U.S. annual average wage rate was given $3,750. from U.S. Business Statistics, 1959 by O.B.E. data. We have already known the Japan's producer's basket of purchasing raw materials Yen value per U.S. one dollar was ¥ 551. Assume U.S. price of "unit of materials" is $1,000., then that of Japan will be ¥551,000. Hence, the slope of isocosts for the economy of U.S. and Japan in 1951 will be estimated as follows:

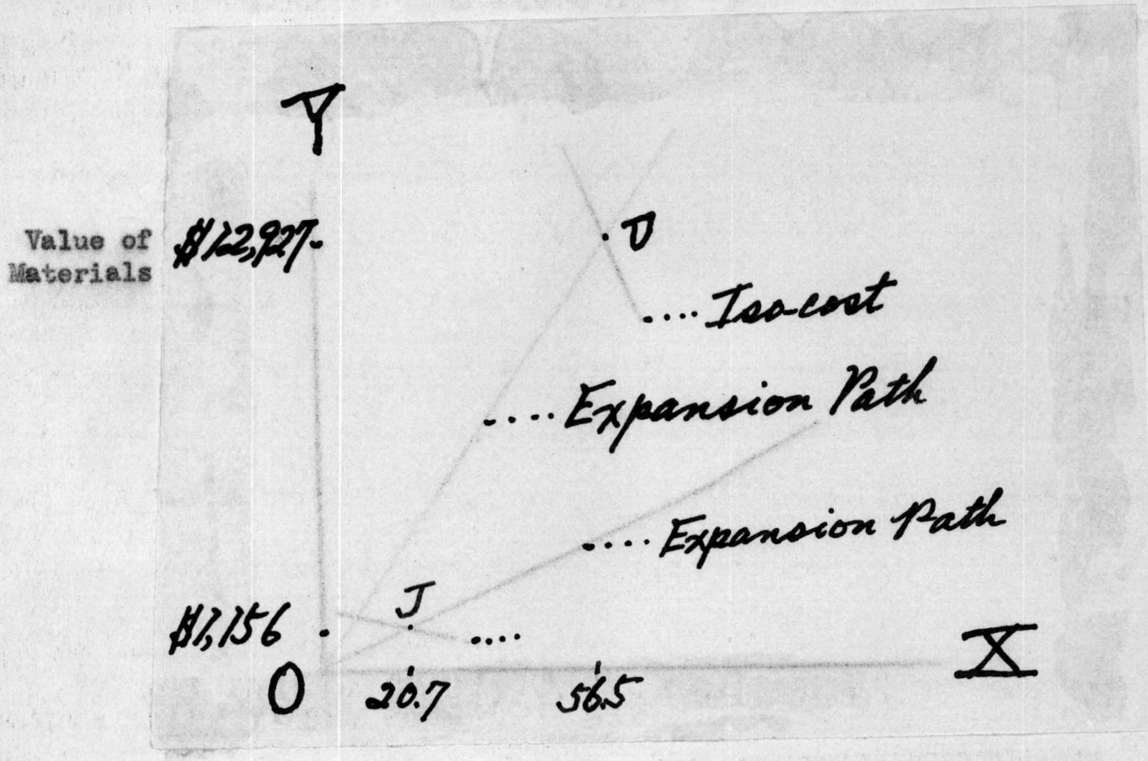
$$\text{Tan } \theta = -\frac{3,750.}{1,000.}$$

$$= -3.75 \quad \ldots \text{U.S.}$$

$$\text{Tan } \theta = -\frac{146,400.}{551,000.}$$

$$\doteq -0.266 \quad \ldots \text{Japan}$$

One of assumptions has been made that two points, $U(x_u, y_u)$ and $J(x_j, y_j)$ have shown the equilibrium conditions for the production functions of each country. This assumption enables isocosts to pass through two points shown in Chart 14. It should be noted that the constant proportional line of factors of production coincides with the "expansion path"[1] showing the path over which resource factors should be combined as output is expanded. In fact, this assumption leads to the minimum costs combination of two factors of production for two countries. The iso-costs for U.S. and Japan will be shown in Chart 15.



Number of Workers

(Unit, Millions)

(Chart 15)

The iso-costs also determine the optimum conditions of structure of production, or combination of two factors of production. Japan's lower scale of wage rate and higher price of materials, which are, of course, the results of abundant labor and scarcity of materials, causes the relative labor intensity and material savings. On the other hand, the U.S. relative higher wage rate and lower price of materials

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[1] Heady, et. al., Op. cit., p. 87.

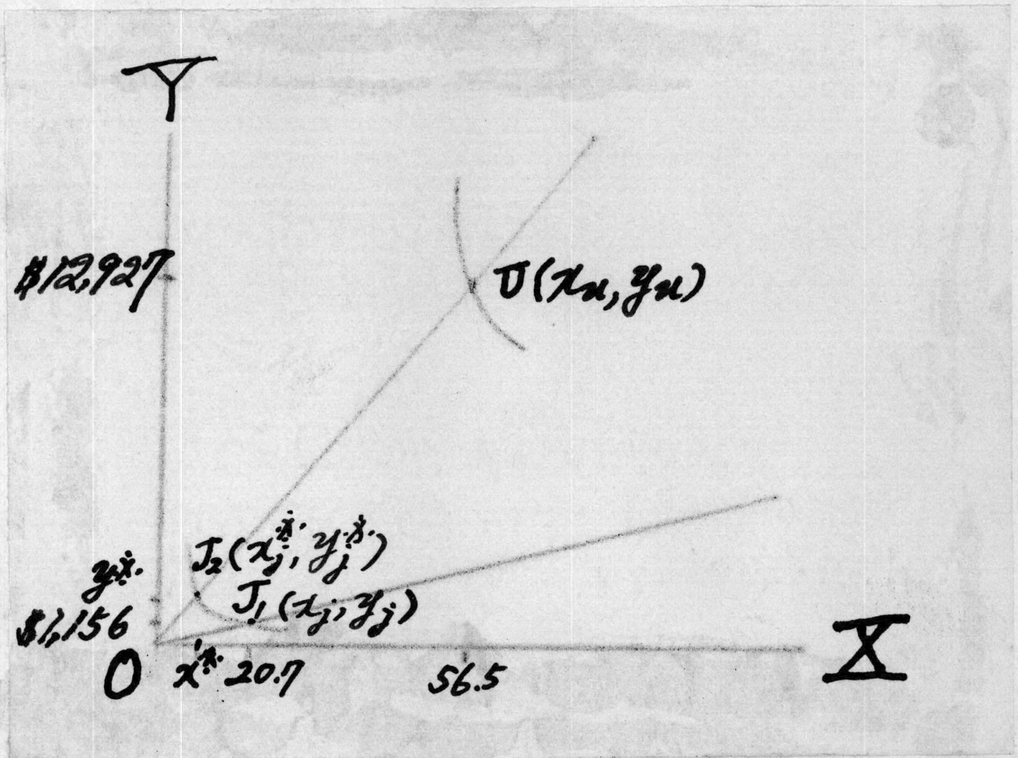
which are results of abundant natural resources and scarcity of labor factors relative to Japan cause the less labor intensity or labor savings and more material use. The U.S. annual average wage rate for the non-agricultural sector in 1951 was, indeed, 47 times higher than that of Japan. Japan's wage rate was converted by 1842 Yen per dollar in 1951.

Finding the Isoquants or Production Indifference Curves

Finally, the isoquants of the two countries will be taken into consideration. Our assumption of the optimum condition of production, again enables us to draw the isoquants of the two countries. The optimum conditions of production, as illustrated in the previous section, implies an equality of the marginal rate of technical substitution to the slope of isocost. In other words, the isoquants will pass two points, $U(x_u,y_u)$ and $J(x_j,y_j)$ on both the scale lines (or expansion path) and the isocosts. Since Japan's isocost is much flatter to X axis than that of U.S., the isoquant at equilibrium point is assumed much flatter curve than that of U.S. Again, from the previous our assumption, that is, the possible substitution of two factors and diminishing marginal rate of technical substitution, enable us to draw the slope of isoquant downward convex to the origin. Isoquants will be drawn by knowing the marginal rate of substitution and the national income for the non-agricultural sector in the two countries and shown in Chart 16.

The different shape of isoquant means the different degree of reliance upon each factor of production at the given value of output in the economy of Japan and U.S. The Japan's isoquant at the given value of output, or $18,847 (¥ 3,471,600.) millions, achieves the optimum conditions

Value of Materials



Number of Workers

(Chart 16)

of combination in labor factor, 20.7 millions and value of materials, $1,156 millions. The U.S. isoquant at the given value of output, $257,393. millions achieves the optimum condition of production at the combination of labor, 56.5 millions and value of materials, $12,927. millions. Japan's isoquant shows that more additional units of labor are required relative to U.S. if one million of dollar value of materials are given up in the two countries, simply because the marginal rate of technical substitution in Japan is less than that of U.S. Conversely, the U.S. isoquant shows that less additional units of labor are required relative to Japan if one million of dollar value of materials are given up in the two countries, simply because the marginal rate of technical substitution in U.S. is higher than that of Japan. At the equilibrium points, the law of diminishing returns is determined by the shapes of isoquants or the size of marginal rate of technical substitution. That is to say, Japan's less marginal rate of technical substitution (-0.266) expresses much sharper diminishing returns as compared to the higher scale of marginal rate of technical substitution in U.S. (-3.75).

Measurements of Diminishing Returns in Japan relative to U.S.

We may be able to estimate roughly relative "diminishing returns" of labor productivity in Japan to U.S. at the optimum condition of production. We have already known the following data:

The U.S.M.T.S. = -3.75

$$\frac{\Delta y_u}{\Delta x_u} = -3.75. \quad \ldots\ldots (1)$$

Japan's M.T.S. = -0.266

$$\frac{\Delta y_j}{\Delta x_j} = -0.266 \quad \ldots\ldots (2)$$

$$\Delta x_j = \frac{1}{M P_{xj}} \quad \ldots\ldots (3)$$

$$\Delta x_u = \frac{1}{MP_{x_u}} \quad \ldots\ldots (4)$$

where M.T.S. denotes for the marginal rate of technical substitution, Δx and Δy denote the marginal input of labor and materials, MP_x denotes the marginal products of labor and u and j respectively stand for U.S. and Japan.

Assume Δy_u equals Δy_j, then, divide (1) by (2).

$$\frac{\Delta x_j}{\Delta x_u} = 14.1$$

Divide (3) by (4),

$$\frac{\Delta x_j}{\Delta x_u} = \frac{MP_{x_u}}{MP_{x_j}}$$

Hence,

$$MP_{xu} / MP_{xj} = 14.1$$

$$MP_{xj} / MP_{xu} = 7.1\%$$

That is to say, the marginal product of labor in Japan is 7.1% of that of U.S. in assuming that the marginal input of material in U.S. equals that of Japan. The relative lower marginal product of labor in Japan to U.S. is a result of law of "diminishing returns". It is clear that lower income per worker in Japan's non-agricultural sector is due to the Japan's lower marginal productivity of labor relative to U.S.

Marginal productivity of two factors will be more generally expressed as follows: Divide (1) by (2), then,

$$\frac{\Delta x_j \Delta y_u}{\Delta x_u \Delta y_j} = 14.1$$

Let y_j equal $1/ MP_{yj}$ and y_u equal $1/MP_{y_u}$

$$\frac{\Delta x_j \Delta y_u}{\Delta x_u \Delta y_j} = \frac{MP_{xu} \quad MP_{y_j}}{MP_{xj} \quad MP_{y_u}} = 14.1$$

$$\frac{\Delta x_j}{\Delta x_u} = 14.1 \frac{\Delta y_j}{\Delta y_u}$$

or $\Delta x_u / \Delta x_j = 0.071 \times \Delta y_u / \Delta y_j$

$$\frac{MP_{xu}}{MP_{xj}} = 14.1 \frac{MP_{y_u}}{MP_{yj}}$$

$$\text{or} \quad \frac{MP_{x_j}}{MP_{x_u}} = 0.071 \frac{MP_{y_j}}{MP_{y_u}}$$

Generally, the marginal productivity of labor in Japan relative to that of U.S. is a function of the marginal productivity of other factors in Japan relative to that of U.S. Usually, the marginal productivity of other resource factor in Japan tends to be higher relative to that of U.S. Hence, our estimate of relative diminishing returns of labor factor in Japan to U.S. is upwardly biased, owing to the assumption that $\Delta y_u / \Delta y_j$ equals MP_{yj} / MP_{y_u} equals 1. Actually, delta y_u (or marginal input of materials in U.S.) is presumed greater than Δy_j (or marginal input of materials in Japan). That is to say,

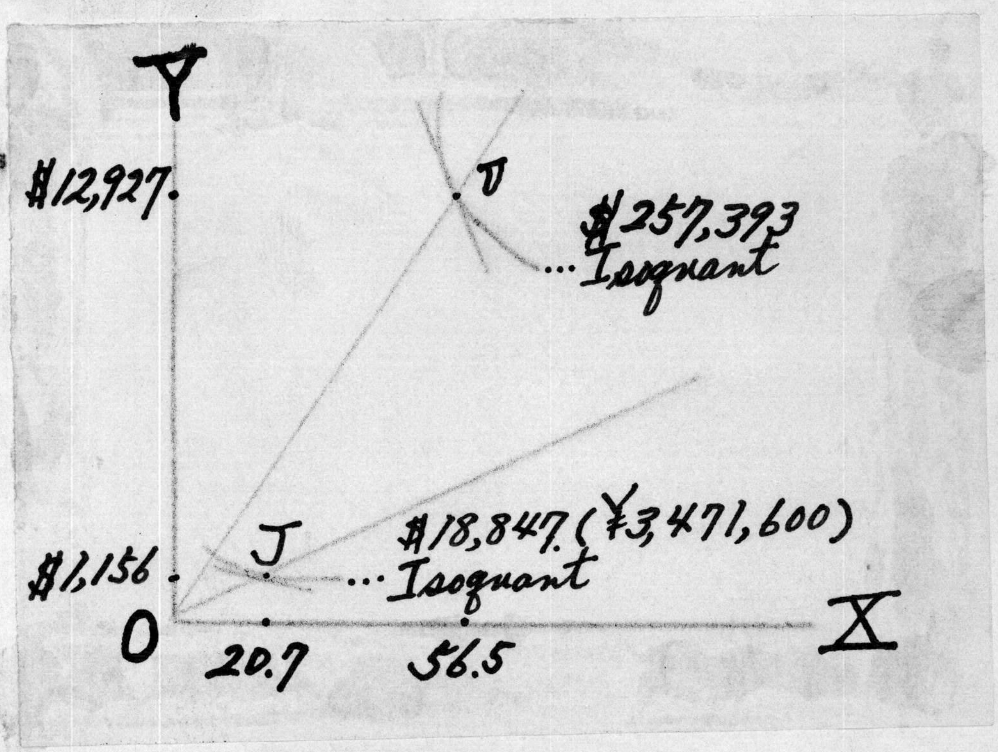
$$\frac{\Delta y_u}{\Delta y_j} > 1 \text{ , and } \frac{MP_{yj}}{MP_{yu}} > 1.$$

The foregoing analysis may be summarized as follows: Japan's lower income per worker relative to U.S. is due to the inefficiency of Japan's non-agricultural sector. Japan's lower productivity of labor relative to U.S. is explained as a result of scarcity of natural resources relative to her workers. Higher pricesof available raw materials and lower wage rates are inevitable and cause the lower marginal rate of technical substitution at the optimum condition of production in Japan relative to the U.S. high marginal rate of technical substitution. Lower marginal rate of technical substitution implies relatively more diminishing returns of factor of production on the horizontal line X axis in the isoquants map or labor factor in our present analysis. The law of "diminishing returns" inherent in Japan as a country of lower endowment of natural resource, indeed, has been exposed in the present analysis. This was the main line of argument for the purpose of explanation of Japan's lower income per worker in the non-agricultural sector.

Estimate Number of Workers and Value of Materials in Japan at the Present Value of Output under the Assumption of U.S. Combination of Factors of Production

Assuming that U.S. proportion of factors is employed in Japan, we estimate the new combination of factors of production at Japan's given value of output in 1951. It is clear that the new position of Japan will take the same slope of isoquant as U.S. The present problem is geometrically illustrated in Chart 17.

$ Value of Materials



Number of Workers
Unit, Million
(Chart 17)

The point J_2 (x^*_j, y^*_j) in Chart 17 is the new position of Japan, and the slope of isoquant at J_2 is assumed the same as the U.S. isoquant at $U(x_u, y_u)$; because we assume that U.S. proportion of factors is employed in Japan at the Japan's given output level. The point J_1(x_j, y_j) is Japan's existing position, so that the slope of isoquant at J_1 is assumed the same as the previous slope of Japan. Problem is now to solve x^*_j and y^*_j. For the sake of solution, we can set four equations as follows:

$$\text{Assume } \frac{dy}{dx} = ax + b$$

$$y = \frac{ax^2}{2} + bx + c$$

$$\text{Then, } ax_j + b = -0.266 \quad \ldots . (1)$$

$$\frac{ax_j^2}{2} + bx_j + c = y_j \quad \ldots . (2)$$

$$ax^*_j + b = -3.75 \quad \ldots . (3)$$

$$\frac{ax^{*2}_j}{2} + bx^*_j + c = y^*_j$$

$$= x^*_j \, (yu / xu) \quad \ldots . (4)$$

From the statistical results, xj, yj, x_u, y_u and y_u/x_u are known. A set of four equations has four unknown variables, x*, a, b, and c, therefore, we will be able to solve them. After a trivial solution, the values of x^*_j, y^*_j, a, b, and c are obtained as follows:[1]

$$x^* = 5.205$$

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[1]See Appendix pp. 184-187 for the detailed calculation.

y* = $1,190.835 (million dollars)

a = 0.22484

b = -4,919

c = 1,209,617,841.

Assuming only two factors of production, materials and labor, that is, ignoring all other determinants of the efficiency of labor such as capital equipment, scientific skills, and economies of scale, we should expect, that if raw materials were available for Japan in 1951, at the same terms of exchange relative to labor, as for the United States in 1951, and assuming that the advantages of increased proportions of materials decrease linearly as the proportions of materials increases, that Japan could have produced with 5.205 million laborers in the non-agricultural sector as much as she produced with 20.7 million laborers. The ratio, 20.7/5.205 equals some 3.977, indicates the proportional increase in output that would have resulted from the existence of the new raw material exchange price. In other words, in place of a value of non-agricultural products of 3,472. billion Yen in 1951, the non-agricultural product would have been 3.977 times as much, namely 13,808. billion Yen of the same purchasing power.

We may now compare this raw material adjusted Japanese product with actual output of the U.S. If we use the estimate of Watenabe and Komiya for the value of the Yen in 1952 and adjusted this to 1951 prices, we find an estimate exchange value of 184.2 Yen in Japan.[1] This is an estimate of the real command over goods and services, namely one

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[1] See Appendix p. 177.

dollar in the U.S.A. bought the same real goods as 184.2 Yen in Japan. Converting our figure of 13,808. billion Yen into dollars, we obtain 74.962 billion dollars as the estimated raw material adjusted value of Japanese output in the non-agricultural sector in 1951. On a per worker basis this is $3,618 per Japanese "raw material adjusted" worker. In the United States itself in 1951 the figure is $4,556, which is based upon national income.

In this way, we reach the conclusion that the income per worker in the non-agricultural sector is actually some 5.0 times as large in the U.S.A. as in Japan. If we adjust the Japanese output for raw material deficiencies in the manner outlined, we find that U.S. output per worker is some 1.259 times as large as in Japan. This suggests that other influence than raw material increase U.S. per non-agricultural worker by a factor of 1.259, while materials differences increase the U.S. non-agricultural output by a factor of 3.977. To put the matter differently, it appears that out of the total difference in real output per non-agricultural worker, some 74.3% is accounted for by greater raw material availability for the U.S.A. and some 25.7% by other factors.[1]

A curious feature of these calculations is the apparent modest cost for Japan's economy of these materials required to achieve this greater productivity in Japan. It is clear from Chart 17 that a rise of materials from 1,156 million dollars of "material units" to 1,191. million dollars would give 5.205 million Japanese workers, the

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[1]See Appendix p. 191 for the detailed calculation.

the same proportion of materials to workers as in the U.S.A. This would cost in the U.S. 1951 dollars 35 million dollars. If it applies to 20.7 million Japanese workers, the cost to Japan would be 4,740. million dollars. This would cost to the U.S. 3,590. million dollars. This is a comparatively small figure as costs and value in the international trade and aid go. Of course, it is valued in terms of the U.S. domestic producer's selling prices, and would be larger when delivered in Japan. When delivery in Japan is considered, the transportation cost would be much higher.[1] Nevertheless, it appears that for a cost to the U.S.A. some 4 billion dollars a year, Japanese output in the non-agricultural sector would be increased some 74.3 per cent.

Estimate of Number of Workers and Value of Materials in the U.S. at the U.S. Present Value of Output under the Assumption of Japan's Combination of Factors of Production

The same analysis can be carried through by constructing an isoquant for the U.S. rather than Japan. Assuming that Japan's proportion of factors is employed in the U.S., we estimate the new combination of factors of production at the U.S.A.'s given value of output in 1951. It is clear that the new position of the U.S. will take the same slope of isoquant as Japan. The present problem is geometrically illustrated in Chart 18.

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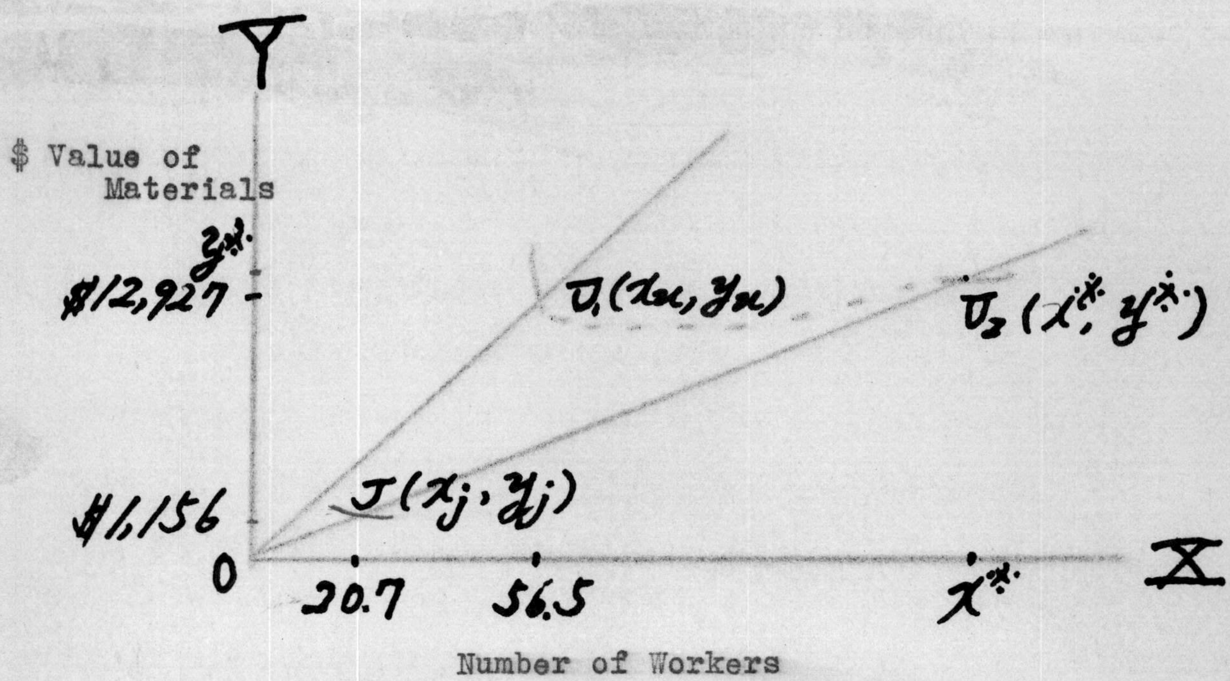
[1]See Appendix pp. 193-194 for the detailed calculation.



Unit, millions

(Chart 18)

The new point U_2 (x*,y*) in Chart 18 is the new position of the U.S., and the slope of isoquant at U_2 is assumed the same as Japan's isoquant at $J(x_j,y_j)$; because we assume that Japan's proportion of factors is employed in the U.S. at the U.S. given value of output level. The point $U_1(x_u,y_u)$ is the U.S.'s existing position, so that the slope of isoquant at U_1 is assumed the same as previous slope of the U.S. The problem is now to solve x* and y*. For the sake of solution, we can set four equations as follows:

$$\text{Assume } dy/dx = ax + b$$

$$y = ax^2/2 + bx \text{ plus } c$$

Then,

$$ax_u + b = -3.75 \quad \ldots\ldots\ldots\ldots (1)$$

$$ax_u^2/2 + bx_u + c = y_u \quad \ldots\ldots\ldots\ldots (2)$$

$$ax^* + b = -0.266 \quad \ldots\ldots\ldots\ldots (3)$$

$$ax^{*2}/2 + bx^* + c = y^*$$

$$= x^*(y_j/x_j) \quad \ldots\ldots (4)$$

From the statistical results, x_u, y_u, x_j, y_j and y_j/x_j are known. A set of four equations has four unknown variables, x^*, a, b, and c, therefore, we will be able to solve them. After a trivial solution, the values of x^*, y^*, a, b, and c are obtained as follows;[1]

$x^* = 253.804$ (million workers)

$y^* \doteq 14{,}173{,}684{,}380.$ (dollars of materials)

$a = 0.017658$

$b = -4.74768$

$c = 13{,}167.05948$

Assuming only two factors of production, materials and labor, that is, ignoring all other determinants of the efficiency of labor such as capital equipment, scientific skills, and economies of scale, we should expect, that if raw materials were available for the U.S.A. in 1951, at the same terms of exchange relative to labor, as for Japan in 1951, and assuming that the advantages of increased proportions of materials decrease linearly as the proportions of materials increases,

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[1]See Appendix pp. 187-190 for the detailed calculation.

that the U.S.A. could have produced with 253.804 million laborers in the non-agricultural sector as much as she produced with 56.5 million laborers. The ratio, (56.5/ 253.804 = 22.3%), indicates the proportional decrease in output that would have resulted from the existence of the new raw material exchange price relative to labor as in Japan. In other words, in place of a value of non-agricultural products of 257,393. million dollars in the U.S.A. in 1951, the non-agricultural product would have been 22.3% as much namely 57.4 billion dollars of the same purchasing power.

On a per worker basis, this is $1,016. dollars per U.S. "raw material adjusted" worker. In Japan itself in 1951 the figure is 910 dollars. In this way, we reach the conclusion that the income per worker in the non-agricultural sector is actually some 5.0 times as large in the U.S.A. If we adjust the U.S. output for raw material deficiencies in the manner outlined, we find that Japan's output per worker is some 82.6% as large as in the U.S.A.'s output per "raw material adjusted" worker. This suggests that other influence than raw material decrease Japan's output per non-agricultural worker by a factor of 82.6%, while materials differences decrease the U.S.A.'s non-agricultural output by a factor of 22.3%. To put the matter differently, it appears that out of the total difference in real output per non-agricultural worker, some 97.1% is accounted for by raw material influence and some 3% by other factors.[1]

A curious feature of these calculations indicates the materials

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[1]See Appendix p. 191 for the detailed calculation.

savings at the expense of labor intensity. It is clear from Chart 18 that an increase of materials from 12,927. million dollars of "material units" to 14,174 million dollars of material units would give 253.804 million workers to produce the same level of non-agricultural outputs in the U.S. in 1951. This would cost to the U.S. more than the existing costs of materials by 1,247. million dollars and 4.5 times greater workers would be required. The U.S. output per non-agricultural worker would become 1,016. dollars which is 1.116 times greater than the Japan's output per non-agricultural worker. It appears that for a cost of 1,247. million dollars of "material units" increased under the Japan's proportion of factors, the U.S. output per non-agricultural worker would be decreased 97.1 per cent.

The reason that the importance of materials appears larger in the calculations given here than in the previous section (summarized on page 149) arises from the nature of the assumption made regarding the shape of the isoquants. Since marginal rate of substitution was assumed to change linearly with the amount of one factor employed, the effect of diminishing returns is larger, the larger the difference in the amount of the factor under consideration. Since the United States is a larger country than Japan, the total effect of diminishing returns is larger when a comparison is made in terms of the U.S. isoquant.

CHAPTER V

CONCLUSION

The aim of the present study has been to estimate the importance of different causes contributing to the observable difference in production of Japan and the United States. In the previous chapters, the agriculture and non-agricultural chapters have been compared on a two factors basis, that is in terms of labor and land in case of agriculture, and labor and materials costs in the case of non-agricultural output. These results now will be summarized, and the role of investment goods discussed briefly.

First, we may recall the role of agricultural and non-agricultural output in the total picture. In the agricultural sector of 1951, Japan's output per agricultural worker was 314 dollars whereas that of the United States was 3,387 dollars. In the non-agricultural sector, Japan's output per worker was 910 dollars, whereas output per non-agricultural worker in the United States was 4,556 dollars. The difference of output per agricultural worker in the non-agricultural sector was 3,646 dollars. In relative terms, the greater productivity of non-agricultural workers is more striking, since the agricultural worker in Japan had an output 9 per cent of that of the United States, whereas the non-agricultural worker in Japan had an output some 20 per cent of that of the United States worker. Since the agricultural sector is a larger share of the total economy in Japan, than in the United States, the overall difference in production Japan and the United States reflects this fact also. We may express in symbols as follows:

	Japan	U.S.
Output Total	G.	g.
Numbers of Workers Total	W.	w.
Agriculture Output	A.	a.
Workers, Agriculture	W_A	w_a
Non-Agriculture, Output	F.	f
Workers Non-agriculture	W_F	w_f

The ratio of the difference of output per worker for U.S. and Japan to output per United States worker may be expressed as follows:

$$\frac{\frac{g}{w} - \frac{G}{W}}{\frac{g}{w}} = \frac{\left(\frac{a}{w_a} - \frac{A}{W_A}\right)\frac{w_a}{w} + \left(\frac{f}{w_f} - \frac{F}{W_F}\right)\frac{w_f}{w} + R}{\frac{g}{w}}$$

where $R = \frac{A}{W_A}\left(\frac{w_a}{w} - \frac{W_A}{W}\right) + \frac{F}{W_F}\left(\frac{w_f}{w} - \frac{W_F}{W}\right)$

Substituting values which have been introduced in earlier chapters, we find

$$\frac{\left(\frac{a}{w_a} - \frac{A}{W_A}\right)\frac{w_a}{w}}{\frac{g}{w}} = \frac{(3,073)(0.093)}{4446} = 0.064$$

This says that the difference of per worker income in Japan and the United States is 3,073. dollars, and this when weighted by the importance of agricultural workers in the United States accounts for 6.4 per cent of the difference in per worker incomes in Japan and the U.S. In other words, if Japan had the same relative agricultural population as the U.S. and the same income per non-agricultural worker as in the U.S., this single factor of difference in income per agricultural worker would make total income per worker in Japan 93.6 per cent of that in the U.S.

Similarly we find,

$$\frac{\left(\frac{f}{W_f} - \frac{F}{W_F}\right)\frac{W_f}{W}}{\frac{g}{W}} = \frac{(3{,}646.)\ (0.907)}{4446} = 71.9\%$$

This says that the difference of non-agricultural income per worker in U.S. and Japan is 3,646. dollars, and when weighted by importance in this sector in U.S. accounts for 71.9 per cent of differences in per-worker income. In other words, if Japan had had the same distribution of population between agriculture and non-agriculture as U.S. and the same income per agricultural worker as U.S., income per worker in Japan would have been 29.1 per cent of the U.S. level.

Finally to account for the difference in distribution of workers between agriculture and non-agriculture percents, we find,

$R = \underline{0.044}$

In other words, if income rates in Japan had been the same as in the U.S., per worker income in Japan would have been 95.6 per cent of the U.S. level, because of the greater importance of agriculture in Japan.

To summarize, we have suggested that lower agricultural wages in Japan by itself reduces total per worker incomes to 93.6 per cent of the U.S. level, the greater agricultural population by itself reduces income per worker in Japan to 95.6 per cent of the U.S. level, while the difference in non-agricultural income per worker by itself reduce them to 29.1 per cent of the U.S. levels. The predominant importance of non-agricultural income per worker is apparent.

To put the matter still differently, we find that the difference in U.S. and Japan for worker income, 7.7 per cent is due to lower agricultural income per worker, 86.9 per cent due to lower non-agricultural worker income and 5.4 per cent due to the differences in distribution of worker between agriculture and non-agriculture for the United States and Japan.

If we consider these results from the standpoint of raising Japanese income levels, it is clear that improving the agriculture situation both in terms of productivity in agriculture situation and in shifting excess labor out of agriculture is not the major problem. Certainly these steps will help, but the larger problem, that is some 87 per cent of the problems is to raise the productivity of the non-agricultural worker. We may then concentrate on the non-agricultural sectors.

To explain the productivity difference in the non-agricultural worker, we have analyzed the sectors in terms of two factors - raw materials and labor representing all other factors - notably capital. We have found that raw material costs can explain much of the productivity difference in Japan and U.S. We have however noted the rather surprising fact that the value of raw materials needed to raise the proportions of materials to labor in Japan to U.S. levels is not very high, even if we allow for diminishing returns and transportation costs. Thus we must consider the capital equipment situation, in order to see whether it may be a larger influence than raw material scarcities.

Statistically as well as conceptically, this is a difficult task, and we can only make some tentative steps along these lines. Now, we may introduce investment goods and compare the hypotheses that raw materials or equipment explains the difference of output per non-agricultural worker.

Statistical Measures Used

To represent the quantity of capital, we have selected producer's durable equipment among all components of gross private domestic investment. Producer's durable equipment bears much more directly industrial production as compared to construction and changes in the business inventories. These other principal components of investment are less directly involved in the production purposes. The figures on new construction include the personal residential housing construction and other buildings of general use. As for changes in business inventories, the production requirements are probably less variable in relation to output than equipment. Moreover they reflect business cycles, and involve special valuation problems.

The statistical data are taken from national income and national wealth data. National income data indicate the new output of producer's durable equipment while national wealth data indicate the total existing value of producer's durable equipment. However, there had been no investigation of national wealth since 1935 until 1955 in Japan. Our analysis will heavily rely upon the national income data, or output of producer's durable equipment. Fortunately, it serves the present purpose to obtain a picture of the ratio of investment goods in Japan to that in the United States and this can be done roughly from available data.

Statistical results of ratio of output of producer's durable equipment to the gross national products in the United States and in Japan in current prices are shown below:

	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
U.S.	5.1	7.1	7.3	6.7	6.7	6.5	6.1	6.1	5.7	5.8
Japan	7.8	7.2	7.9	8.6	9.8	12.1	11.3	11.6	11.3	9.7

Sources: (1) U.S. Income and Output, 1958.

(2) Nihon Keizai Tokei Shu, 1958. & National Income and National Economic Accounts of Japan, 1930-1955. November, 1956.

We notice the greater relative importance of producer's durable equipment in the output of Japan compared to that of the United States in the postwar decade. The figures of Japan are some two times greater than those of the United States since 1951. Since we have calculated the ratio of Japan's gross national products to the U.S. gross national products, the above table will suggest the ratio of Japan's output of equipment to the U.S. output of equipment in 1951 as below:

$$E^J = 0.121\ Y^J$$

$$E^U = 0.065\ Y^U$$

$$E^J / E^U = 0.121/0.065\ (Y^J / Y^U)$$

$$= \underline{0.158}$$

$$\frac{E^J}{W^J} / \frac{E^U}{W^U} = \underline{0.43}$$

where E, Y and W denote the output of equipment, the gross national products and non-agricultural workers; and J and U indicate respectively Japan and the United States. That is, Japan's output of equipment per non-agricultural worker in 1951was 43 per cent of that of the United

States. These estimates depend upon the use of an exchange rate of 184.2 Yen per dollar, the figure obtained by adjusting the 1952 figure computed by Watanabe and Komiya for all G.N.P. items.

For national wealth, some summary figures are obtainable for Japan in the year 1955. For the United States wealth data are obtainable prior to 1945 in some detail through the studies of Raymond Goldsmith.[1] For later years, estimates for a few aggregates only are available. It is very difficult to compare figures in the forms presented, since it is not known to what degree the classification used, and the depreciation and price adjustments are compatible. Indeed, the overall figures for equipment do not appear consistent, the data for Japan as given 10,135. billions of Yen (50.6 billions of dollars, which is estimated by use of an exchange rate of 199.8 Yen per dollar,[2] the figure obtained by adjusting the 1952 figure computed by Watanabe and Komiya) in Nihon Keizai Tokei Shu being very high relative to the United States. It seems likely that some items included, possibly railway lines, are classed as structures in the U.S.A. data. Also furniture appears very high for Japan. Then it seems better to make comparisons for some smaller classifications, where comparatibility seems more likely. In the table below we show the wealth estimates which we take from Nihon Keizai Tokei Shu (Japanese Economic Statistics), 1958 and for U.S. derived from national income and related data.

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[1]Goldsmith, W. Raymond, A Study of Saving in the United States, Vol. I, II, III, 1897-1949, Princeton, Princeton University, 1955.

[2]See Appendix, p. 177.

TABLE XXII

Ratio of Equipment per U.S. Worker to Equipment per Japanese Worker, 1955

	1) Japan	2) U.S.	3) Ratio of U.S. to Japan (2)/(1)	4) Ratio of Equipment per U.S. worker to Japan. (3) / 2.7 (ii)
	(Unit: Millions of Dollars)			
1) Machine & (i) Equipment	8,764	70,801	8.1	3
2) Railroad Equipment, Air craft, Cars & others (Trucks, buses & trailers)	3,168	21,109	6.7	2.5
3) Ships & Boats	1,512	2,528	1.7	0.63
4) Cultery & Hand Tools	2,367	774	0.32	0.12
5) Total	15,811	95,212.	6.02	2.22

Sources: (1) A Study of Saving in the United States, Vol. I., 1955.

(2) U.S. Income and Output, 1958.

(3) Nihon Keizai Tokei Shu (Japanese Economic Statistics), 1958

Remarks: (i) Components of Machine and Equipment are construction machinery, mining & office machinery, metal working machinery, special industrial machinery, office & store machinery, service industry & household machinery, general industrial machinery and electrical machinery.

ii) The ratio of the U.S. non-agricultural worker to Japan in 1951 was 2.7.

The breakdown of U.S. figures on equipment shown in Table XXII are computed by using the dollar value data on annual depreciation, the rate of depreciation of each components[1] in 1945 given in the studies of Raymond Goldsmith, and value of output of equipment (1946-1954) given in the U.S. Income and Output. The total value of each class of equipment is derived by applying to the 1945 values, and by adding production in subsequent years (also depreciated). The calculations were made in constant dollars.

By these means, it was calculated that the ratio of equipment per Japanese non-agricultural worker to that of the United States was 45 per cent in 1955. The ratio of output of equipment per Japanese non-agricultural worker to the United States obtained from National Income data in 1951 was 43 per cent. Hence, we may roughly estimate that equipment per Japanese non-agricultural worker was 43 per cent of that of the United States in 1951. This figure may be too high, since equipment output in Japan in the periods (1951-1955) was large.

Analysis Regarding Raw Materials vs. Equipment

For the purpose of estimating the output difference per non-agricultural worker in the two countries due to raw material deficiency per unit of equipment in 1951, we will apply the same method as in Chapter IV. First of all, we have to find the marginal rate of technical substitution for raw materials and equipment in the two countries.

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[1]Depreciation rates of each components are as follows: Industrial Machinery and Equipment (20), Electrical Equipment (30), Office Machinery (8), Railway (28), Ships and Boats (30), Air Craft (5), Tools (5) and Trucks (6). Inside of bracket shows years and data as given in the studies of Goldsmith.

At equilibrium, the marginal rate of technical substitution for materials and equipment is equal to cost of equipment to market price per "unit of raw material." The market price of "unit of equipment" is determined by the rate of return per "unit of equipment", however, it is technically hard to find the rate of return per unit of equipment due to lack of statistical data; therefore, for the sake of simplicity, we will make an assumption that the rate of return in real terms per unit of real capital are the same in Japan and the U.S. This would be done to actual conditions if capital moved internationally fully. (Japan's rate of return would probably be higher than that of the U.S. when we consider relative high rate of saving due to high corporate profits in Japan as explained in Chapter II, the scarcity of capital in Japan and the low cost of consumer services in Japan.) Under this assumption, we will be able to find the ratio of marginal rate of technical substitution for material and equipment in the United States and in Japan. We will bear in mind, however, the probable error in the assumption.

The ratio of marginal rate of technical substitution for material and equipment in U.S. to that of Japan may be computed from the ratio of price per unit of materials in Japan to price of unit of materials in the U.S. As we have calculated the cost of raw materials worth one billion dollars in the U.S., as costing 551 billion Yen in Japan, and as the cost of one dollar of all goods in Yen in the U.S. is estimated as costing 184.2 Yen in Japan, we have for the ratio of marginal technical substitution of material for equipment in equilibrium.

$$\frac{M.T.S.^{U}\ (R.E)}{M.T.S.^{J}\ (R.E)} = \frac{\dfrac{\text{Price, Equipment}^{U}}{\text{Price, Materials}^{U}}}{\dfrac{\text{Price, Equipment}^{J}}{\text{Price, Material}^{J}}}$$

$$= \frac{\text{Price, Materials}^{J}}{\text{Price, Materials}^{U}}$$

$$= \frac{551}{184.2} = \underline{2.99.}$$

For computing purpose it is useful to write this $2.99 = \frac{-3.75}{-1.258}$.[1]

If the rate of return on equipment is higher in Japan, then the ratio would be less than 2.99.

One approach to estimating the importance of equipment is to assume that labor is not productive, that is, has zero marginal productivity beyond the amount of labor per unit of equipment employed in the U.S. This says that labor is required in production in a fixed ratio with equipment, but that additional labor is not productive. This is an extreme assumption, which overstates the importance of equipment. It is an easy one to apply however and this is why it is introduced here.

In the previous chapter the statistics were intorduced the non-agricultural employment in 1951 was 56.5 millions in the U.S. and 20.7 millions in Japan. Let us state arbitralily that the U.S. has 56.5 units of capital in the non-agricultural use. If Japan has 43 per cent of this per worker as argued above, it would have 0.43 X 20.7 or 8.9

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[1]See Appendix pp. 195-197.

units of capital employed in the units so defined. Thus under our assumption that labor "doesn't count", the total supply of capital in Japan is 8.9 and 56.5 in U.S. We can now apply the same analysis as before regarding diminishing returns from raw material scarcity versus labor, only now it is versus capital.

The equations are:

$$a\,x_j + b = -1.258$$

$$a\,x_j^2 + b x_j + c = y_j$$

$$a\,x^* + b = -3.75$$

$$a x^{*2} + b\,x^* + c = y^* = x^*\,(\,y^U / x^U)$$

After the trivial solution,[1] x*, the amount of equipment required in Japan to produce its output if raw material per unit of equipment were the U.S. ratio, is found to be 5.261. With this, we will be able to calculate the poorness of Japanese relative to the United States due to Japan's raw material shortage. We find that Japanese income per non-agricultural worker would become thirty-four per cent of the U.S. level in place of 20 per cent.

$$\frac{8.9}{5.261} \times 0.2 = \underline{0.34.}$$

The difference of output per non-agricultural worker between the two countries would be reduced by 17 per cent on this shortage if the Japanese raw material deficiencies per unit of equipment were eliminated. The other 83 per cent is due to shortage of equipment. Our calculation

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[1]See Appendixpp. 198-199.

is shown:

$$\frac{0.34 - 0.2}{0.8} = \underline{0.1729.}$$

Combining this with our previous results, we find that the difference of output per non-agricultural worker between U.S. and Japan could be explained to the extent of 74 per cent by the raw material deficiencies per non-agricultural worker; if we assume equality in equipment per worker between the two countries, the effects of materials are only 17 per cent, equipment and labor being surplus. When analysis is in terms of diminishing returns, we may put the conclusion in the form that the diminishing returns of labor due to the scarce resource factor in Japanese non-agricultural sector appear if capital is considered abundant in Japan as in the U.S.; but was much less due to scarce resource factor, if equipment is considered scarce. If the price on equipment in Japan is higher, then the effect of raw materials would be greater.

In general it must be concluded that the effects of raw materials shortages, are appreciable and seem to account for at least some 17 per cent of the difference in income per non-agricultural worker. Our brief glance at the capital of Japan suggests however, that is probably the major factor in the non-agricultural sector. This is borne out further, by the low cost of materials required to raise Japanese quantities to U.S. levels, and also by the rising real income in Japan since 1951, which is probably due more to capital accumulation than raw material prices improvement, though both factors have been at work.

Policy Goal For Japanese Economy

An interesting fact emerging from the foregoing analysis was the surplus workers exist not only in the agricultural sectors but also in the non-agricultural sectors in Japan at least in comparison with the United States. The surplus workers in the Japanese agricultural sector were serious elements from the standpoint of "diminishing returns" compared not only to the Japanese non-agricultural sector but also the U.S. agricultural sector. Moreover, the difference of output per worker between U.S. and Japan mainly comes from differential productivity in the non-agricultural sector rather than from productivity in the agricultural sector or distribution of employees between the agricultural and non-agricultural sectors. The difference of products per non-agricultural worker between U.S. and Japan can be explained by some 74 per cent due to raw material deficiencies versus labor and by 17 per cent due to raw material deficiencies vs. equipment. The difference of products per agricultural worker between U.S. and Japan is explained to the extent of 24 per cent by the scarce agricultural land versus all other factors.

This analysis of comparative productivity suggests that Japan should emphasize to increase productivity of the non-agricultural sector. To offset the sharp diminishing returns of labor in Japan's agricultural sector and a shift of workers from agricultural to non-agricultural sector, would increase agricultural productivity in Japan. For this purpose, Japan should import more raw materials; and increase the producer's durable equipment, mainly machine and equipment.

Japan's industrial structure has been and should be further adjusted to the foreign market sturcture in the postwar periods. That is, Japan should continue to shift from a country of textiles to machinery and similar industries, because the demand for products of heavy industry has been very high in the postwar foreign market. Japan, indeed, needs both raw materials and machinery and equipment for heavy industry in order to export the products of heavy industry. It is necessary for Japan to purchase the cheap raw materials and to modernize and to accumulate the machinery and equipment.

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APPENDIX

Appendix I

The Estimated Exchange Rate

Yen per Dollar in the Postwar Japan.

	(1) Price index for U.S. G.N.P. 1952 = 100	(2) Price Index for Japan's G.N.P.	(3) Relative Change of Price Index of Japan to U.S. (2)/(1)	(4) Yen per Dollar. (3) X 1952 Watanabe & Komiya rate
1946	76.0	14.7	19.3	36.4
1947	84.6	37.1	43.9	82.8
1948	89.7	64.5	71.9	135.5
1949	89.9	77.8	86.5	163.0
1950	91.2	80.8	88.6	167.0
1951	98.1	95.9	97.7	184.2
1952	100.0	100.0	100.0	188.5
1953	100.9	105.5	104.6	197.2
1954	102.0	109.5	107.4	202.4
1955	103.2	109.4	106.0	199.8

Sources: 1) U.S. Income and Output, 1958.

2) National Income and National Economic Account of Japan, 1956.

3) "Findings From Price Comparisons, Principally Japan VS. The United States", Memorandum Number C-5, Stanford University.

Appendix II

Japan's Imported Commodity By Quantity and Value

Total Import Value in 1951- ¥ 737,241 (Millions)

Commodity	Quantity	Value in Japan	Wholesale Price per unit in U.S. (Nov. 1951)
1. Rice	5,687,650. (KOku)	37,890,582. (thousands	$ 0.103 per lbs:(Rexora)
2. Wheat	11,986,376	58,421,372.	$ 2.425 per Bushel Nov. 1951 Soft White No. 1 / Oregon
3. Barley	8,590,400	30,923,153.	$ 1.578 per bushel Barley No. 3, Minneapolis
4. Soybeans	2,402,548	17,330,929.	$ 2.90 per bushel
5. Cotton	380,456 (TON)	168,916,938.	$ 0.417 per lb. Average 14 spot market.
6. Wool	125,812 (lbs)	70,991,578.	$1.970 per lb. (GD. FR. combining and Staple)
7. Crude Wood	7,054 (KOku)	5,483,598	
8. Sugar	553,745 (ton)	33,126,882	$ 0.059 per lb.
9. Salt	1,808,058 (ton)	12,335,807	$21.900 per ton
10. Anthracite	143,151 (ton)	1,160,143	$14.513 per net ton Chestnut, Pa. mine.
11. Coking Coal	1,781,872 (ton)	16,360,561	$12.70 Producer's price.
12. Boiler Coal	9,891 (ton)	86,330	$ 6.756 per net ton
13. Lignite	1 (ton)	2	
14. Gas		457	$ 0.244 per gal. Propane Houston
15. Crude Petroleum	2,925,838 (k.l)	24,000,649.	$ 2.400 per BBL West Texas
16. Gasoline	10,815 (k.l)	296,080.	$ 0.120 per gal. California
17. Kerosene	315,329 (k.l.)	2,949,107.	$ 0.090 per gal. Oklahoma

Commodity	Quantity	Value in Japan	Wholesale Price per unit in U.S. (Nov. 1951)
18. Heavy fuel Oil A. B.	1,953,659 (k.l)	12,133,325	$ 0.083 per gal. Calif.
19. Heavy fuel Oil, C.	75,183	587,757	$ 1.700 per BBL. Pacific Coast
20. Copper ores	836 (ton)	191,205.	$ 0.24 per lb. Ave. price : 1896-1955
21. Iron ore	3,088,793 (ton)	20,917,562.	$ 8.450 per gross ton Mesabi, Bessemer
22. Pig iron	43,499 (ton)	801,524.	$52.00 per gross ton Basic
23. Hot rolled, Ordinary steel	12,701 (ton)	670,809.	$117. per short ton
24. Hot rolled, special steel	11,586 (ton)	206,779.	$111. per short ton
25. Steel pipes & tubes	268 (ton)	78,239.	
26. Cold finished & coated steel	10,734 (ton)	922,651.	$189. per short ton
27. Copper	3 (ton)	978.	$ 0.245 per lbs. copper, ingot electrolytic.
28. Lead	7,213 (ton)	1,546,275.	$ 0.190 per lbs, lead, pig, common.
29. Zinc	12,348 (ton)	3,316,437.	$ 0.203 per lbs, Zinc, slab, prime western.
30. Copper rollings & drawings:	14 (ton)	4,795.	
31. Electric wires & cables	58 (ton)	5,765.	
32. Aluminum rollings & drawings	4 (ton)	3,269.	
33. Rayon Pulp	56,119 (long ton)	6,575,184.	
34. Paper Pulp	47,449 (long ton)	5,312,898.	
35. Foreign style paper	1,323 (lbs)	107,732.	
36. Lumber	578 (1000 koku)	646,417.	
37. Automobile tires	2,300	34,304.	
38. Rayon filament	60 (1000 lbs)	13,542.	

39. Viscose & acetate	41 (1000 lbs)	10,624.	
40. Vinylon & Nylon	6 (1000 lbs)	3,097.	$ 0.617 per lbs.
41. Cotton Yarn	469	72,237.	$ 0.70 per lbs. Cared, Weaving, 10/1
42. Spun rayon		377.	
43. Spun synthetic yarn	3 (1000 lbs)	5,241.	
44. Woolen & worsted Yarn (pure, mixed)	342	322,826	$ 2.453 Bradford, weaving
45. Silk filament spun silk fabrics,	91 (1000 yd.)^2	56,474.	
46. Rayon filament fabrics	n.a.	47,363.	
47. Cotton fabrics	704 (1000 yd.)^2	131,110.	
48. Spun rayon fabrics	215 (1000 yd.)^2	51,421.	
49. Woolen & worsted fabrics	2,198 (1000 yd.)^2	2,308,651.	
50. Ammonia	n.a. (ton)	12.	$90.1 per Ton
51. Sulfuric acid	n.a. (ton)	2.	$20.0 per Ton
52. Soda ash	2,477 (ton)	35,998.	
53. Sodium hydroxide (Solvey process)	25 (ton)	1,587.	$ 3.350 per 100 lbs.
54. Calcium cyanamide	n.a. (ton)	1.	
55. Cement	15	1,028.	$ 3.28 per BBL, Portland 1958 Mar.
56. Sheet glass	4,024 (case equivalents)	18,458	1/4 inch Plate glass

Appendix III

Estimate of Land Influence on Real Income per Agricultural Worker as a Portion of Total Difference, 1951

A) Using formula, $A^* = B L^k M^{*1-k}$

1) U.S. output per agricultural worker in 1951. . . . . . $3,495.

2) Output per Japanese "Land adjusted" Worker $1,098.1

3) Japan's output per agricultural worker in 1951 . . . . $ 314.7

4) Actual difference between (1) and (3). $3,180.3

This quantity (4) is the total difference in output per worker to be explained.

5) The difference between (2) and (3) . . . . $ 783.4

This is the calculated difference per worker due to land quantities difference.

6) (5) divide by (4). 24.6%

This is the per cent of difference in per capita output due to land quantity.

B) Using formula, $A^* = B L^{k'} M^{*1-k'}$

1) U.S. output per agricultural worker in 1951. . . . . . $3,495.

2) Output per Japanese "Land adjusted" worker . . . . . . $ 841.7

3) Japan's output per agricultural worker in 1951 . . . . $ 314.7

4) Actual difference between (1) and (3). $3,180.3

This is the total difference in output per worker to be explained.

5) The difference between (2) and (3) . . . . $ 527.0

This is the calculated difference in per capita output due to land.

6) (5) divide by (4) 16.6%

This is the % of difference in per capita output due to land quantity.

Appendix IV

Problems in Index Numbers of the Gross National Products and National Income[1]

Homogeneity of products is assumed for measurement purpose by establishing substitutability either in consumer choices, or in production processes. These methods are taken from economic theory which is largely based on substitution possibilities. The principle theorem of competitive equilibrium theory states that marginal rates for either consumer or producer choices will equal the ratios of market prices for physical alternative. Both the Office of Business Economics of the Department of Commerce in the U.S.A. and Economic Planning Board in Japan seem to approve of the dual approach since it defines two measures, that of gross national product and that of national income.

a) Consumer Approach

The consumer approach is represented by gross national product measures. Problems in this approach as treated by Professor Simpson are solved by use of the opportunity cost principle of evaluation and by use of the devices of a typical household, in which average quantities of goods are consumed. Economic goods which are substitutes for a considerable number of other consumer products are true consumer products. Those which are complementary to consumer goods, are productive

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[1]Simpson, B. Paul: "Approaches to National Output Measurement" Journal of the American Statistical Association, Vol. 53, December, 1958, pp. 948-962.

"Transformation Functions in the Theory of Production Indexes" Journal of the American Statistical Association, Vol. 46, June, 1951, pp. 225-232.

or intermediate goods. Each consumer good is valued at the gross market price.

The relative change in value of product in two periods or places equals the ratio of number of households times price index times satisfaction level index.

> The satisfaction index may be obtained by using the linear indifference function of one period to determine a bundle of goods equivalent in satisfaction to actual consumption of a typical household in the other period, which bundle has the property that each good is the same multiple of consumption of the other period. The satisfaction index will be a Paasche or Laspeyre formula depending on whether the set of goods of which period or place is used as a comparison.[1]

b) Production Approach

The production approach is represented by national income. Assuming the cost of factors of products are C_x per unit of x and C_y per unit of y, we can argue that C_x / C_y determines the marginal equivalence of x and y, since the cost of factors used in producing a unit of y will hire factors necessary to produce this number of units of x.

> Assume the existence of constant product curves for each period approximated by a linear constant value functions. We ask what proportional increase in each of the outputs of Period I could have been produced with the factors of Period II. Alternatively we ask about the proportional change of factors of period I had been directed to producing products of period II. Familiar Paasche and Laspeyre index formulas are so derived.[2]

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[1] Simpson, B. Paul, "Approaches to National Output Measurement" Op. cit., p. 955.

[2] Ibid., p. 959.

Appendix V

Estimate x*, y*, a, b, and c.

$$ax_j + b = -0.266 \quad \ldots\ldots\ldots (1)$$

$$ax_j^2/2 + bxj + c = y_j \quad \ldots\ldots\ldots (2)$$

$$ax^* + b = -3.75 \quad \ldots\ldots\ldots (3)$$

$$ax^{*2}/2 + bx^* + c = x^* (y_u/x_u) \quad \ldots\ldots\ldots (4)$$

From our statistical data:

$$x_j = 20.7$$

$$y_j = 1{,}156$$

$$x_u = 56.5$$

$$y_u = 12{,}927$$

$$y_u/x_u = 228.8$$

Substituting these actual figures to the above equations:

$$20.7a + b = -0.266 \quad \ldots\ldots\ldots (1)'$$

$$\frac{20.7^2}{} a + 20.7b + c = 1{,}156 \quad \ldots\ldots (2)'$$

$$\text{or } 214.2a + 20.7b + c = 1{,}156 \quad \ldots\ldots (2)'$$

$$ax^* + b = -3.75 \quad \ldots\ldots\ldots (3)'$$

$$\frac{ax^{*2}}{2} + bx^* + c = 228.8x^* \quad \ldots\ldots\ldots (4)'$$

(1)' - (3)

$$20.7a - ax^* = 3.484$$

$$a(20.7-x^*) = 3.484$$

$$a = \frac{3.484}{20.7-x^*}$$

$$b = -0.266 - 20.7a$$

$$= -0.266 - \frac{72.1}{20.7-x^*}$$

(2)' - (4)'

$$214.2a-ax^{*2}/2 + 20.7b - bx^{*} = 1{,}156-228.8x^{*}$$

$$a(214.2 - x^{*2}/2) + b(20.7 - x^{*}) = 1{,}156-228.8x^{*}$$

$$\frac{3.484}{20.7-x^{*}}(214.2 - x^{*2}/2) + (20.7-x^{*})(-0.266 - \frac{72.1}{20.7-x^{*}})$$

$$= 1{,}156-228.8x^{*}$$

$$3.484(214.2 - x^{*2}/2) + (20.7 - x^{*})^2(-0.266 - \frac{72.1}{20.7-x^{*}})$$

$$=(1{,}156-228.8x^{*})(20.7-x^{*}).$$

$$3.484 \times 214.2 - 1{,}742x^{*}2-0.266(20.7-x^{*})^2 -72.1(20.7-x^{*})$$

$$=(1{,}156 - 228.8x^{*})(20.7-x^{*})$$

$$746.3 - 1.742x^{*2} - 113.98 - 11.0124x^{*} - 1{,}492.5 - 0.266x^{*2}+72.1x^{*}$$

$$= 23{,}929.2 - 1{,}156x^{*} - 4{,}7362x^{*} + 228.8x^{*2}$$

$$-x^{*2}(1{,}742 + 0.266 + 228.8) + x^{*}(11.0124 + 72.1 + 1{,}156 + 4{,}736.2)$$

$$+ (746.3 - 113.98 - 1{,}492.5 - 23{,}929.2) = 0$$

$$-230{,}808x^{*2} + 5{,}964.31x^{*} -24{,}789.4 = 0$$

$$230.808x^{*2} - 5{,}964.3x^{*} + 24{,}789.4 = 0$$

$$230.808x^{*2} - 5{,}964.3\ x^{*} + 24{,}789.4 = 0$$

$$x^{*} = \frac{5{,}964.3 \pm \sqrt{(5.964.3)^2 - 4 \times 230.808 \times 24{,}789.4}}{461.6}$$

$$x^{*} = \frac{5{,}964.3 \pm \sqrt{12{,}686{,}507.15}}{461.6}$$

$$x^{*} = \frac{5{,}964.3 \pm 3{,}561.8}{461.6}$$

$$x^{*} = 20.637 \text{ or } 5.2047227$$

<u>5.2047 is a desirable answer.</u>

$y^* = x^* \, (y_u / x_u)$

$= 5.2047 \times 228.8$

$= 1{,}190.83536$

$a = \dfrac{3.484}{20.7 - 5.2047}$

$= \dfrac{3.484}{15.49531}$

$= \underline{0.22484237}$

$b = -0.266 - \dfrac{72.1}{15.4953}$

$= -0.266 - 4.653024$

$= \underline{-4.919}$

$c = -0.22484 \text{ X } (20.7)^2 / 2 + 4.919 \text{ X } 20.7 + 1{,}156$

$= -0.22484 \times 214.2 + 4.919 \text{ X } 20.7 + 1{,}156$

$c = \underline{1{,}209.662572}$

Estimate of x*, y*, a, b, and c is obtained as follows:

$x^* = 5.2047227$

$y^* = 1{,}190.83536$

$a = 0{,}22484237$

$b = -4.919$

$c = 1{,}209{,}66625$

<u>Check our estimate of x*, a, b, and c.</u>

$ax_j + b = 0.22484237 \text{ X } 20.7 - 4.919$ . . . . (1)

$= -0.264763$

$ax_j^2/2 + bx_j + c = y_j = 1{,}156$ . . . . (2)

Or $\dfrac{0.22484}{2} (20.7)^2 + (20.7)(-4.919) + 1{,}209{,}66625$

$= \underline{1{,}156.0132}$

$ax^* + b$ . . . . (3)

$= 0.22484 \times 5.2047 - 4.919$

$= 1.170225 - 4.919$

$= -3.748775$

$\frac{ax^{*2}}{2} + bx^* + c = x^*(y_u/x_u)$ . . . (4)

$= 1,191.590.$

$= \frac{0.22484\,(5.2047)^2}{2} + (5.2047)\,(-4.919) + 1,209,666$

$= 3.045 - 25.602 + 1,209,666 = \underline{1,209,617841}$

Estimate of x*, y*, a, b, and c at the equilibrium of the U.S. given value of outputs.

$ax_u + b = -3.75$ . . . . (1)

$\frac{ax_u^2}{2} + bx_u + c = y_u$ . . . . . (2)

$ax^* + b = -0.266$ . . . . . (3)

$\frac{ax^{*2}}{2} + bx^* + c = x^*\,(yj/xj)$. . (4)

From our statistical data, we know:

$x_u = 56.5$

$x_j = 20.7$

$y_u = 12,927$

$y_j = 1,156$

Substitute these actual figures to the above equations:

$56.5a + b = -3.75$ . . . . (1)'

$\frac{(56.5)^2}{2}\,a + 56.5b + c = 12,927$

$1,596,125a + 56.5b + c = 12,927$ . . . . (2)'

$$ax^* + b = -0.266 \quad ....(3)'$$

$$\frac{x^{*2}a}{2} + bx^* + c = 55.845x^* \quad ....(4)'$$

(3) - (1)'

$$ax^* - 56.5a = 3.75 - 0.266$$

$$= 3.484$$

$$a(x^* - 56.5) = 3.484$$

$$a = \frac{3.484}{x^* - 56.5}$$

$$b = -3.75 - 56.5a$$

$$= -3.75 - 56.5 \left(\frac{3.484}{x^* - 56.5}\right)$$

$$= -3.75 - \frac{196.846}{x^* - 56.5}$$

(4)' - (2)'

$$\frac{x^{*2}}{2} a - 1,596.125\, a + bx^* - 56.5b = 55.845x^* - 12,927$$

$$a(x^{*2}/2 - 1,596.125) + b(x^* - 56.5) = 55.845x^* - 12,927$$

$$\frac{3.484}{\quad} (x^{*2}/ 2\ 1,596.125) + (x^* - 56.5)\left(-3.75 - \frac{196.846}{x^* - 56.5}\right)$$

$$= 55.845x^* - 12,927$$

$$3.484 (x^{*2}/2 - 1,596.125) + (x^* - 56.5)^2\left(- 3.75 - \frac{196.846}{x^* - 56.5}\right)$$

$$= (55.845x^* - 12,927)(x^* - 56.5)$$

$$1.742x^{*2} - 3.484 \times 1,596.125 - 3.75 (x^* - 56.5)^2 - 196.846 (x^* - 56.5)$$

$$= 55.845x^*(x^* - 56.5) - 12,927.(x^* - 56.5)$$

$$57.853x^{*2} - 16,309.1465x^* + 736,793.976 = 0$$

$$x^* = \frac{16,309.1465 \pm \sqrt{(16,309.1465)^2 - 4 \times 57.853 \times 736,793.976}}{115.706}$$

$$= \frac{16,309.1465 \pm 13,057.6}{115.706}$$

$= 28,101$ or $\underline{253.804}$

It is desirable to have 253.804, because 28101 is less than 56.5 millions.

$$a = \frac{3.484}{x^* - 56.5}$$

$$= \frac{3.484}{197.304}$$

$= 0.017658$

$$b = -3.75 - \frac{196.846}{197.304}$$

$= -3.75 - 0.99767871$

$= -4.74767871$

$c = 12,927. - 28.18437525 + 268.243847115$

$= \underline{13,167.05948}$

$y^* = x^*(y_j / x_j) = 55.845\ x^*$

$= 14,173.68438$

<u>Check</u>

1) $56.5 \times 0.017658 + (- 4.74767871$

$= 0.997677 - 4.74767871$

$= \underline{-3.75000171}$

2) $1,596.125\ (0.017658) + 56.5\ (-4.74767871 + 13,167.05948$

$= 28.18438 - 268.24385 + 13,167.05948$

$= \underline{12,927.}$

3) $(0.017658)\ (253.804) + (-4.74768 = 4.481671$

$= \underline{0.266009}$

4) $ax^{*2} = 0.008829 \times 64,416.470416 = 568.733017358$

$bx^{*} = -4.74767871 \times 253.804 = 1,204.97984731284$

$c = 13,167.05948$

Total **14,940.77235**

$x^{*}\left(\frac{Y_j}{X_j}\right) = 253.804 \times 55.8454106$

$= 14,173.7885919224$

Appendix VI

Estimate of Raw Material Influence on Real Income Per Non-agricultural Worker as a Portion of Total Difference

A) Using Isoquants for Japanese Output (page 145)

1a) U.S. output per non-agricultural worker $4,556
(Using exchange rate of Yen per dollar) ¥839,215

2a) Output per Japanese "raw material adjusted" worker. . $3,618
(Using exchange rate of Yen per dollar ¥666,436

3a) Japan's output per non-agricultural worker. . . . . . $ 910
(Using exchange rate of Yen per dollar ¥167,622

4a) Actual difference between (1a) and (3a) $3,646
(Using exchange rate of Yen per dollar ¥671,593

This quantity (4a) is the total difference in output per worker to be explained.

5a) The difference between (2a) and (3a). $2,708
(Using exchange rate of Yen per dollar. ¥498,814

This is the calculated difference per worker due to raw material difference.

6a) (5a) divide by (4a) 74.3%

This is the per cent of difference in per capita output due to raw material.

B) Using Isoquants for U.S. output. (page 149)

1b) Japanese output per non-agricultural worker . . . . . . $ 910
(Applying exchange rate of Yen per dollar) ¥167,622

2b) Output per "raw material adjusted" U.S. worker . . . $ 1,016
(Applying exchange rate of Yen per dollar). ¥187,147

3b) Output per U.S. worker. . . . . $ 4,556
(Applying exchange rate of Yen per dollar). ¥839,215

4b) The difference of (3b) and 1b) . . . . $ 3,646
(Applying the exchange rate Yen per dollar) ¥671,593

This is the total difference in output per worker to be explained.

5b) The difference of (3b) and (2b) . . . . $ 3,540
(Applying the exchange rate Yen per dollar. ¥652,068

This is the calculated difference per worker due to raw material difference.

6b) (5b) divide by (4b) 97.1%

This is the per cent of difference in per worker output due to raw material.

Appendix VII

Rough Estimate of Transportation Cost

The transportation cost of imports from the U.S.A. may be roughly estimated as follows:

(1) $P^J. Q^J. - P^U. Q^J$ = Transportation cost.

where $P^J. Q^J.$ stands for the Japanese imports value and $P^U. Q^J$ stands for the value of Japan's import quantities evaluated in terms of the U.S. wholesale prices. The transportation cost can be expressed in terms of either U.S. dollar or Japanese Yen, since the official exchange rate of Yen per dollar in 1952 was fixed at 360 Yen per dollar.

(2) $P^J. Q^J - P^U. Q^J. \times 360$ = Yen of Transportation Cost.

(3)----(2) divide 360

$P^J. Q^J/360 - P^U. Q^J.$ = Yen of Transportation cost / 360

= Dollars of transportation cost.

Our research has been made in principal imports commodities from U.S. in 1952 such as raw cotton, wheat, coal, iron ore, barley, crude oil & petroleum and rayon pulp. Since the U.S.A. is using the different measurement of quantity units from the international standard, the calculation of conversion is rather troublesome to reduce to the same units of quantities. One of the examples of our calculation is illustrated in iron ores imported from the U.S.A. as follows:

1 Metric Ton = 0.98419 long ton

1 long Ton = 1,016 metric ton

Price of iron ore per 1 metric ton = $9.00

Japan's imported iron ores evaluated in terms of U.S. wholesale price . . . . . .

1,426,000 X 9 = $ 12,800.000.

Japan's import iron ores from U.S. in terms of Yen . .

360 Yen X 12.8 = 4,608. Million Yen.

Japan's import cost of iron ores from U.S. in terms

of Yen . . . . .11,920. Million Yen.

Hence, the transportation cost is:

¥ 11,920 - ¥ 4,608. = ¥ 7,312. Millions

¥ 7,312 / ¥ 360 = $ 20.3 Millions.

The transportation cost is some 160% of the import value in terms of the U.S. wholesale value. (7,312 / 4,608 = 1.6.) The results of our calculation of transportation cost are shown below:

Japanese Transportation Cost From the U.S.A.
1952, (Unit...Millions of Dollars)

	(1) Value of Import quantities in terms of U.S. wholesale price.	(2) Transportation cost in dollars	(3) The per cent of transportation cost to value of import quantities. (2) ÷ (1)
1. raw cotton	151.0	41.3	26%
2. wheat	106.0	7.9	7.7%
3. coal	40.4	18.3	45.5%
4. iron ores	12.8	20.3	160.0%
5. barley	21.4	5.8	27.6%
6. crude oil & petroleum	15.7	12.0	76.5%
7. rayon pulp	33.1	1.9	5.7%

Sources: (1) Ministry of Finance, Economic Statistics of Japan, 1956, The Bank of Japan

(2) U.S. Bureau of Labor Statistics, Wholesale Price Index, 1956.

Appendix VIII

Marginal Rate of Technical Substitution, Material V.S. Capital

1) Wage Rate per Worker ^{J}/ Price per Unit of Materials ^{J}

$= M.T.S.^J_{(R.\ L)}$

$= -0.266$

2) Wage Rate per Worker ^{U}/ Price per Unit of Materials^U

$= M.T.S.^U_{(R.\ L.)}$

$= -3.75$

3) Wage Rate Per Worker ^{J}/ Rate of Return Per Unit of Equipment ^{J}

$= M.T.S.^J_{(C.\ L)}$

4) Wage Rate per Worker ^{U}/ Rate of Return Per Unit of Equipment^U

$= M.T.S.^U_{(C.L.)}$

5) (1) / (3),

Rate of Return per Unit of Equipment^J / Price Per Unit of Materials^J

$= MTS^J_{(R.L.)} / M.T.S.^J_{(C.L.)}$

$= -0.266 / M.T.S.^J_{(C.L.)}$

$= M.T.S.^J_{(R.C)}$

6) (2) / (4),

Rate of Return per Unit of Equipment ^{U}/ Price per Unit of materials^U

$= M.T.S.^U_{(R.L.)} / M.T.S.^U_{(C.L.)}$

$= -3.75 / M.T.S.^U_{(C.L.)}$

$= M.T.S.^U_{(R.C)}$

If we assume,

$$\frac{b \text{ Wage Rate per Worker}^J}{\text{Rate of Return Per Unit of Equip.}^J} = \frac{\text{Wage Rate Per Worker}^U}{\text{Rate of Return per Equip.}^U}$$

and also we assume,

Rate of return per unit of Equip. $^U = 1$

Rate of return per unit of Equip. $^J = 1.$

7) (4) / (3)

$$b = \frac{3750}{792.4} = \frac{\text{M.T.S.}^U (\text{C.L.})}{\text{M.T.S.}^J (\text{C.L.})}$$

$$b = 4.73 = \text{M.T.S.}^U (\text{C.L}) / \text{M.T.S.}^J (\text{C.L.})$$

8) (6) / (5),

$$\frac{\text{M.T.S.}^U (\text{R.C})}{\text{M.T.S.}^J (\text{R.C.})} = \frac{-3.75}{\text{M.T.S.}^U (\text{C.L.})} \times \frac{\text{M.T.S.}^J (\text{C.L.})}{0.266}$$

$$= \frac{-3.75}{-0.266} \times \frac{1}{b}$$

$$= \frac{-3.75}{-0.266 \times 4.73}$$

$$= \frac{-3.75}{-1.258} = 2.98$$

Hence, $\text{M.T.S.}^U (\text{R.C.}) = -3.75$

$\text{M.T.S.}^J = -1.258$ (Under the assumption of the same rate of return per unit of equipment for U.S. and Japan.)

9) (6) / (5)

$$\frac{\text{M.T.S.}^U (\text{R.C.})}{\text{M.T.S.}^J (\text{R.C.})} = \frac{\text{Price per Unit of Materials}^J}{\text{Price per Unit of Materials}^U}$$

$$= \frac{551}{184.2} = 2.99$$

We can obtain the same result as (8). This figure of marginal rate of technical substitution between raw materials and producer's durable equipment is the ratio of that of the U.S. to that of Japan. Unless we know the rate of return per unit of equipment in two countries, we will not be able to find the absolute value of marginal rate of technical substitution between materials and capital.

Appendix IX

Estimate of New Material Costs to Japan under the U.S. Marginal Rate of Technical Substitution for Material and Equipment

If we take material costs on the vertical line Y axis, and producer's durable equipment on the horizontal line X axis, we will be able to draw the isoquants map for Japan and the United States at the given output levels. If we assume dy/dx equals ax + b, and y equals $ax^2 + bx + c$, Japan's new material costs can be estimated by the following equations.

$$ax_j + b = -1.258$$

$$ax_j^2/2 + bx_j + c = y_j = x_j\ (y_j/x_j)$$

$$ax^* + b = -3.75$$

$$ax^{*2}/2 + bx^* + c = y^* = x^*\ (y_u/\ x_u)$$

where x* and y* denote respectively for Japan's new material costs and producer's durable equipment and subscriptions u and j indicate U.S. and Japan. Since we know that x_j equals 8.9, y_j equals 1,156. x_u equals 56.5 and y_u equals 12,927., the above four equations with respect to four unknown variables will be solved.

(1) $8.9\ a + b = -1.258$

(2) $(8.9)^2 a/2 + 8.9b + c = 1{,}156$

(3) $ax^* + b = -3.75$

(4) $ax^{*2}/2 + bx^* + c = x^*\ \ (12{,}927/56.5) = x^*\ 228.79646$

(1) - (3),

$$8.9\ a - a\ x^* = 2.492$$

$$a = \frac{2.492}{8.9 - x^*}$$

$$b = -1.258 - \frac{22.179}{8.9-x^*}$$

$$c = 1,167.196 - \frac{98.6957}{8.9 - x^*} + \frac{202.83}{8.9-x^*}$$

Substitute these results to (4).

$$230.042\ x^{*2} - 3,203.48469\ x^* + 10,486.96329 = 0$$

$x^* = \underline{5.261}$

$y^* = \underline{12,036.9817606}$

$a = \underline{0.6848}$

$b = \underline{-7.35281}$

$c = \underline{1,195.812268}$

<u>Check</u>

(1) $8.9\ a + b$

$= \underline{-1.25809}$ . . .O.K.

(2) $39.61\ a + 8.9\ b + c$

$= 27.124328 - 65.440009 + 1,195.812268$

$= 1,157.497119$ . . . O.K.

(3) $a\ x^* + b$

$= 3.6027328 - 7.35281$

$= -3.7500772$ . . . . O.K.

(4) $ax^{*2}/2 + bx^* + c = 1,203.69817606$

$= 9.47698860 - 38.68313341 + 1,195.8122$

$= \underline{1,166.606056}$

Typed by Edith Jones