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THE PROCESS OF INDUSTRIALIZATION

by

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Note:

This is one of a series of studies that will be subsequently incorporated in a book on Patterns of Development.

Related papers include:

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1. "Patterns of Industrial Growth" (AER, 1960),
2. "The Pattern of Japanese Growth" (Econometrica, 1962) (with S. Shishido and T. Watanabe,
3. "Development Patterns: Among Countries and Over Time" (with L. Taylor, Rev. Econ. Stat., 1968).
4. "A Uniform Study of Development Patterns" (with C. Sims, and H. Elkington, Economic Development Report No. 148, 1969).

attached

A Preliminary version of the present paper was circulated as Economic Development Report No. 1 (1965).

Two technical annexes are available separately:

A. Szasz, "The Process of Industrialization: Appendix on Computation", Economic Development Report No. 144 (1969);

H. Chenery and W. Ginsberg, "Simulating the Process of Industrialization", Economic Development Report No. 147 (1969).

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THE PROCESS OF INDUSTRIALIZATION[1]

The preceding chapters represent two of the principal empirical approaches to the study of economic development. Studies of a single country over time determine the interrelations among structural changes in particular cases. Intercountry comparisons determine the range of variation of individual structural features, such as demand, trade or factor use. The two approaches are therefore complementary and need to be combined to derive an empirically based theory of industrialization.

If statistical data and analytical resources were plentiful, a logical combination would be a mixed cross-section, time series analysis, based on parallel studies of a number of countries over periods of forty or fifty years. Although this type of analysis has been attempted at the aggregate level,[2] statistical materials do not permit its application to the disaggregated study of industrialization and structural change. A less ambitious compromise is needed to bring together the results of existing country studies and intercountry comparisons.

The approach followed here is a generalization of the preceding analysis of Japanese industrialization that is achieved by substituting general structural relations for some of those that are specific to Japan. The variation in demand and trade with rising income observed in Japan will be replaced by estimates of typical intercountry relations. Similarly, a general production function relating capital and labor used in each sector to the wage level will be substituted for the specific variation in factor inputs.

The cross-section model estimated in this way will be used to extend the results of preceding chapters in two directions. First, it is used to test the generality of the development processes that were described for Japan and other countries in chapter 4. Second, the cross-section model helps to explain the sources of the patterns of structural change that were identified in chapters 2 and 3.[3/] The cross-section estimates of elements of the inter-industry model are limited to structural relations that are critical to these two purposes.

Although most of development theory is based on informal comparisons among countries, there has been little use of econometric techniques for estimating cross-section models and interpreting their results. It must therefore be demonstrated that a formal model provides a useful way of organizing partial cross-section relations into a comprehensive analysis of structural change. Although the statistical limitations to this procedure are serious, they do not appear to be more restrictive than those implied by the alternative approach of estimating structural relations from time series extending over several decades.

A. A GENERAL MODEL OF STRUCTURAL CHANGE

Methodology

The preceding study of Japanese development illustrates the main purpose of a general model of structural change: to specify the more immediate determinants of output and resource allocation in each sector of the economy and to measure their effects. This purpose can be pursued with varying degrees of generality, depending on which elements are taken to be exogenous. The Japanese model corresponds to the Leontief "open" input-output system that is commonly used for planning purposes; domestic demand, imports and exports are all determined exogenously. In a more general formulation, the composition of demand and trade can be made a function of variables such as the income level and the growth rate. Similarly, factor inputs can either be assumed to depend only on levels of sector output or can be determined from production functions and factor prices.

The model developed here is a pure cross-section model in the sense that all of the structural relations refer to a single period. In most respects such a model is formally similar to a pure time series model. While the latter assumes that behavioral relations hold for a single economic unit over a specific time interval, a cross-section model assumes that behavioral relations apply to a set of units (households, firms, or countries) at a single point in time. When more data become available, the two sets of observations can be combined in a mixed time series, cross-section model that can allow for variation in either type of relation.[4/]

The design of the present cross-country model is determined largely by the availability of data. Its potential usefulness is suggested by the stability of the cross-section relations for production and trade that was shown in chapters 2 and 3. Preliminary tests also show considerable uniformity among countries in input-output relations and in demand functions, the other principal elements. The usefulness of combining these separate relations in a single cross-section model will be tested by comparing the growth patterns that it generates to the direct estimates of production patterns given in chapter 3.

To explain inter-country growth patterns, exogenous variables are chosen to represent underlying factors affecting the sectoral allocation of resources. If structural change followed the same pattern in every country, the level of income would be the only exogenous variable needed. The inclusion of additional variables is based on the statistical tests of industry growth functions described above. The indices of scale and trade orientation developed in chapter 2 are retained here. Measures of capital inflow and relative factor costs are needed to complete the model.

Cross-section and time-series models both require rather strong assumptions if they are used to analyze future change. In cross-section analysis, we assume that as the income level of a country or other economic unit rises, it takes on the structure and behavior of units now at that level of income. In time-series analysis, we assume that the changes in structure and behavior reflected in past trends will continue into the future. Changes in tastes and technology are thus incorporated in each type of model, using different simplifying assumptions. In one case they are assumed to vary uniformly with time; in the other case, with income level. We can only determine from empirical tests which type of simplification is more valid.

Model Structure

Since the Japanese interindustry model forms the core of the cross-section model, a similar classification of economic activity into fifteen branches of industry and eight other sectors is used. The composition of demand and trade is made a function of per capita income and other exogenous variables. The formal structure of the model is summarized in four sets of equations that perform the following operations:

(i) Specification of the aggregate composition of demand and trade as a function of the income level and other exogenous variables.

(ii) Disaggregation of each of the five aggregate components of demand and trade into twenty-three commodity groups which are then consolidated into a single vector of net final demands.

(iii) Calculations of the twenty-three production levels by application of an input-output model to the net final demands found in stage (ii).

(iv) Determination of the amounts of labor and capital used in each sector.

The structure of the model is such that these four sets of equations can be solved in sequence without any feedback from later to earlier stages. As shown in Table 4 below, the aggregate levels of consumption and investment found in step 1 become predetermined variables for step 2; the sector final demands from step 2 are predetermined variables for step 3; the production levels from step 3 are predetermined for step 4. The model as a whole therefore determines the sectoral allocation of commodities and factors of production as a function of the set of exogenous variables.

The required functions are estimated from cross-country analysis of data for the period 1950-1964. The present section discusses the general nature of these structural relations; further detail is given in the appendix.

Aggregate Relations. The set of aggregate relations is used in the model so that relations estimated from a large sample of countries can form the basis for the detailed breakdown. Instead of determining the consumption of food directly as a function of income, for example, I estimate consumption as a share of income and then food as a share of consumption. This procedure takes advantage of the fact that a much larger sample of countries is available for the aggregate estimates, which therefore have greater statistical reliability. Following this logic, functions will be estimated for each of the five principal components of the gross domestic product: consumption, investment, government expenditure, exports and imports. Each aggregate will serve as a control total for its sector components.

The five aggregate variables are related by the accounting identity for gross domestic product:[5/]

(1) $Y = C + I + G + E - M$

where Y is gross domestic product, C is private consumption, I is gross domestic investment, G is government expenditure, E is exports, and M is imports.

The nature and causes of variation among countries in the composition of GDP have been widely discussed by Kuznets (1966) and others. The principal source of variation is the change in income level. Following the reasoning of chapter 2, this variable is introduced in a non-linear logarithmic form. Other exogenous variables may have a direct effect on one or two components and indirectly affect the others because they are components of the whole. Thus the rate of growth is directly associated with the share of investment and the size of the country directly affects the shares of imports and exports.

Because the shares of the five components are interrelated, the same regression equation is fitted for each.[6/]

$$\text{(2)} \quad \ln S_k = a_o + a_1 \ln y + a_2 (\ln y)^2 + a_3 \ln N + a_4 \left(\frac{\Delta Y}{Y}\right)$$

where S_k is the share of the given component in GDP, y is per capita GDP, N is population, and $\frac{\Delta Y}{Y}$ is the annual growth rate of GDP.

The sample of countries available for estimating these functions consists of 61 countries of a million or more population for which the requisite data are given by the United Nations over most of the period 1950-1964.[7/] Estimates of the parameters for each of the five components are given in Table A-1 of the appendix.

The results of this analysis are illustrated in figures 1 and 2. As income rises from \$100 to \$1500 per capita, the share of consumption falls from 77% to 62% of GDP while gross investment, government expenditure and the trade balance (E-M) all increase. As noted earlier, the shares of exports and imports are mainly determined by the size of the country and show little variation with the level of income.[8/]

<u>Composition of Demand and Trade</u>. The elements of equation (1) are disaggregated to give a commodity balance of the following form for each of the twenty-three sectors of the economy:

$$\text{(3)} \quad X_i - W_i = C_i + G_i + I_i + E_i - M_i \qquad (i = 1 \ldots 23)$$

where X_i is total production of commodity i per capita, W_i is its intermediate use in other sectors, and C_i, G_i, I_i, E_i and M_i represent the disaggregation of the components of GDP. Subsequent analysis will focus on the relative importance of changes in total domestic demand ($D_i = C_i + G_i + I_i$) and net trade ($T_i = E_i - M_i$) in each sector.

Input-output accounts provide a consistent conceptual framework for the sector analysis. Fifteen national input-output tables were used as a basis for inter-country comparisons of the elements in these equations. Supplementary sources were also utilized to estimate the elements of consumption and investment that constitute the largest sources of change in the pattern of demand. The principal sources are intercountry comparisons of budget studies by Houthakker (1957) and of national accounts categories in Watanabe (1962).

The basic equation used to determine the composition of each element of domestic demand is of the form:

(4) $\log S_i = \alpha_o + \alpha_1 \log S$

where S represents total consumption, investment or government expenditure per capita. For imports and exports, the equations take the form:

(5) $\log X_i = \beta_o + \beta_1 \log y + \beta_2 \log N$

where X_i is imports (or exports) per capita of commodity i. This specification was discussed in chapter 2.

Of the eighty non-zero relations of this type, principal attention was given to those having the greatest effect on the pattern of output. Rough approximations were used for many minor elements. The set of parameters used in the simulation model is given in Table A-2.

The principal sources of variation in demand are summarized in Table 1. The predominant change in the composition of consumption is the fall in the share of foodstuffs and the accompanying shift within this total from unprocessed to processed foods. The other principal necessities, clothing and textiles, remain fairly constant, while durables and other manufactures increased their share substantially. The rising share of investment in GNP raises the demand for construction and equipment. The share of services remains fairly constant.

The change in the trade pattern shown in Table 2 is even more pronounced than the change in domestic demand. Manufactured exports rise from less than 10% to more than 50% of the total as income rises to $800 per capita. The typical country becomes a net exporter of manufactured goods somewhere around $1000 per capita.

In summary, the changes in the composition of domestic demand and trade are comparable in magnitude. Both produce a relative decline in the net demand for primary products and a relative rise in the demand for manufactured goods. Subsequent analysis will show the way in which these shifts are translated into changes in patterns of production and factor use.

Interindustry Demand. Even at low income levels roughly half of all commodities produced (sectors 1-18) constitute inputs to other sectors of production. At high income levels the share of interindustry demand for commodities reaches sixty per cent of their total output. An analysis of structural change must therefore pay as much attention to interindustry relations as to changes in final demand.

TABLE 1

Demand Response to Rising Income[a]

Sector	Income Level 400 Final Demand (D) C (1)	G (2)	I (3)	D (4)	Change in D 200 - 400 (5)	Change in D 400 - 800 (6)	Income Elasticities 100 - 400 (7)	400 - 1500 (8)
1. Agriculture	36.6	0.5	0.0	37.1	9.1	10.0	0.5	0.3
2. Coal and Oil	0.0	0.5	0.0	0.5	0.3	0.6	1.1	1.2
3. Other Mining	1.1	0.0	0.0	1.1	0.9	3.3	2.2	2.0
4. Food and Tobacco Products	54.0	2.3	0.0	56.3	28.5	51.4	1.1	0.9
5. Clothing	9.9	0.7	0.0	10.6	5.7	11.1	1.2	1.0
6. Textiles	16.0	0.0	0.0	16.0	7.6	12.4	1.0	0.8
7. Leather Products	1.7	0.0	0.0	1.8	1.0	1.7	1.1	1.0
8. Lumber and Wood Products	3.2	0.2	0.0	3.4	2.5	8.2	1.9	1.7
9. Paper and Printing	4.0	0.7	0.0	4.7	2.4	4.5	1.1	1.0
10. Rubber Products	1.9	0.2	0.0	2.1	1.3	3.3	1.4	1.3
11. Chemicals	4.4	0.1	0.0	4.5	2.3	4.0	1.1	0.9
12. Coal and Petroleum Products	1.7	0.2	0.0	1.9	1.3	4.0	1.7	1.6
13. Non-Metallic Mineral Products	0.9	0.0	0.0	0.9	0.4	0.5	0.8	0.7
14. Metal Products	5.6	0.2	0.0	5.8	4.0	11.8	1.7	1.5
15. Machinery	1.1	0.5	15.2	16.8	9.3	20.7	1.2	1.2
16. Transport Equipment	0.5	0.0	11.5	12.0	6.7	15.3	1.2	1.2
17. Manufacturing, n.e.c.	2.8	0.2	0.0	3.0	1.9	4.6	1.5	1.3
18. Construction	0.0	0.9	43.5	44.4	24.3	53.8	1.1	1.1
19. Electricity, Gas, Water	7.4	0.5	0.0	7.9	4.1	7.7	1.1	0.9
20. Trade	56.5	0.5	3.9	60.9	29.3	55.3	1.0	0.9
21. Real Estate	15.5	0.5	0.0	16.0	7.6	13.0	1.0	0.8
22. Transport and Commun.	3.8	1.9	0.4	6.0	2.6	3.9	0.9	0.7
23. Other Services	53.8	36.1	0.0	89.9	47.2	95.5	1.1	1.0
TOTALS	282.3	46.7	74.4	403.4	200.3	396.6		

[a]Computed from basic simulation run given in appendix table A-4 with population size of 10 million.

TABLE 2

Trade Response to Rising Income[a/]

	Income Level $400			Change from $200 - $400			Change from $400 - $800		
Sector	Exports E (1)	Imports M (2)	Net Trade T (3)	Exports E (4)	Imports M (5)	Net Trade T (6)	Exports E (7)	Imports M (8)	Net Trade T (9)
1. Agriculture	39.3	12.6	26.7	14.7	7.6	7.1	9.7	17.2	-7.5
2. Coal and Oil	0.5	2.3	-1.8	0.3	1.8	-1.5	0.5	8.2	-7.7
3. Other Mining	2.4	1.3	1.1	1.4	0.8	0.5	1.9	2.1	-0.2
4. Food and Tobacco Products	8.0	6.6	1.4	6.4	3.1	3.3	24.0	5.3	18.7
5. Clothing	0.5	0.7	-0.2	0.3	0.3	0.0	0.6	0.5	0.1
6. Textiles	1.2	5.4	-4.2	0.8	1.5	-0.7	1.6	1.7	-0.1
7. Leather Products	0.2	0.9	-0.7	0.1	0.5	-0.3	0.2	0.9	-0.7
8. Lumber and Wood Products	0.7	1.8	-1.1	0.5	1.0	-0.5	1.6	2.4	-0.8
9. Paper and Printing	1.9	4.5	-2.6	1.6	2.3	-0.7	7.1	4.3	2.8
10. Rubber Products	0.3	0.6	-0.3	0.2	0.1	0.1	0.5	0.3	0.2
11. Chemicals	5.0	3.4	1.6	3.7	1.6	2.1	10.2	2.5	7.7
12. Coal and Petroleum Products	0.4	4.3	-3.9	0.3	2.0	-1.8	0.5	3.5	-3.0
13. Non-Metallic Mineral Products	0.7	1.1	-0.4	0.5	0.4	0.1	1.3	0.7	0.6
14. Metal Products	0.7	6.9	-6.2	0.6	3.7	-3.1	3.0	7.5	-4.5
15. Machinery	0.5	10.0	-9.5	0.4	4.8	-4.3	2.4	8.2	-5.8
16. Transport Equipment	0.5	5.3	-4.9	0.4	2.0	-1.7	1.7	3.0	-1.3
17. Manufacturing, n.e.c.	1.2	0.0	1.2	0.9	0.0	0.9	3.3	0.0	3.3
18. Construction	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	3.3
19. Electricity, Gas, Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20. Trade	10.1	9.9	0.2	5.2	4.9	0.3	11.1	10.0	1.1
21. Real Estate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22. Transport and Commun.	3.9	3.9	0.1	2.0	2.0	0.1	4.3	3.9	0.4
23. Other Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS	77.9	81.4	-3.5	40.4	40.5	-0.1	85.5	82.1	3.4

a/ Computed from estimates of equations (2) and (5) given in appendix Tables A-1, A-2 and A-4 with population size of 10 million. Components are adjusted proportionately to equal totals.

The simplest interindustry model is based on the assumption of constant input-output coefficients. Before this assumption was adopted here, extensive tests were made[9] to determine whether a systematic variation of input coefficients with income level could be discovered. Although numerous examples were found of individual commodities like electric power whose intensity of use varies with the income level, such variation is largely concealed by aggregation.

As a first approximation, the cross-section model will therefore employ the constant coefficient input-output model of chapter 4, which can be rewritten from equation (4.1) as:

(6) $X_i = W_i + D_i + T_i$ (i = 1 ...n)

where $W_i = \sum_j a_{ij}X_j$ (intermediate demand)

$D_i = C_i + G_i + I_i$ (domestic final demand)

$T_i = E_i - M_i$ (net trade)

The solution to this set of n equations (4.2) gives the sector production levels as a function of domestic demand and net trade:

(7) $X_i = \sum_j r_{ij} (D_j + T_j)$ (i = 1 ... n)

Value added is assumed to be a constant function of output:

(8) $V_i = v_i X_i$ (i = 1 ... n)

Equations (7) and (8) constitute the basic interindustry model.

Although no variation in input coefficients will be assumed in the current version of the model, it is desirable to estimate a representative interindustry structure rather than to use a set of coefficients for a single country. This has been done by taking the 1951 Japanese coefficient matrix of chapter 4 as a point of departure and adjusting it on the basis of Watanabe's comparison of input-coefficients in fifteen countries. The revision procedure used international prices when they were notably different from Japanese prices of imported goods and used average ratios of value added to output in each sector. The "normal" input-output matrix that results from this set of adjustments is given in table A-3.

Table 3 gives the solution to the interindustry model at an income level of $400, which is based on the normal demand and trade vectors of Tables 1 and 2. Columns (1) and (2) indicate the relative importance of intermediate and final domestic demand. Subsequent analysis will show that the growth of intermediate demand is a major element in explaining the changing structure of production.

The assumption of constant input coefficients performs the same function in the cross-section model that it did in the historical model of chapter 4. It enables us to measure the consequences of changes in final demand with no change in technology, which implicitly provides a residual measure of technological variation. A comparison of these two measures -- among countries and over time -- provides a further test of the plausibility of the cross-section model.

Table 3

Total Demand and Supply at Income Level $400[a]

Sector	Intermediate Demand (W_i)	Domestic Demand (D_i)	Net Trade (T_i)	Production (X_i)	Value Added (V_i)
1. Agriculture	47.9	37.1	26.7	111.8	76.2
2. Coal and Oil	6.5	0.5	-1.8	5.2	3.9
3. Other Mining	6.3	1.1	1.1	8.5	6.4
4. Food and Tobacco Products	39.8	56.3	1.4	97.6	29.8
5. Clothing	5.3	10.6	-0.2	15.7	8.6
6. Textiles	13.0	16.0	-4.2	24.8	11.0
7. Leather Products	0.3	1.8	-0.7	1.4	0.4
8. Lumber and Wood Products	4.9	3.4	-1.1	7.2	2.8
9. Paper and Printing	14.3	4.7	-2.6	16.4	7.5
10. Rubber Products	3.5	2.1	-0.3	5.3	3.3
11. Chemicals	17.7	4.5	1.6	23.8	12.0
12. Coal and Petroleum Products	4.3	1.9	-3.9	2.3	0.6
13. Non-Metallic Min. Products	8.3	0.9	-0.4	8.7	6.1
14. Metal Products	25.0	5.8	-6.2	24.6	9.5
15. Machinery	6.8	16.8	-9.5	14.1	8.8
16. Transport Equipment	2.2	12.0	-4.9	9.4	3.5
17. Manufacturing, n.e.c.	7.2	3.0	1.2	11.4	5.1
18. Construction	9.9	44.4	0.0	54.3	25.1
19. Electricity, Gas, Water	4.8	7.9	0.0	12.7	8.4
20. Trade	18.8	60.9	0.2	79.9	66.1
21. Real Estate	3.3	16.0	0.0	19.4	16.7
22. Transport and Commun.	15.4	6.0	0.1	21.5	15.3
23. Other Services	24.8	89.9	0.0	114.7	73.1
TOTALS	291.5	403.4	-3.4	690.6	400.0

a/ Computed by applications of equations (7) and (8) with given values of D_i and T_i and the elements of the input-output solutions (r_{ij}) given in appendix Table A-3.

<u>Factor Use</u>. Chapter 2 shows a pattern of intercountry variation in the composition of employment that is different from the pattern of output variation. The proportion of employment in agriculture drops more rapidly than does the share of value added, indicating a larger rise in labor productivity than the average for the economy. In the service sectors, the opposite is true; while total employment in services rises with the income level, the share of value added remains almost constant. As Kuznets has shown (1966, p. 415), the result is that the initial differences in labor productivity in low-income countries tend to be reduced as income rises.

To explore this phenomenon, the simulation model includes a separate production function for each sector of production. Although this part of the analysis will be given in chapter 6, the procedure is summarized here.

The model employs the CES function of Arrow, Chenery, Minhas and Solow (ACMS, 1962), which has a constant elasticity of substitution between capital and labor and assumes neutral increases in efficiency. Since the function was developed to explain the observed intercountry variation in value added per unit of labor, it is well suited for the present purposes. It permits us to explore the effects on factor allocation of different elasticities of substitution between labor and capital, which appears to be one of the important causes of the general pattern described above.

The CES function specifies value added for each sector as the following function of labor and capital inputs:

(8) $V = \gamma\ [\delta\ K^{-\rho} + (1-\delta)\ L^{-\rho}]^{-1/p}$

and where $\gamma = \gamma(y)$ is the neutral efficiency parameter, ρ is a substitution parameter, and δ is the distribution parameter. This function has been estimated from two types of intercountry data: (i) observations on labor use, wage rates, and value added in manufacturing for a large number of countries, and (ii) observations on both labor and capital for all sectors in Japan and the United States.10/

Since technical change is assumed to be neutral and a function of the income level only, the amount of labor and capital required to produce a specified level of value added in sector i can be determined in two separate steps: determination of the capital-labor ratio and determination of the factor inputs at a given level of efficiency. The efficient capital-labor ratio in a given sector can be calculated from the following function of σ, δ, and the relative cost of labor and capital, w/r (ACMS, p. 233):

(9) $\frac{K}{L} = \left(\frac{\delta}{1-\delta}\right)^{\sigma} \left(\frac{w}{r}\right)^{\sigma}$

The labor required to produce a given amount of value added is then determined from equation (8) as:

(10) $L = \frac{V}{\gamma}\ [\delta\ \left(\frac{K}{L}\right)^{-\rho} + (1-\delta)\ ]^{\frac{1}{\rho}}$

This formulation takes the relative cost of labor and capital (w/r) as an exogenous variable. In a more complete model this proportion would be determined as a function of the level of income, the rate of growth and other variables. In the simulations in chapter 6 an illustrative variation in relative factor costs and efficiency with income will be based on the U.S.-Japanese comparison.

Simulation of Development Patterns

The four sets of functions just described comprise a multi-sector model of production and trade which translates an increase in national product into increases in value added and factor use. Table 4 summarizes the relations among the functions and shows how solutions to each successive stage provide values of the exogenous variables for the next. While the model analyzes the supply side of the economy in some detail, it does not include the structure of income generation, taxation, savings and consumption.[11/] Instead, I have estimated typical consumption and investment patterns without attempting to explain how they are generated.

The main use of this model is to show the way in which the economic structure is altered as the level of income rises. A typical simulation experiment is carried out by assuming values for the exogenous variables in stage I and increasing the level of income from $100 to $1500 by increments of $100, solving the equations in Table 4 at each level. Since the cost of such experiments is quite low,[12/] they can be repeated to determine the general properties of the model as well as to analyze any particular set of assumptions.

The technique of simulation is particularly well suited to these purposes. In a complex economic system the adequacy of any specification of functional relations must be determined from solutions to the system as a whole. Simulation

TABLE 4

Summary of Simulation Procedure

Operation	Variables Exogenous[1/]	Endogenous	Function	Control Totals[2/]
I. Determine shares of Demand and Trade in GDP	y, N, (Y) F	C, I, G, E, M	(2) $S = a_o + a_1 \ln y + a_2 (\ln y)^2 + a_3 \ln N + a_4 (\frac{\Delta Y}{Y})$	$Y = C + I + G + (E-M)$ $M = E + F$
II. Disaggregate elements of Final Demand and Trade	C^*, I^*, G^* E^*, M^*, Y, N	C_i, I_i, G_i E_i, M_i	(4) $\log S_i = \alpha_o + \alpha_1 \log S$ (5) $\log X_i = \beta_o + \beta_1 \log Y + \beta_2 \log N$	$\Sigma S_i = S$ $\Sigma E_i = E$ $\Sigma M_i = M$
III. Determine Levels of Production and Value Added	$D_i = (C_i^* + I_i^* + G_i^*)$ $T_i = (E^*_i - M_i^*)$	X_i V_i	(7) $X_i = \Sigma r_{ij} (D_i + T_i)$ (8) $V_i = v_i X_i$	$\Sigma D_i + \Sigma T_i = Y$ $\Sigma V_i = V = Y$
IV. Determine Capital and Labor Inputs by Sector	V_i^*, $\frac{w_i}{r_i}$	K_i, L_i	(10) $\frac{K_i}{L_i} = \left(\frac{\delta}{1-\delta}\right)^{\sigma} \left(\frac{w}{r}\right)^{\sigma}$ (11) $L_i = \frac{V_i}{\delta} \left[\delta \left(\frac{K}{L}\right) + (1-\delta)\right]^{\frac{1}{\rho}}$	$\Sigma L_i = L$

1/ Starred exogenous variables are determined in previous stages.

2/ Control totals are imposed on stages I and II by adjusting components proportionately.
Totals in stage III are properties of the input-output model.

experiments are part of the process of inductive theorizing because a study of these solutions suggest areas in which further refinement of the model is needed.

B. THE NORMAL PROCESS OF INDUSTRIALIZATION

The first use of the intersectoral model is to analyse the process of industrialization in typical circumstances. "Normal industrialization" is simulated by varying the level of per capita income with average values for the other exogenous variables. This basic solution is then compared to the direct estimates of production patterns from chapters 3 and 4 to determine whether the growth paths generated by the model are useful approximations to reality.

Earlier chapters showed that the factors affecting the economic structure vary in importance as income levels rise. For purposes of this analysis, I will divide the process of industrialization into two parts: an earlier stage in which the output of the primary sector is larger than that of industry, and a later stage in which industry predominates. The cross-section model will be shown to simulate the observed intercountry pattern somewhat better in the later stage, since data for the structural estimates come mainly from countries with incomes of over $300 per capita.

General Performance of the Model

Since a comprehensive model estimated from a variety of sources cannot be expected to reproduce very exactly the changes observed in any single variable, it is necessary to judge its results in overall terms. Two principal tests are applied to determine the model's validity for the present purpose. The first is whether the pattern of change in the major components of production is similar to the cross-country pattern that is independently observed. The second is whether the effects of the factors omitted from the model, represented by the differences between the simulated and observed patterns, resemble the patterns of residual variation in the historical analyses of chapter 4.

Figure 3 gives an overall comparison of the change in industrial structure produced by the simulation model as income is increased from $100 to $1500 to that observed in cross-country regressions.[13/] The greatest difference between the two patterns is in the decline of primary production by 31% of GNP (from 41% to 10%) in the regression results as compared to a decline of only 20% in the model. Conversely, the model shows a smaller rise in the other two types of production.

These differences are largely concentrated in the early stage of growth below an income level of $300. Above this level, the rise of industry is 12% of GNP in both cases and the differences in the other sectors are much reduced.

A more detailed comparison of the patterns produced by the model to the regression results in twelve industrial sectors is given in Table 5 and figures 5a to 5n below.

Levels of value added are higher in the model than the regression estimates in almost all industrial sectors.[14/] This is allowed for in comparing the model's performance to the regression patterns in figure 5 by setting the model values equal to the regression results at an income level of $400.[15/] Although at higher income levels the growth elasticities from the model agree fairly well with the regression results, at lower income levels the regression elasticities in the industrial sectors are consistently higher.

To find an explanation for these differences at lower incomes, I refer back to the preceding study of Japanese industrial growth over forty years. There it was observed that the intermediate use of manufactured goods by other industries increased much more rapidly than would be predicted from the assumption of constant input coefficients, while the intermediate use of primary products grew less rapidly. A similar phenomenon appears in the cross-country simulation model. The two sets of results are set out in a comparable form[16/] in figure 4 to bring out the similarities in the patterns of residual variation. The interval selected for comparison from the cross-country results ($200 to $400) has an increase in total industrial output per capita of 160%, the same as the increase in Japan for a smaller rise in income.[17/] The sectoral breakdown of this increase in figure 4 shows a general similarity in the two patterns but more pronounced differences in Japan between the rapidly growing and slow growing sectors.[18/]

The pattern of residual variation is of particular significance in interpreting the simulation model. In each industry the residual results from two sets of factors: the omission from the model of variation in tastes, technology and other structural relations and errors of estimation. In the Japanese study it was possible to determine increases in final demand and trade directly and hence to attribute the systematic elements of residual variation to changes in technology and organization alone. A comparison of the two sets of residuals suggests that a similar interpretation of the cross-country differences is also plausible.

Figure 4 shows that the share of the residual is highly correlated with the rate of growth of the sector in both Japan and the cross-country analysis.[19/] The five most rapidly growing sectors -- paper, metals and metal products, rubber, chemicals and petroleum and non-metallic minerals -- are the same in both cases. Technological change measured by greater intermediate use throughout the economy has been shown to account (directly and indirectly) for from 23% to 45% of the increase in output of these sectors in Japan.[20/]

There is an unexplained residual of similar proportions in figure 4b between the simulated output and the regression values for these five sectors. Since the output of these industries goes mainly to other sectors, there is a strong case for imputing these residuals primarily to technological differences associated with rising income in the cross-country comparison as well as in Japan.

Reduction in the intermediate use of agricultural and mineral products caused primary output to grow considerably more slowly in Japan than would have been the case with constant input coefficients. The magnitude of this phenomenon is less in the cross-country comparison, in which the actual increase in output is 12% lower than that given by the simulation model over the specified income range.

These comparisons[21/] suggest two conclusions as to the difference between the simulation model and the cross-country regressions in the lower income ranges. First, it seems very likely that the main source of the residual variation is a change in technology and organization that increases the intermediate use of commodities as industry develops. Second, the fact that the residual variation in each sector is roughly proportional to its growth elasticity means that the omission of technological change from the simulation model does not greatly distort the growth patterns that it produces. In the industrial sectors, the simulation model fairly systematically underestimates the increase in the share of each industry by 30 to 40% in the lower income levels.[22/]

At higher income levels, figure 3 and Table 5 show much smaller differences between the model and the regression results. The only comparable historical analysis of technological change in higher income countries is that of Leontief for the United States between 1919 and 1939. In this period there was a substantial decline in intermediate use of primary products, which is consistent with the regression

TABLE 5

Comparison of Growth Elasticities from Model to Regression Results

Growth Elasticity[a]

SECTOR	Model No.	ISIC No.	Lower Income Range (100-400) Regression (1)	Model (2)	(2)/(1) (3)	Higher Income Range (400-1500) Regression (4)	Model (5)	(5)/(6) (6)	(Value at y = $400) Regression Value (7)	Model[d] ÷ Regression (8)
a. Aggregate Sectors[b]										
Primary	1-3	0,1	.56	.74	1.32	.44	.60	1.36	81.06	1.07
Industry	4-18	2-4	1.43	1.20	.84	1.31	1.19	.91	105.25	1.27
Services	19-23	5-9	1.10	1.02	.93	1.08	.99	.92	184.00	.98
									380.31	
b. Industry Sectors[c]										
Paper and Printing	9	27-28	1.94	1.21	.62	1.51	1.36	.90	5.82	1.30
Mfg, n.e.c.	17	39	1.91	1.12	.59	1.52	1.17	.77	2.20	2.30
Rubber Prods.	10	30	1.89	1.23	.65	.99	1.16	1.17	1.67	1.95
Non-Met. Min. Prods.	13	33	1.84	1.17	.64	1.09	1.16	1.06	5.25	1.16
Clothing	5	24	1.82	1.14	.63	1.24	.99	.80	7.35	1.17
Metal Prods.	14-16	34-38	1.82	1.42	.78	1.71	1.43	.84	17.94	1.21
Chem. & Pet.	11-12	31-32	1.75	1.25	.71	1.37	1.20	.88	8.04	1.57
Textiles	6	23	1.45	1.29	.89	.85	.98	1.15	9.37	1.18
Lumber & Wood	8	25,26	1.42	1.42	1.00	1.39	1.52	1.09	5.23	.53
Construction	18	40	1.36	1.11	.82	1.16	1.11	.96	22.98	1.09
Leather Prods.	7	29	1.17	1.16	.99	.98	.98	1.00	.95	.37
Food	4	20-22	.98	1.13	1.15	1.08	1.09	1.01	18.45	1.62
									105.25	

a/ Elasticity of sectoral per capita output with respect to per capita income computed from terminal values over specified income range.

b/ Regression values from Table II. ___, regression B. Model elasticities computed from appendix table .

c/ Regression values computed from Table III. ___. Values at $\bar{y}$ = $400 adjusted by a factor of 1.10 to equal the aggregate value for industry.

d/ Model values from appendix table A-4.

results of Table 6. In other sectors the effects of technological change were relatively small.[23/] In the cross-country analysis the residual variation attributable to technological differences and other factors is also fairly small.

These several comparisons suggest that the simulation model provides a useful basis for studying the effects of demand and trade on the composition of output. So far as can be judged from the limited historical evidence, the proportion of industrial growth to be explained by technological change declines with rising income levels and is of the right order of magnitude in the simulation results. The decline of primary production is significantly understated by the simulation model, but this discrepancy is clearly the result of a reduction in primary input requirements as industrialization proceeds.

The Role of Domestic and International Sectors

Industrialization is the result of a complex interaction between increasing domestic demand and changing comparative advantage and the indirect repercussions of both on other sectors. For analytical purposes, it is useful to think of this process as being composed of two parts: a "demand response" to rising income and a "trade response" that measures the adjustment of the pattern of supply to the pattern of demand. Since modern theories of balanced growth stress the limitations to the trade adjustment, it is important to determine its quantitative significance for particular sectors.

Equation (6) enables us to express the growth of each sector as the sum of three components:

$$X_i = D_i + (E_i - M_i) + W_i = Y_i + W_i \qquad (6a)$$

where $T_i = (E_i - M_i)$ is net trade and $Y_i = D_i + (E_i - M_i)$ is net exogenous demand. Development paths of each sector are shown in figures 5a to 5n by plotting the solutions for these variables for the case of normal industrialization.24/

Inspection of these results shows that there is considerable variation in the relative importance of the three components, D, T, and W. We can distinguish first between domestic sectors, in which the trade component of growth is not important, and international sectors, where it is. A second distinction is that between commodities used primarily for final consumption or investment and those used mainly by other industries. Although these differences are somewhat blurred by the aggregation into a limited number of sectors, they provide a useful basis for growth accounting and the analysis of structural change.25/

Table 6 and figure 5 present a two-way classification of the fourteen sectors designed to bring out differences in both demand effects and supply conditions. The domestic sectors approximate nontraded goods since the trade terms in equation (6b) are small. The pure cases are services and construction, in which $\eta_D = \eta_Y$. In the other domestic sectors, the growth of output parallels the growth of domestic demand because changes in net trade are relatively insignificant.26/

TABLE 6

Sources of Growth in Domestic and International Sectors[a]

Domestic Sectors

SECTOR	Model No.	V_i	Weights[b] $\frac{D}{D+W}$	Growth Elasticities[c] η_D	$\eta_Y - \eta_D$	η_W	η_X	$\eta_{\hat{X}}$
Low Growth								
a. Food	4	29.8	.58	.97	.18	1.08	1.12	1.03
b. Leather	7	0.4	.85	1.04	.04	1.10	1.08	1.07
c. Services	19-23	179.6	.73	.99	0	1.03	1.01	1.09
d. Construction	18	25.0	.82	1.14	0	.94	1.11	1.26
		234.8						
High Growth								
e. Lumber & Wood	8	2.8	.47	1.81	.59	1.16	1.51	1.40
f. Clothing	5	8.6	.68	1.07	.04	.97	1.06	1.53
		11.4						
Total V		246.2						

International Sectors

SECTOR	Model No.	V_i	Weights[b] $\frac{D}{D+W}$	Growth Elasticities[c] η_D	$\eta_Y - \eta_D$	η_W	η_X	$\eta_{\hat{X}}$
Low Growth								
g. Primary	1-3	86.4	.39	.44	-.25	1.09	.66	.5[illegible]
h. Textiles	6	11.0	.55	.88	.27	1.09	1.11	1.1[illegible]
		97.4						
High Growth								
i. Rubber	10	3.3	.42	1.38	.42	.94	1.20	1.44
j. Non-Met. Min. Prods.	13	6.1	.10	.74	2.12	1.13	1.18	1.46
k. Chemicals	11-12	12.6	.25	1.17	2.27	1.10	1.30	1.56
l. Mfg. nec	17	5.1	.30	1.38	.20	.93	1.17	1.71
m. Paper & Printing	9	7.5	.24	1.01	1.27	1.17	1.31	1.72
n. Metal Prod.	14-16	21.7	.50	1.25	.74	1.23	1.44	1.76
		56.3						
Total V		153.7						

a. The sequence of sectors corresponds to figure 5.
b. Weights are taken from the solution for y = $400 in the Appendix.
c. Growth elasticities are measured for the income range $200 to $800. They correspond to the curves in figure 5. The growth elasticity of the regression function ($\eta_{\hat{X}}$) is measured in the same way.

The sectors in which changes in net trade significantly modify the effects of rising domestic demand are classified as international sectors. An approximate measure of the direct effects of trade is the difference between the growth elasticity of domestic final demand (η_D) and the elasticity of total net final demand (η_Y)[27/]. At one extreme, the trade effects of rising income on primary production are strongly negative, reflecting the shift of comparative advantage from agriculture to industry. At the other extreme, chemicals, paper and metal products show strongly positive trade effects that raise their output elasticities well above the growth of direct and intermediate domestic demand.

This four-way classification leads to the following general description of the role of different types of sector in development. These statements are illustrated in figure 5.

(i) The growth of the domestic sectors is primarily determined by income elasticities of final demand. These sectors comprise some sixty per cent of total output and include the principal necessities -- food, clothing, shelter -- as well as services. Since final demand for these products is much more important than intermediate use, they fit the simple concept of balanced growth quite well.

(ii) The growth of the international sectors depends as much on the trade response as on the growth of domestic final demand. The trade response lowers the growth of primary output and raises that of the intermediate industrial sectors.

(iii) Technological change acts to raise the growth of intermediate demand for manufactured goods and lower intermediate use of primary products. These effects are concentrated in the international sectors.[28]

The Causes of Industrialization

The simulation model determines the proximate causes of industrialization by linking changes in sector output to systematic variation in demand and trade. To secure comprehensive measures of these phenomena, we need to trace the increase in intermediate demand to changes in the exogenous variables. Once this has been done for the normal pattern, the same technique can be applied to analyse other patterns of development.

The procedure will follow that of chapter 4 but will use definitions that are better adapted to measuring the trade response. As before, industrialization is defined by the changes in the composition of output that accompany a rise in per capita income. No change in composition implies that each sector expands in proportion to the increase in GNP, which will be designated as:

$$\rho = V^q/V^o.$$ [29]

Several definitions of a constant trade structure are compatible with proportional growth in demand and output. The choice of concepts can therefore be made on grounds of economic rationale as well as mathematical convenience. The alternatives are shown by multiplying the elements in equation (6) by ρ:

$$\rho X_i - \sum_j a_{ij} \rho X_j = \rho (D_i + E_i - M_i) \qquad (12)$$

It is convenient to associate a change in the trade structure with a shift in comparative advantage. If relative costs remain unchanged among types of production that substitute for imports (and if the opportunity cost of earning foreign exchange also remains constant), the share of imports in the supply of each commodity group will tend to be constant. The ratio of imports of a given commodity to GNP may go up or down, however, depending on the growth of demand. I therefore define a constant import structure as a fixed share of imports in total supply of each commodity equal to that in the base Year:

$\mu_i^o = \frac{M_i^o}{Z_i^o}$. The share of domestic prodoction in total supply is $s_i = \frac{X_i}{Z_i}$, where $Z_i = X_i + M_i$ and $s_i = (1 - \mu_i)$.

Since changes in the composition of domestic demand are determined by the Engel curves, it is convenient to define a constant demand structure by unit income elasticity for each commodity. A consistent treatment of foreign demand then requires that structural change also be measured by departures from porportional growth of exports.[30/]

From these definitions of a constant structure, we can express the proximate cause of a change in the composition of output as a function of changes in the structure of demand and supply. As in chapter 4, the "deviation" in each element is defined as the difference between its actual value at income level q and proportional expansion from the base value.

Thus, $\delta X_i^q = X_i^q - \rho X_i^o$, $\delta D_i^q = D_i^q - \rho D_i^o$, etc. Based on the definition of a constant import structure, the deviation in output is expressed as the sum of a demand effect with no change in supply proportions plus the direct effect of import substitution in that sector:

$$\delta X_i = s_i^o \, \delta Z_i + (s_i^q - s_i^o) \, Z_i^q \qquad (13)$$

where s_i^o is the share of domestic supply in the base period. The second term corresponds to the usual definition of import substitution in a given sector as the replacement of imports by domestic production.

The deviation in total supply (δZ_i) is determined as in chapter 4 from a solution to the input-output system. From equation (IV.4) we have:

$$\delta X_i = \sum_j r_{ij} \delta D_j + \sum_j r_{ij} \delta E_j - \sum_j r_{ij} \delta M_j$$

This expression can be simplified by defining the total of the direct and indirect effects of the deviations in all elements of domestic demand as: $\delta X_{D_i} = \sum_j r_{ij} \delta D_j$. Similarly, $\delta X_{E_i} = \Sigma r_{ij} \delta E_j$ and $\delta X_{M_i} - \Sigma r_{ij} \delta M_j$. The deviation in total supply is then the sum of the direct and indirect effects of the deviations in the three exogenous variables:

$$\delta Z_i = \delta X_i + \delta M_i = \delta X_{D_i} + \delta X_{E_i} + \delta M_i - \delta X_{M_i} \qquad (14)$$

Equation (14) enables us to express the deviation in sector output as a function of structural changes in imports, exports and domestic demand. Substituting (14) into (13) gives:

$$\delta X_i = \overset{(a)}{s_i^o \delta X_{D_i}} + \overset{(b)}{s_i^o \delta X_{E_i}} + s_i^o(\delta M_i - \delta X_{M_i}) \overset{(c)}{+} (s_i^q - s_i^o)\, z_i^q \qquad (15)$$

The deviation from proportional growth in output in sector i is thus the sum of three sets of structural changes:[31/]

(a) effects of deviation in domestic demand in all sectors with a constant import structure;

(b) effects of deviations in exports in all sectors with a constant import structure;

(c) direct and indirect effects of changes in the import structure.

Equation (15) measures the causes of deviation from proportional growth for any segment of the growth paths shown in figure 5. Since the relative importance of the components varies with the level of per capita GNP, this calculation must be made for successive increments in income. The total income range from \$100 to \$1500 is therefore divided into four intervals by setting ρ equal to 2.0. Equation (15) is applied first to measure the causes of the deviations from proportional growth of each sector in the normal solution as GNP rises from \$100 to \$200 per capita. The calculation is repeated for the intervals \$200 to \$400, \$400 to \$800, and \$800 to \$1500. Summary measures of the causes of industrialization are obtained by aggregating the causal elements for the primary sectors (1-3) and the industrial sectors (4-18) of the model. These results are shown graphically in figure 6. (Since the total share of the service sectors remains almost constant, they will be omitted from further analysis.)

These charts show that the relative importance of the three causes varies considerably as income rises. At low income levels demand and trade responses are equally important in explaining the rise of industry; while demand effects (and technological change) are the dominant causes of the decline of primary production.[32] In the later stages of growth, however, trade effects predominate in causing both the continued rise of industry and the steady decline of primary output.[33]

The relative importance of the two components of the trade response also changes considerably as income rises. While export effects are insignificant at very low income levels, they outweigh import substitution as a cause of industrialization above a level of $400. Similarly, the continued decline of the primary sectors is largely due to the low growth of primary exports.

C. VARIATION IN THE TRADE RESPONSE

Many issues of development policy center on the nature of the trade response in an optimal development sequence. Theoretical discussion has tended to focus on two extreme cases: (i) balanced growth, in which import substitution predominates; and (ii) specialization, in which export growth is the principal element of the trade response. The present analysis suggests that the normal development pattern is roughly midway between these cases.

I now wish to study the effects of representative trade patterns that approach more closely the extremes of specialization and balanced growth. The statistical results of chapter 2 suggest the types of country which approximate these assumptions. Balanced growth is characteristic of large countries, where the small ratio of trade to GNP limits the possibility of differences between supply patterns and demand patterns. Specialization is most pronounced in small countries with rich natural resources, which have the greatest opportunity to exploit their comparative advantage in primary exports and to supply their industrial demands from imports. A country receiving a large inflow of capital has a similar opportunity to specialize, although the overall effects on its economic structure are somewhat different.

The previous description of these country groups provides a basis for a series of experiments designed to determine the quantitative significance of typical differences in trade patterns. In order to isolate the effects of the trade response, the demand vectors and other elements in the model will be held constant except for minor adjustments necessary to secure consistent sets of exogenous variables. The results of the simulation experiments will be compared to the estimates of sector output already made for two of these country groups in order to judge how much of their systematic differences from the normal development pattern are accounted for by variations in the trade response.

Representative Trade Responses[34]

The trade response reflects both the choice between satisfying increasing demand through trade or through domestic production and the country's comparative advantage as between primary production and manufacturing. The three cases are designed to bring out the effects of representative differences in these features: they omit the additional variation in the composition of imports and exports that would doubtless be revealed by more detailed study.

The three responses are illustrated in figure 7, which compares these export patterns to the normal (Case A). In Cases B and C, the most important differences from the normal trade response are in the volume and composition of exports. Case D, a country receiving a substantial inflow of external capital, retains the normal export pattern of Case A and increases the level of imports.

Case B: The Large Country Trade Response. The effect of country size on the volume of imports and exports is included in the basic specification of the simulation model. To facilitate subsequent comparison to the earlier statistical analysis of large country growth patterns, I define a large country as one having 40 million people, about the median of the L sample in chapter 2. The trade effects of changing the population size from 10 to 40 million are shown in figure 7 and Table 7.[35]

Primary exports per capita by the large country are much less than those of the normal country at all income

TABLE 7

Effects of Alternative Trade Responses on Output[a]

(y = $400)

		Case A Normal Growth		Case B Large Country		Case C Small Primary Exporter		Case D Aid Recipient	
A. Trade Response		Value	Index	Value	Index	Value	Index	Value	Index
Primary Exports (E_p)		42.1		20.1		57.9		45.8	
Manufactured Exports (E_m)		21.8		26.0		7.9		23.7	
Total Exports (E)		77.9		56.2		80.2		84.8	
Total Imports (M)		81.3		54.2		90.5		124.0	
Trade Balance (F)		-3.4		2.0		-10.3		-39.2	
B. Simulated Value Added by Sector	Sector No.								
International Sectors									
1. Agriculture	(1)	76.2		61.8	.81	85.8	1.13	75.2	.99
2. Mining	(2-3)	10.2		11.8	1.16	9.6	.94	8.5	.83
3. International Industry		67.4		78.7	1.17	59.3	.88	59.0	.88
a. Textiles	(6)	11.0		13.4	1.22	9.9	.90	10.3	.94
b. Paper & Printing	(9)	7.5		8.2	1.09	6.4	.85	7.1	.95
c. Rubber	(10)	3.3		3.5	1.07	3.1	.96	3.0	.91
d. Chemicals & Petroleum	(11-12)	12.6		13.7	1.08	9.8	.78	10.9	.87
e. Non-Met. Minerals	(13)	6.1		6.5	1.06	5.6	.92	6.1	1.00
f. Metals	(14)	9.5		11.7	1.24	8.7	.92	7.5	.79
g. Metal Products	(15-16)	12.3		16.6	1.35	11.0	.89	9.3	.76
h. Manufacturing n.e.c.	(17)	5.1		5.2	1.02	4.8	.95	4.8	.94
Total International		153.8		152.3	.990	154.7	1.005	142.7	.928
Domestic Sectors									
4. Domestic Industry	(4,5,7, 8,18)	66.6		67.8	1.02	64.6	.97	69.7	1.05
5. Services	(19-23)	179.6		179.8	1.00	180.7	1.01	187.7	1.05
Total Domestic		246.2		247.6	1.006	245.3	.996	257.4	1.045

a. Source: Solutions for experiments B, C, D, Chenery and Ginsberg (1969).

levels. The large country initially exports more manufactured goods, but above $600 this component also falls below the normal pattern.

<u>Case C: The Primary Export Response</u>. A similar procedure was followed to determine a typical trade response for a small country specializing in primary exports. For Case C the separate regressions for primary and manufactured exports were taken as a point of departure, based on the sample of small primary-oriented countries in chapter 2. Figure 7 shows that primary exports continue to rise with income (unlike the normal pattern) while manufactured exports lag far behind the normal.[36/] The sectoral disaggregation of these two totals was based on the regression equations in the model, as in the case of large countries.[37/]

<u>Case D: Trade Response to Capital Inflow</u>. A country receiving a net inflow of capital has to adjust its economic structure so that total demand exceeds total domestic supply by this amount. To simulate the trade response of a recipient of foreign aid, I have varied the excess of imports over exports without altering the commodity breakdown of trade determined by the model. Thus the export pattern shown for the normal case in figure 7 applies with small changes to Case D as well.

The country receiving aid is assumed to increase its domestic demand by the amount permitted by the additional imports.[38/] The capital inflow illustrated in Case D is equal to 10% of GNP or 32% of imports, which is representative of the upper quartile of aid recipients discussed in chapter 7. (The dynamics of this process, in which a higher level of investment leads to more rapid growth, are discussed in chapter 7.)

Effects on Industrial Growth Patterns

The results of these three simulation experiments are summarized in Table 7, where they are compared to the normal output pattern at an income level of $400. Discussion is facilitated by dividing the sectors into the international and domestic categories and concentrating attention on the former.

Case B shows that the trade response typical of the large country only affects production in the international sectors. Mining and international industry increase and there is a corresponding reduction in agriculture. This reduction is caused by a fall in agricultural exports from 35% of total production in the normal case to 20% for the large country. This drop in export earnings is offset by greater import substitution in manufacturing and a rise in domestic production in all the international industries, particularly metals, metal products and textiles.

The adjustment in production to the primary export trade response is the opposite of the large country response in magnitude and composition. The trade response of Case C consists of greater than normal primary exports offset by lower manufactured exports within a fairly constant total. The impact on all the international sectors is in the opposite direction from Case B.

In both examples the large change in trade pattern has a minimal impact on the domestic sectors, which comprise 60% of the total output of the economy. This result strengthens the value of this conceptual framework for analysing development patterns.

Case D illustrates quite a different type of adjustment in the pattern of development resulting from a substantial inflow of capital at a constant level of GNP. In this situation higher total demand acts to raise output while greater imports reduce it in some sectors. The net result of a 9% increase in total resources over Case A is a 5% rise in production in the domestic sectors, a constant level for agriculture and a reduction of more than 10% in international industry and mining. While the sectoral distribution of this contraction of the international sectors is partly the result of the assumption of a proportional rise in each import, the general pattern of the aid response is a necessary consequence of the need to transfer resources in the form of tradeable goods. Aid therefore produces an increase in the allocation of local resources to the domestic sectors and reduces the need for growth of international industries.[39/]

A comparison of these results to the independent regression estimates for the L and SP countries shows that the trade differences only account for less than half of the observed deviations from the normal pattern.[40/] The residual variation associated with size and resources is somewhat similar to the residual associated with increasing income. All three factors have a substantially greater effect on the composition of output as measured by the regression analysis than that which is captured in the model, although the overall patterns are similar. Even though the representative trade patterns have been crudely estimated, it is unlikely that trade differences alone can account for a much higher proportion of the observed differences from the normal patter of output.

Figure 8 analyses the causes of the deviations from proportional growth of industry in the large country simulation in the same way as was done for the normal country in figure 6. Since the large country industrializes earlier, it has larger deviations from proportional growth up to an income level of about $300 but smaller ones thereafter. Import substitution is initially more important in the large country, but its effects are quickly exhausted at higher incomes. Exports also play less of a role in large countries. The pattern of output therefore follows more closely the pattern of domestic demand. Even so, trade effects outweigh demand effects over most of the income range, demonstrating that a closed economy is not a good approximation to reality for even a large country.

This set of experiments extends the more intuitive explanations of the causes of differences in development patterns that were derived from multiple regression analysis in chapter 3. The direct effects of differences in import and export patterns appear to be only part of the explanation of the observed variation in production patterns. There is a substantially greater production of internationally traded industrial goods in large countries than would be predicted by trade differences alone. This suggests an increase in the use of intermediate manufactures per unit of output as total industrial production increases, similar to the phenomenon observed with rising income. As a first approximation, the large country can be thought of as having an industrial sector typical of that of a country of average size and a higher income level. Similarly, the industrial sector of the primary exporter resembles that of a normal country of lower income. In both cases, the residual variation attributable to technological differences is as large as the direct effects of trade differences.

D. CONCLUSIONS

The cross-section model provides a useful link between the descriptive analyses of industrial structure in Part I and the planning models to be developed in Part II. Its main function has been to explain the interrelations among various types of structural change as income rises. These results provide a basis for designing planning modelsthat can determine the desirability of alternative future development patterns.

As a methodological experiment, the estimation of elements of a cross-section model from various sources has provided a usable basis for explaining the main features of the process of industrialization. The main weakness of the current estimates is the lack of an explicit specification of the effects of technological variation, which can therefore only be inferred by studying the residual variation in output.

Although a model based on cross-section estimates appears to require rather strong assumptions as to the uniformity of tastes and technology, the results of the present experiments suggest that they are no stronger than those implied by time series estimates over thirty or forty years. In fact, there seems to have been more technological change in Japan over a forty year period than is implied by a corresponding growth of industry in the cross-section model. Instead of being used only because they are the only source of information on the effects of large differences in income, cross-section estimates may prove to be more stable than the comparable time series equations.41/

The explanation of the causes of industrialization that can be derived from the cross-country simulations goes considerably beyond the results inferrable from statistical analysis alone. The intermediate industrial sectors which develop most rapidly can only be analysed in relation to the increase in industries that use their products. The model brings out the complex interaction between changes in demand, trade and production in a general equilibrium framework. Although the present formulation ignores price effects, this simplification permits changes in output to be decomposed into three separate factors: demand, trade and technological change. The more complete analysis of trade shows it to be even more important than was suggested by earlier studies.[42/] While technological change is important, its effects are concentrated in the industries that emerge at the later stages and they are generally additive to the effects of demand and trade.

Although the simulation model was developed to make use of cross-section estimates of structural relations, the same methodology can be applied to explore the implications of alternative development policies in a single country. This would formalize and extend the more intuitive projections that are usually made in formulating development programs. The relation between such a simulation approach to planning and formal optimizing procedures is taken up in subsequent chapters.

FOOTNOTES

1/ An earlier version of this chapter was prepared in collaboration with Tsunehiko Watanabe and presented to the Rome Congress of the Econometric Society (Chenery and Watanabe, 1965). Moises Syrquin, William Ginsberg and Allan Samansky carried out the revision and extension of the basic model. Econometric aspects of the analysis are described more fully in Chenery and Ginsberg (1969).

2/ Perhaps the best example is Edward Denison's comparative study of postwar growth in nine advanced countries (1967), in which comparable models are applied to each.

3/ This decomposition of sector growth into component parts is somewhat analogous to the aggregate "sources of growth" analysis of Denison (1967) and others in that it determines to what extent existing theory can account for the observed increases in output.

4/ A comparison of the three types of model is given by Christ (1966, pp. 102-109).

5/ Although the basic U.N. data used in this analysis usually refer to GDP, the term "GNP per capita" is used in the text as an indicator of income level because of its greater familiarity.

6/ The equation has the form of regression B in chapter 2 with the growth rate added.

7/ Since the equations were estimated separately for each component, their total does not automatically equal 100%. The discrepancy turned out to be less than 2.5% over the range of per capita income considered ($100-1500). C, I, G, and (E-M) are adjusted proportionately to equal Y in all applications.

8/ Since the trade data on which these regressions are based do not include all elements of the balance of payments, the intercept in the pooled export regression was adjusted to make exports equal imports at an income level of $800 in the normal case. This adjustment was not carried out for the separate regressions for large and small countries.

9/ See Chenery and Watanabe (1958) and Watanabe (1961).

10/ The present estimates are based on a detailed study of capital and labor use in the United States and Japan by Bickel (1966), which also give an estimate of relative efficiency in each sector. Parameter values are given in chapter 6.

11/ It should be feasible to extend the cross-section approach to determine typical structural relations for these elements as well. Whether they will prove to be as uniform as the technologically based relations describing production and trade is a matter for empirical exploration.

12/ The simulation program currently used is described in Chenery and Ginsberg (1969). The program also determines the separate effects of changes in demand and trade and other partial relationships. A simulation involving 20 solutions takes less than a minute of computer time.

13/ Regression values are taken from regression B in chapter 2. Since they fall short of total GNP by some 5% on the average, the discrepancy is distributed proportionately.

14/ The principal sources of discrepancies in the levels of value added are the constant terms in the functions for consumer demand and the constant ratios used in converting from total output the value added. There is also a discrepancy of about 10% between the sector total and the aggregate regression for all industry.

15/ The total of the aggregate regressions is 5% less than the total value added at this level of income. The discrepancy between the model and the regressions for industry as a whole is about the same magnitude. Since the performance tests apply only to changes from this level, the regression results have not been adjusted to add up to total income. Adjustments required in the constant term are shown in column 8 of Table 5.

16/ Sectors 5, 6 and 7 of the simulation model are consolidated to fit the Japanese sectoral classifications. The sequence of sectors in both charts follows the growth indices of the cross-country regressions.

17/ Per capita GNP in Japan rose 70% over the period. As discussed in chapter 4, the greater rise in industry is largely attributable to the change in trade patterns. Demand effects were also greater in paper, textiles and clothing, and construction than in the cross-country pattern.

18/ In both charts, the distribution of industrial value added in the base year is given by the width of the bars, while the ratio of terminal to initial values is given by the height. Food processing has a greater weight and construction a lesser weight in Japan in the base year because of the lower income level.

19/ In figure 4 the residual is shaded and shown as a percentage of the increase in the sector from the base year.

20/ The chart is based on table IV.6. Technological change includes both direct and indirect effects of changes in input-output coefficients over the period 1914-1954. The miscellanous category (ISIC 39) is shown for completeness but omitted from discussion.

21/ In the remaining sectors of moderate growth, the residual variation is significantly positive for textiles, clothing and construction in both studies and negligible for food and services. These differences are also roughly proportional to the rates of growth.

22/ The difference is exaggerated by the fact that the data available for estimating demand functions for the model was not sufficient to attempt a non-linear formulation. Use of a non-linear regression equation for output tends to exaggerate the differences between the simulated and observed growth elasticities at high and low income levels in sectors such as rubber products, non-metallic minerals, and textiles.

23/ Leontief (1953, Table) calculates that intermediate demand for agricultural products in 1939 would be overstated by 20% if 1919 input coefficients were used. In no other sector was the difference as much as 10%.

24/ The left hand side of each chart, which compares the model results to the regression analysis, was discussed in the preceding section. The 23 sectors are aggregated to 14 for this purpose. The calibration of the model to equal the regression value at an income of $400 per capita is shown by the curve M'.

25/ Equation (6) can also be expressed in terms of growth elasticities:

$$\eta_X = \overset{(a)}{\frac{D}{X}\eta_D} + \overset{(b)}{\left[\frac{E}{X}\eta_E - \frac{M}{X}\eta_M\right]} + \overset{(c)}{\frac{W}{X}\eta_W} = \frac{Y}{X}\eta_Y + \frac{W}{X}\eta_W \qquad (6b)$$

At any given income level the growth elasticity of output is equal to the sum of (a) the contributions of domestic demand, (b) the contributions of changes in trade and (c) the contributions ofintermediate demand.

26/ A sector such as leather goods, in which the proportion of net imports to output does not change much, behaves like a domestic sector even though the share of imports is significant.

27/ The trade term (b) in equation (6b) can be expressed as:

$\frac{Y}{X}\eta_Y - \frac{D}{X}\eta_D$, which in most sectors is approximately equal

to $\frac{D}{X}[\eta_Y - \eta_D]$ since T is relatively small.

28/ Some part of the residual variation between the model and the regression estimates is undoubtedly due to inaccurate estimates of demand elasticities, as in the case of clothing. Correcting this error would have no effect on the central distinction between demand effects and trade effects.

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29/ When the import surplus either is zero or expands in proportion to GNP, ρ is equal to the increase in final demand (λ) used in chapter 4.

30/ Equation (12) shows that proportional growth of output with constant import ratios requires proportional growth of total demand ($D_i + E_i$).

31/ The main change from the accounting conventions used in chapter 4 is to define factors (a) and (b) with a constant import share in supply and to treat the remaining changes as import effects. The relative importance of (a) and (b) is thus reduced by the factor

$$s_i^o = (1 - \mu_i^o).$$

32/ It should be recalled that technological change contributes an additional 30-40% to the growth of industry in the lower levels above that shown by the model and an even larger amount to the decline of primary output.

33/ This result confirms my earlier conclusion (Chenery, 1960) that trade effects outweigh demand effects as a cause of rising industry.

34/ Only the general assumptions underlying these examples are discussed here. Details of the estimation procedure are given in Chenery and Ginsberg (1969).

35/ Since a large change in an independent variable in the regression equations may produce erratic results, these results were controlled by estimating separate equations for primary and manufactured exports for the large country group. The primary export results agree closely with the results in the model up to a level of $1000 and exceed them increasingly thereafter. The manufactured exports for the L group as a whole were consistently about 75% of the total of the individual elements shown in figure 7, suggesting that the population effect is understated in the linear multiple regression equations. The example may be more representative of a somewhat smaller country.

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TABLE A-1

Parameters for Stage I Equations[a]

Components		a_0	a_1 (lny)	a_2 $(\text{lny})^2$	a_3 (ln N)	a_4 $(\frac{\Delta Y}{Y})$
Consumption	(C/Y)	-.63 (.13)	.1757 (.04)	-.0206 (.00)		-.3326 (0.8)
Government Expenditure	(G/Y)	-1.97 (.41)	.1894 (.14)	.0262 (.01)	.6368 (.27)	
Investment	(I/Y)	-3.00 (.38)	.2668 (.13)	.0097 (.01)	1.67 (.24)	
Exports: Pooled Sample[b]	(E/Y)	-1.509	1.068 (.02)		-.226 (.02)	
Imports: Pooled Sample[b]	M/Y	-.96	1.006 (.02)		-.284 (.02)	
Exports: Large Countries[c]	(E/Y)	-1.38 (.23)	1.064 (.03)		-.312 (.04)	
Imports: Large Countries[c]	(M/Y)	-.44 (.16)	.968 (.02)		-.380 (.03)	
Exports: Small Countries[c]	(E/Y)	-2.14	1.097 (.02)		.032 (.03)	
Imports: Small Countries[c]	(M/Y)	-1.48	1.051 (.02)		.1123 (.02)	

Exogenous Variables: (lny), $(\text{lny})^2$, (ln N), $(\frac{\Delta Y}{Y})$

a) Based on a sample of 61 countries for the period 1951-1964 (719 observations). Standard errors are given in parentheses. Data and procedures are given in Chenery and Ginsberg (1969).

b) The intercept is adjusted to make E = M at an income level of $800.

c) Parameters for large and small countries are used in the simulation experiments in part C.

TABLE A-2

Parameters for Stage II Equations[a]

Sector		Consumption α_o	Consumption α_1	Investment α	Government α	Exports[b] β_o	Exports[b] β_1	Exports[b] β_2	Imports[b] β_o	Imports[b] β_1	Imports[b] β_2
1		.452	.473	0	.0104	.948	.628	-.560	-2.138	1.396	-.239
2		0	0	0	.0104	-4.906	1.406	.394	-5.876	2.363	0
3		-5.747	2.374	0	0	-2.757	1.153	0	-4.048	1.563	0
4		- .980	1.126	0	.0500	-5.225	2.305	0	-1.125	1.003	-.374
5		-1.97	1.23	0	.0151	-4.939	1.425	.397	- .967	.866	-.757
6	(c)	(-1.250)	(1.106)	0	0	-5.316	1.540	.628	.274	.555	-.536
7		-2.66	1.20	0	.0009	-4.817	1.322	.266	-2.171	1.143	-.470
8		-4.60	2.10	0	.0047	-5.231	1.910	0	-2.439	1.320	-.406
9		-2.170	1.150	0	.0142	-6.434	2.531	0	-1.842	1.118	-.249
10		-3.59	1.60	0	.0047	-5.887	1.743	.348	- .699	.578	-.540
11		-2.057	1.120	0	.0019	-4.384	1.904	0	-1.026	.956	-.507
12		-4.466	1.937	0	.0047	-6.316	1.645	.726	-1.195	1.007	-.438
13		-2.167	.876	0	0	-5.178	1.874	0	-1.298	.853	-.478
14	(d)	(-3.640)	(1.855)	0	.0047	-8.821	2.786	.628	-1.946	1.209	-.222
15		-3.82	1.60	.2039	.0104	-8.982	2.861	.550	-1.037	1.015	-.343
16		-5.66	2.20	.1546	0	-7.826	2.562	.348	- .397	.790	-.507
17		-3.43	1.60	0	.0047	-6.752	2.229	.449	0	0	0
18		0	0	.5842	.0198	0	0	0	0	0	0
19		-1.95	1.17	0	.0104	0	0	0	0	0	0
20	(e)	(.20)		.0526	.0104	(.1298)			(.1217)		
21		-1.31	1.04	0	.0104	0	0	0	0	0	0
22	(f)	(-.846)	(1.125)	.0047	.0397	(.0503)			(.0474)	0	0
23		-1.114	1.180	0	.7743	0	0	0	0	0	0

(a) Source: Chenery and Watanabe (1965) and Chenery and Ginsberg (1969).

(b) For sectors 20 and 22, fixed sharesof total exports and total imports are assumed to allow for trade margins.

(c) Consumption parameters shown are for sectors (5+6). Consumption in sector 6 is derived by difference.

(d) Consumption parameters shown are for (14+15+16). Consumption in sector 14 is derived by difference.

(e) Consumption in sector 20 is $.20C^*$.

(f) Consumption parameters shown are for (21+22+23). Consumption in sector 22 is derived by difference.

25.

TABLE A-3: Parameters for Stage III Equations[a]

Elements of Inverse Matrix (r_{ij}) and Value Added Vector (v_i)

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.1226	0.0345	0.0362	0.3204	0.1297	0.3366	0.5192	0.5355	[illegible]	0.3051	0.0945	0.0426
2	0.0112	1.0365	0.0296	0.0279	0.0068	0.0163	0.0215	0.0133	0.0199	0.0064	0.0446	0.5565
3	0.0056	0.0145	1.0215	0.0157	0.0029	0.0054	0.0072	0.0055	0.0082	0.0031	0.0299	0.0152
4	0.0304	0.0035	0.0149	1.3928	0.0084	0.0122	0.0168	0.0160	0.0139	0.0092	0.0190	0.0156
5	0.0177	0.0033	0.0039	0.0203	1.0833	0.0181	0.0423	0.0121	0.0144	0.0064	0.0073	0.0043
6	0.0172	0.0040	0.0040	0.0142	0.4883	1.2947	0.0608	0.0103	0.0165	0.1443	0.0081	0.0045
7	0.0004	0.0001	0.0000	0.0007	0.0021	0.0043	1.0420	0.0002	0.0001	0.0006	0.0001	0.0001
8	0.0065	0.0147	0.0095	0.0182	0.0027	0.0056	0.0083	1.1219	0.0080	0.0024	0.0065	0.0105
9	0.0154	0.0048	0.0064	0.0616	0.0086	0.0159	0.0175	0.0116	1.4802	0.0067	0.0313	0.0124
10	0.0151	0.0084	0.0018	0.0083	0.0042	0.0085	0.0514	0.0031	0.0075	1.0054	0.0071	0.0074
11	0.0436	0.0295	0.0383	0.0824	0.0158	0.0316	0.1559	0.0355	0.0373	0.0626	1.3199	0.0445
12	0.0136	0.0129	0.0243	0.0125	0.0030	0.0069	0.0129	0.0097	0.0089	0.0053	0.0306	1.0668
13	0.0069	0.0074	0.0068	0.0261	0.0022	0.0046	0.0083	0.0074	0.0045	0.0027	0.0145	0.0079
14	0.0232	0.0398	0.1376	0.0641	0.0111	0.0238	0.0231	0.0243	0.0325	0.0105	0.0641	0.0892
15	0.0082	0.0206	0.0047	0.0058	0.0072	0.0161	0.0066	0.0056	0.0071	0.0039	0.0050	0.0146
16	0.0035	0.0008	0.0008	0.0025	0.0008	0.0016	0.0025	0.0026	0.0024	0.0011	0.0014	0.0024
17	0.0250	0.0054	0.0090	0.0142	0.0070	0.0117	0.0329	0.0136	0.0066	0.0075	0.0082	0.0064
18	0.0266	0.0275	0.0130	0.0201	0.0087	0.0165	0.0166	0.0157	0.0214	0.0088	0.0181	0.0220
19	0.0070	0.0428	0.0244	0.0263	0.0076	0.0143	0.0144	0.0164	0.0195	0.0045	0.0309	0.0291
20	0.0504	0.0197	0.0270	0.0625	0.0250	0.0505	0.0737	0.0374	0.0680	0.0203	0.0468	0.0342
21	0.0063	0.0019	0.0053	0.0047	0.0013	0.0027	0.0040	0.0034	0.0026	0.0019	0.0036	0.0031
22	0.0218	0.0259	0.0250	0.0565	0.0129	0.0234	0.0461	0.0529	0.0755	0.0098	0.0379	0.0634
23	0.0624	0.0141	0.0275	0.0669	0.0228	0.0396	0.0405	0.0394	0.0867	0.0212	0.0514	0.1125
v_j	.6820	.7451	.7461	.3058	.5500	.4440	.2590	.3870	.4590	.6160	.5040	.2520

TABLE A-3 (cont.)

	13	14	15	16	17	18	19	20	21	22	23
1	0.0184	0.0295	0.0152	0.0444	0.1127	0.0170	0.0254	0.0178	0.0084	0.0258	0.0922
2	0.0320	0.0724	0.0211	0.0526	0.0177	0.0197	0.2074	0.0052	0.0024	0.0138	0.0106
3	0.1804	0.1955	0.0438	0.0666	0.0111	0.0013	0.0125	0.0038	0.0068	0.0136	0.0075
4	0.0039	0.0080	0.0033	0.0058	0.0097	0.0178	0.0030	0.0080	0.0055	0.0057	0.1469
5	0.0042	0.0058	0.0060	0.0115	0.0334	0.0064	0.0032	0.0023	0.0010	0.0162	0.0099
6	0.0051	0.0137	0.0064	0.0155	0.1129	0.0085	0.0032	0.0050	0.0012	0.0124	0.0074
7	0.0000	0.0001	0.0012	0.0053	0.0007	0.0001	0.0000	0.0001	0.0000	0.0004	0.0004
8	0.0104	0.0122	0.0154	0.0360	0.0204	0.0293	0.0186	0.0069	0.0033	0.0144	0.0062
9	0.0254	0.0112	0.0157	0.0131	0.2742	0.0239	0.0055	0.0305	0.0039	0.0177	0.0421
10	0.0029	0.0054	0.0044	0.0423	0.0044	0.0079	0.0047	0.0075	0.0011	0.0158	0.0053
11	0.0348	0.0237	0.0323	0.0323	0.1140	0.0370	0.0121	0.0072	0.0051	0.0138	0.0444
12	0.0037	0.0848	0.0204	0.0331	0.0106	0.0190	0.0199	0.0039	0.0024	0.0436	0.0060
13	1.0290	0.0290	0.0151	0.0229	0.0064	0.1027	0.0082	0.0023	0.0112	0.0073	0.0099
14	0.0418	1.4224	0.2912	0.4542	0.0484	0.1787	0.0729	0.0215	0.0201	0.0780	0.0310
15	0.0021	0.0171	1.1091	0.1453	0.0071	0.0265	0.0120	0.0052	0.0035	0.0200	0.0224
16	0.0006	0.0014	0.0007	1.0735	0.0014	0.0025	0.0010	0.0014	0.0006	0.0211	0.0106
17	0.0031	0.0090	0.0080	0.0105	1.0698	0.0208	0.0051	0.0273	0.0026	0.0137	0.0143
18	0.0052	0.0186	0.0090	0.0137	0.0108	1.0127	0.0277	0.0129	0.1083	0.0274	0.0322
19	0.0144	0.0411	0.0155	0.0232	0.0129	0.0104	1.0179	0.0035	0.0019	0.0160	0.0121
20	0.0168	0.0474	0.0365	0.0666	0.0751	0.0858	0.0229	1.0141	0.0106	0.0257	0.0478
21	0.0013	0.0029	0.0014	0.0024	0.0026	0.0042	0.0019	0.0142	1.0009	0.0033	0.0169
22	0.0215	0.0471	0.0226	0.0359	0.0403	0.0675	0.0393	0.0422	0.0133	1.0383	0.0331
23	[illegible]	0.0386	0.0195	0.0293	0.0388	0.1156	0.0170	0.0554	0.0381	0.0416	[illegible]
24	.6972	.3850	[illegible]	.2729	.4426	.4612	.6630	.8272	.8638	.7115	.6373

Source: [illegible] (19[illegible]5).

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TABLE A-4a

Basic Solutions for Income Level 100
(N=10 million, $\frac{\nabla y}{y}$ = 5%)

	C	G	I	D	E	M	T	T+D	W	X	V
TOTAL	76.73	10.59	15.20	102.51	18.16	20.67	-2.51				
1	19.90	0.11	0.00	20.01	13.43	1.96	11.47	31.48	11.28	42.76	29.17
2	0.00	0.11	0.00	0.11	0.05	0.09	-0.04	0.07	1.15	1.22	0.91
3	0.05	0.00	0.00	0.05	0.39	0.16	0.24	0.28	1.11	1.39	1.04
4	12.52	0.53	0.00	13.05	0.27	1.77	-1.50	11.55	8.77	20.32	6.22
5	2.01	0.16	0.00	2.17	0.06	0.23	-0.18	2.00	1.34	3.34	1.84
6	4.15	0.00	0.00	4.15	0.12	2.67	-2.56	1.60	2.55	4.15	1.84
7	0.36	0.01	0.00	0.37	0.03	0.20	-0.17	0.20	0.05	0.26	0.07
8	0.21	0.05	0.00	0.26	0.04	0.32	-0.28	-0.02	1.02	1.00	0.39
9	0.90	0.15	0.00	1.05	0.05	1.03	-0.98	0.07	3.00	3.07	1.41
10	0.24	0.05	0.00	0.29	0.02	0.31	-0.29	0.00	0.96	0.96	0.59
11	1.02	0.02	0.00	1.04	0.29	0.97	-0.68	0.36	3.99	4.36	2.20
12	0.14	0.05	0.00	0.19	0.03	1.14	-1.11	-0.93	0.99	0.06	0.02
13	0.26	0.00	0.00	0.26	0.04	0.37	-0.33	-0.05	1.77	1.72	1.20
14	0.46	0.05	0.00	0.53	0.01	1.39	-1.38	-0.85	4.53	3.69	1.42
15	0.14	0.11	3.10	3.35	0.01	2.64	-2.64	0.71	1.33	2.04	1.28
16	0.03	0.00	2.35	2.38	0.01	1.92	-1.91	0.46	0.47	0.94	0.35
17	0.35	0.05	0.00	0.40	0.04	0.00	0.04	0.44	1.98	2.42	1.07
18	0.00	0.21	8.68	9.09	0.00	0.00	0.00	9.09	2.62	11.71	5.40
19	1.02	0.11	0.00	1.73	0.00	0.00	0.00	1.73	1.01	2.74	1.32
20	15.35	0.11	0.80	16.25	2.36	2.52	-0.16	16.10	4.59	20.69	17.11
21	4.03	0.11	0.00	4.14	0.00	0.00	0.00	4.14	0.85	4.99	4.31
22	1.32	0.42	0.07	1.81	0.91	0.98	-0.07	1.74	3.53	5.27	3.75
23	11.63	3.13	0.00	19.61	0.00	0.00	0.00	19.81	6.27	26.08	16.62
ADJUSTMENT	0.9022	0.9982	1.0000		1.1065	1.3039					

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TABLE A-4b

Basic Solutions for Income Level 200

(N=10 million, $\frac{\nabla y}{y}$ = 5%)

	C	G	I	D	E	M	T	T+D	W	X	V
TOTAL	147.90	21.85	33.63	203.38	37.43	40.81	-3.38				
1	27.72	0.23	0.00	27.95	24.59	5.04	19.55	47.50	23.29	70.78	48.27
2	0.00	0.23	0.00	0.23	0.17	0.46	-0.29	-0.07	2.70	2.54	1.96
3	0.23	0.00	0.00	0.23	1.03	0.45	0.58	0.81	2.61	3.42	2.55
4	26.76	1.09	0.00	27.87	1.57	3.47	-1.90	25.97	18.76	44.73	13.68
5	4.61	0.33	0.00	4.94	0.18	0.41	-0.24	4.70	2.67	7.37	4.05
6	6.41	0.00	0.00	6.41	0.40	3.85	-3.45	4.96	5.95	10.91	4.84
7	0.81	0.02	0.00	0.83	0.07	0.42	-0.35	0.48	0.13	0.61	0.16
8	0.83	0.10	0.00	0.94	0.19	0.78	-0.59	0.35	2.22	2.56	0.99
9	1.95	0.31	0.00	2.26	0.32	2.18	-1.86	0.40	6.47	6.87	3.15
10	0.70	0.10	0.00	0.80	0.09	0.45	-0.37	0.44	1.93	2.27	1.40
11	2.18	0.04	0.00	2.22	1.30	1.84	-0.54	1.68	8.34	10.01	5.05
12	0.50	0.10	0.00	0.61	0.11	2.25	-2.14	-1.53	2.03	0.50	0.12
13	0.50	0.00	0.00	0.50	0.18	0.65	-0.47	0.03	3.83	3.85	2.69
14	1.70	0.10	0.00	1.81	0.09	3.15	-3.06	-1.25	10.53	9.28	3.57
15	0.41	0.23	6.86	7.50	0.07	5.23	-5.16	2.33	3.00	5.33	3.33
16	0.12	0.00	5.20	5.32	0.08	3.26	-3.18	2.14	1.03	3.17	1.18
17	1.01	0.10	0.00	1.12	0.25	0.00	0.25	1.36	3.79	5.15	2.28
18	0.00	0.43	19.64	20.08	0.00	0.00	0.00	20.08	5.13	25.21	11.52
19	3.57	0.23	0.00	3.80	0.00	0.00	0.00	3.80	2.19	6.00	3.97
20	29.58	0.23	1.77	31.58	4.86	4.97	-0.11	31.47	9.27	40.74	33.70
21	8.15	0.23	0.00	8.38	0.00	0.00	0.00	8.38	1.69	10.07	9.69
22	2.36	0.87	0.16	3.39	1.88	1.93	-0.05	3.34	7.35	10.59	7.60
23	25.76	16.89	0.00	42.65	0.00	0.00	0.00	42.65	12.46	55.11	35.12
ADJUSTMENT	0.9213	0.9982	1.0000		1.3112	1.2764					

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TABLE A-4c

Basic Solutions for Income Level 400

(N=10 million, $\frac{\Delta y}{Y}$ = 5%)

	C	G	I	D	E	M	T	T+D	W	X	V
TOTAL	232.26	46.71	74.45	403.44	77.91	81.35	-3.44				
1	36.64	0.48	0.00	37.13	39.27	12.55	26.72	63.85	47.92	111.77	76.23
2	0.00	0.48	0.00	0.48	0.47	2.26	-1.79	-1.31	6.49	5.19	3.36
3	1.06	0.00	0.00	1.06	2.37	1.26	1.11	2.17	6.35	8.51	6.35
4	53.99	2.33	0.00	56.32	8.03	6.59	1.44	57.76	39.31	97.57	29.84
5	9.94	0.70	0.00	10.64	0.50	0.72	-0.22	10.42	5.26	15.63	3.62
6	15.96	0.00	0.00	15.96	1.20	5.35	-4.15	11.81	13.01	24.82	11.02
7	1.71	0.04	0.00	1.75	0.19	0.88	-0.69	1.07	0.28	1.35	0.35
8	3.16	0.22	0.00	3.38	0.74	1.84	-1.10	2.27	4.91	7.18	2.78
9	3.99	0.66	0.00	4.65	1.92	4.48	-2.56	2.10	14.34	16.44	7.54
10	1.92	0.22	0.00	2.14	0.30	0.64	-0.34	1.80	3.49	5.29	3.26
11	4.37	0.09	0.00	4.46	5.04	3.39	1.65	6.11	17.71	23.82	12.01
12	1.71	0.22	0.00	1.93	0.35	4.28	-3.93	-1.99	4.33	2.34	0.59
13	0.86	0.00	0.00	0.86	0.68	1.12	-0.44	0.42	8.32	8.74	6.09
14	5.61	0.22	0.00	5.83	0.65	6.39	-6.23	-0.40	24.96	24.55	9.45
15	1.13	0.48	15.16	16.80	0.49	10.01	-9.51	7.29	6.78	14.07	8.79
16	0.48	0.00	11.51	11.99	0.47	5.33	-4.87	7.13	2.24	9.37	3.49
17	2.76	0.22	0.00	3.00	1.20	0.00	1.20	4.20	7.23	11.43	5.05
18	0.00	0.92	43.49	44.42	0.00	0.00	0.00	44.42	9.90	54.32	25.05
19	7.42	0.48	0.00	7.90	0.00	0.00	0.00	7.90	4.80	12.70	8.42
20	56.46	0.48	3.92	60.86	10.11	9.90	0.21	61.07	13.83	79.90	66.10
21	15.54	0.48	0.00	16.03	0.00	0.00	0.00	16.03	3.33	19.36	16.72
22	3.76	1.85	0.35	5.96	3.92	3.86	0.06	6.03	15.42	21.45	15.26
23	53.76	36.10	0.00	89.86	0.00	0.00	0.00	89.38	24.93	114.72	73.11
ADJUSTMENT	0.6971	0.9982	1.0000		1.3552	1.2084					

TABLE A-4d

Basic Solutions for Income Level 800

(N=10 million, $\frac{\Delta y}{Y}$ = 5%)

	C	G	I	D	E	M	T	T+D	W	X	V
TOTAL	532.23	103.16	164.57	800.00	163.43	163.44	-0.00				
1	45.59	1.07	0.00	47.06	48.99	29.79	19.19	66.25	98.45	164.71	112.33
2	0.00	1.07	0.00	1.07	1.01	10.50	-9.50	-9.43	15.70	7.28	5.42
3	4.43	0.00	0.00	4.43	4.25	3.36	0.89	5.32	15.91	21.13	15.77
4	102.51	5.15	0.00	107.66	32.03	11.92	20.11	127.78	84.01	211.79	64.76
5	20.15	1.55	0.00	21.71	1.07	1.18	-0.10	21.60	10.31	31.91	17.55
6	25.41	0.00	0.00	28.41	2.82	7.09	-4.27	24.13	26.85	50.98	22.54
7	3.41	0.09	0.00	3.50	0.39	1.76	-1.37	2.14	0.61	2.74	0.71
8	11.12	0.48	0.00	11.60	2.25	4.15	-1.90	9.70	11.09	20.79	9.05
9	7.70	1.46	0.00	9.16	8.97	8.77	0.20	9.35	32.87	42.23	19.38
10	4.93	0.46	0.00	5.42	0.31	0.86	-0.05	5.36	6.70	12.06	7.43
11	3.27	0.20	0.00	8.46	15.22	5.93	9.29	17.76	37.67	55.43	27.94
12	5.44	0.40	0.00	5.93	0.83	7.76	-6.87	-0.94	9.61	8.57	2.19
13	1.39	0.00	0.00	1.39	2.00	1.82	0.18	1.57	18.18	19.75	13.77
14	17.07	0.48	0.00	17.55	3.65	14.36	-10.71	6.84	60.18	67.02	25.80
15	2.90	1.07	33.56	37.53	2.90	16.24	-15.34	22.19	15.47	37.56	23.54
16	1.01	0.00	25.44	27.26	2.22	8.31	-6.09	21.16	4.91	26.08	9.72
17	7.13	0.48	0.00	7.61	4.53	0.00	4.53	12.14	13.85	25.39	11.50
18	0.00	2.04	90.14	98.16	0.00	0.00	0.00	98.18	18.85	117.03	53.97
19	14.42	1.07	0.00	15.55	0.00	0.00	0.00	15.55	10.49	26.04	17.27
20	106.40	1.07	8.66	116.16	21.21	19.39	1.32	117.51	38.56	156.06	129.10
21	27.05	1.07	0.00	29.02	0.00	0.00	0.00	29.02	6.52	35.54	30.70
22	5.07	4.09	0.77	9.93	8.22	7.75	0.47	10.40	32.62	43.02	30.51
23	105.88	79.73	0.00	185.42	0.00	0.00	0.00	185.42	49.77	235.18	149.88
ADJUSTMENT	0.9346	0.9982	1.0000		1.0936	1.0399					

TABLE A-4e

Basic Solutions for Income Level 1500
(N=10 million, $\frac{\Delta Y}{Y}$ = 5%)

	C	G	I	D	E	M	T	T+D	W	X	V
TOTAL	933.92	217.20	336.54	1427.67	321.31	308.97	12.33				
1	53.65	2.25	0.00	56.11	46.41	61.11	-14.70	41.41	187.39	228.80	156.04
2	0.00	2.25	0.00	2.25	1.55	39.57	-38.02	-35.76	34.40	-1.36	-1.02
3	15.09	0.00	0.00	15.09	5.61	7.67	-2.05	13.04	36.03	49.07	36.61
4	173.31	10.64	0.00	184.15	87.09	19.09	67.99	252.14	161.57	413.71	126.51
5	36.12	3.27	0.00	39.39	1.68	1.73	-0.05	39.34	13.90	58.24	32.03
6	45.05	0.00	0.00	45.05	4.73	8.57	-3.84	41.22	49.28	90.50	40.18
7	6.01	0.20	0.00	6.20	0.57	3.07	-2.50	3.70	1.19	4.89	1.27
8	32.50	1.02	0.00	33.52	4.78	8.12	-3.34	30.18	23.31	53.49	20.70
9	13.15	3.08	0.00	16.26	28.10	15.11	13.00	29.26	69.42	98.59	45.30
10	10.85	1.02	0.00	11.90	1.55	1.06	0.49	12.39	12.27	24.66	15.19
11	13.93	0.41	0.00	14.34	32.16	9.22	22.94	37.29	72.73	110.02	55.45
12	14.51	1.02	0.00	15.53	1.60	12.46	-10.86	4.57	20.22	24.89	6.27
13	2.04	0.00	0.00	2.04	4.15	2.65	1.50	3.54	36.75	40.29	28.09
14	45.47	1.02	0.00	44.49	13.42	26.19	-12.78	31.71	133.66	165.37	63.67
15	6.41	2.25	68.62	77.28	11.19	29.45	-18.25	59.03	32.30	91.33	57.60
16	5.61	0.00	52.03	57.64	7.10	11.65	-4.55	53.09	10.06	63.15	23.55
17	15.73	1.02	0.00	16.75	11.74	0.00	11.74	28.49	25.20	53.69	23.76
18	0.00	4.29	196.51	200.90	0.00	0.00	0.00	200.90	33.56	234.46	108.13
19	25.07	2.25	0.00	27.35	0.00	0.00	0.00	27.35	20.87	48.22	31.97
20	166.70	2.25	17.70	206.74	41.71	37.60	4.10	210.85	74.24	285.08	235.82
21	45.02	2.25	0.00	47.27	0.00	0.00	0.00	47.27	11.96	59.23	51.17
22	5.16	8.61	1.58	15.35	16.16	14.55	1.52	16.86	64.16	81.02	57.65
23	134.17	167.68	0.00	352.05	0.00	0.00	0.00	352.05	54.06	446.10	284.30
ADJUSTMENT	0.7486	0.9982	1.0000		0.6983	0.9296					

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Fig. I

VARIATION IN COMPOSITION OF GROSS NATIONAL PRODUCT WITH INCOME LEVEL

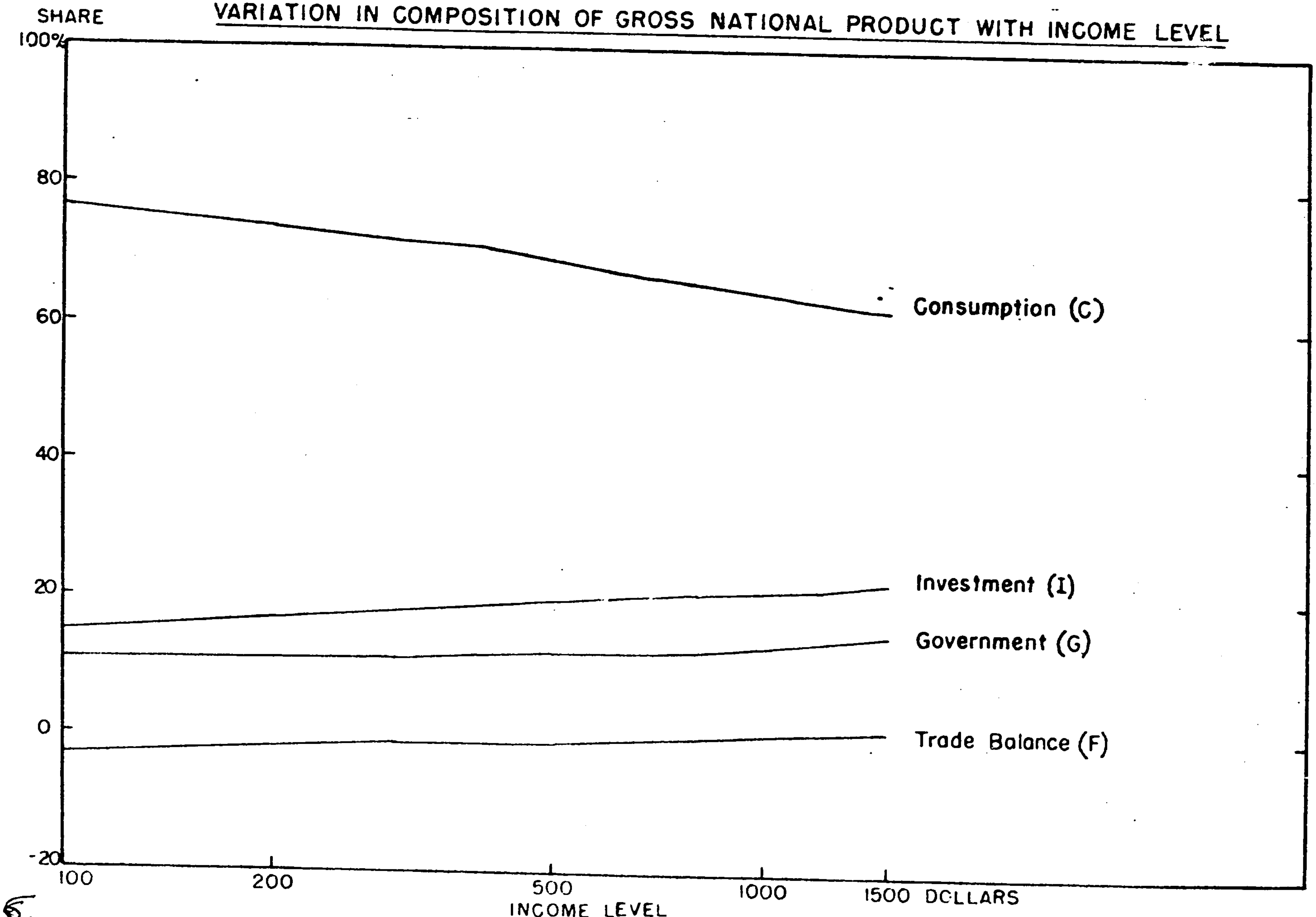

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Fig. 2

VARIATION IN IMPORTS AND EXPORTS WITH INCOME LEVEL

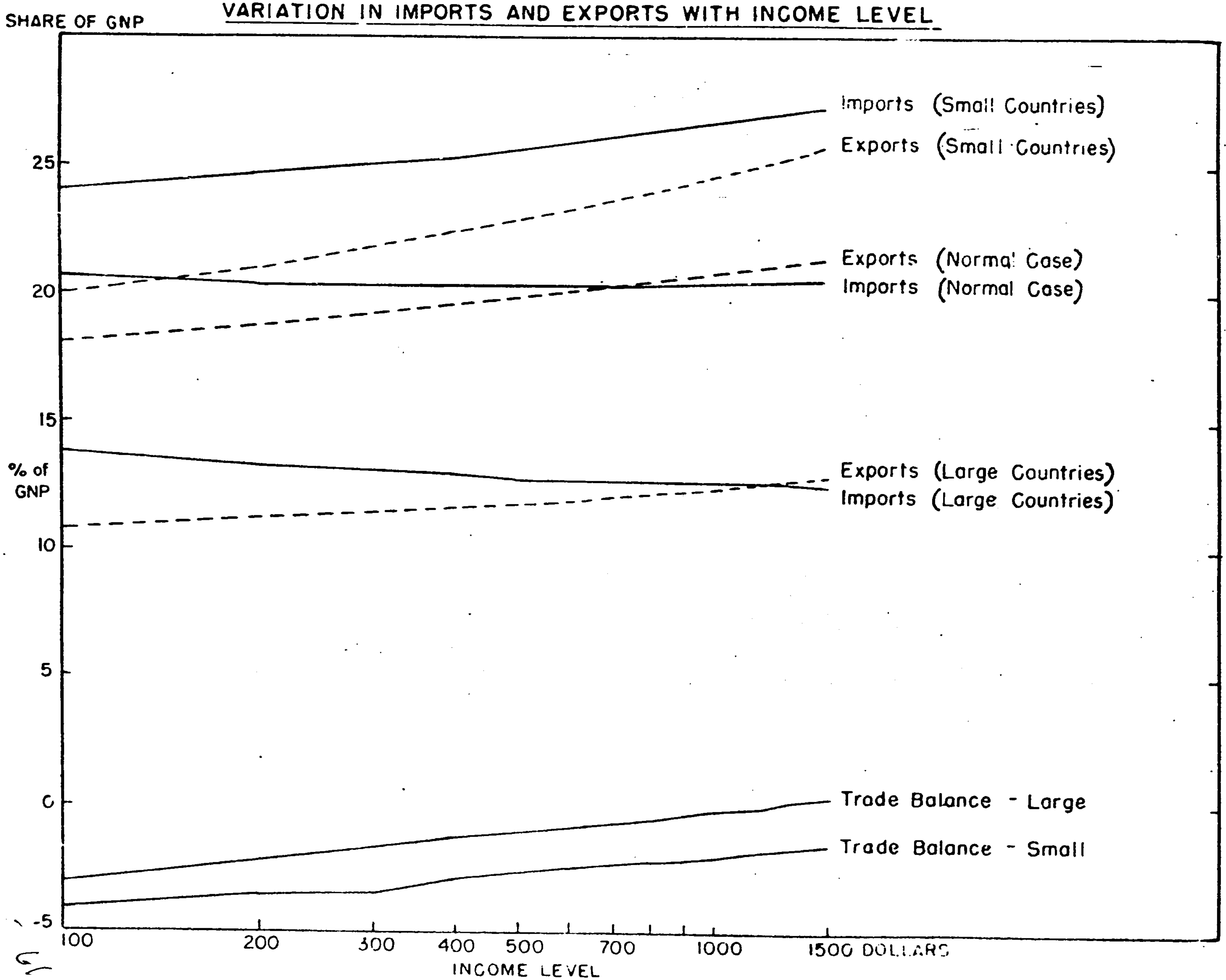

Fig. 3

NORMAL VARIATION IN INDUSTRIAL STRUCTURE
WITH INCOME LEVEL

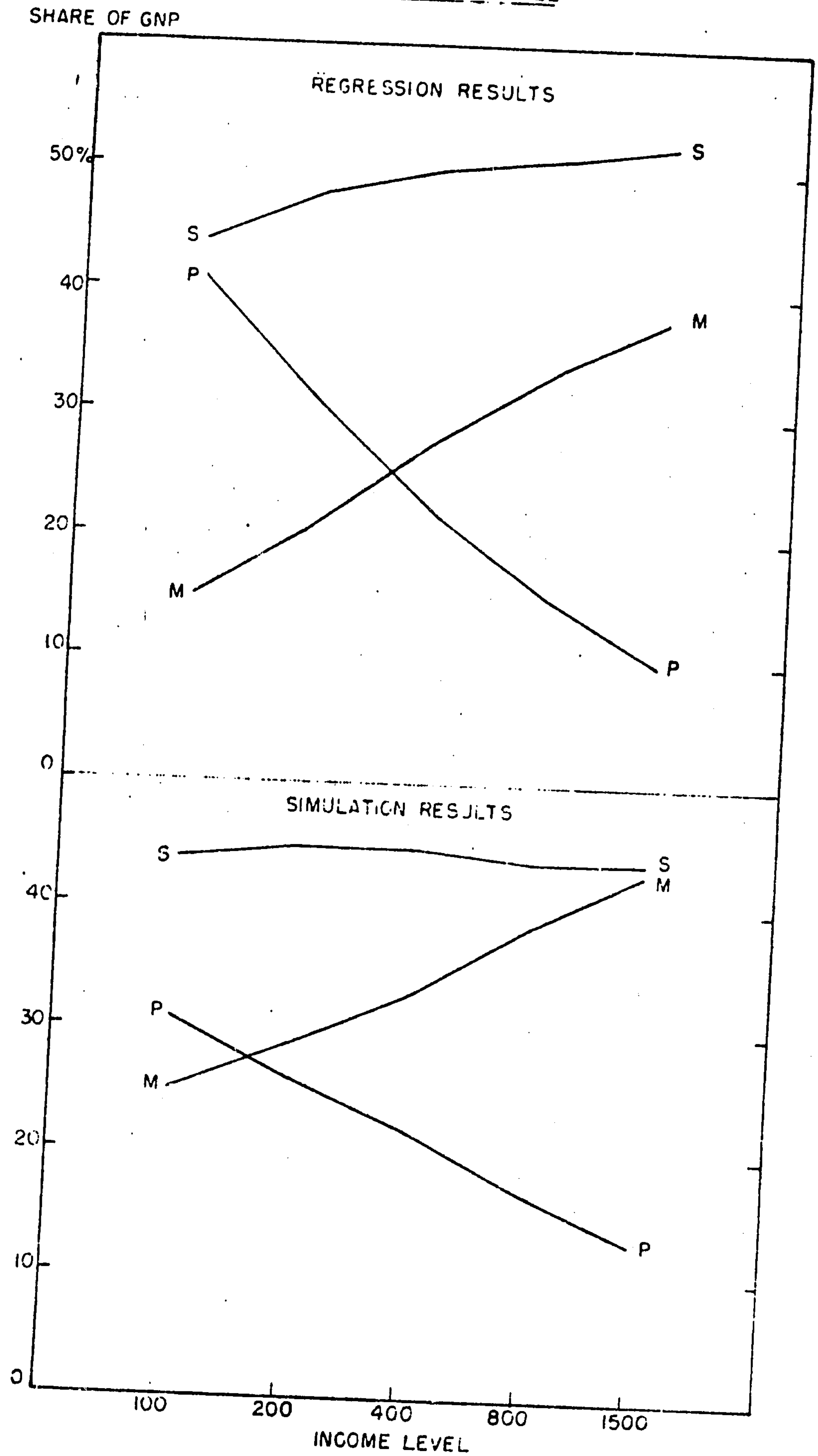

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Fig. 4 a

INCREASE IN INDUSTRIAL OUTPUT : PER CAPITA
JAPAN 1914-1954

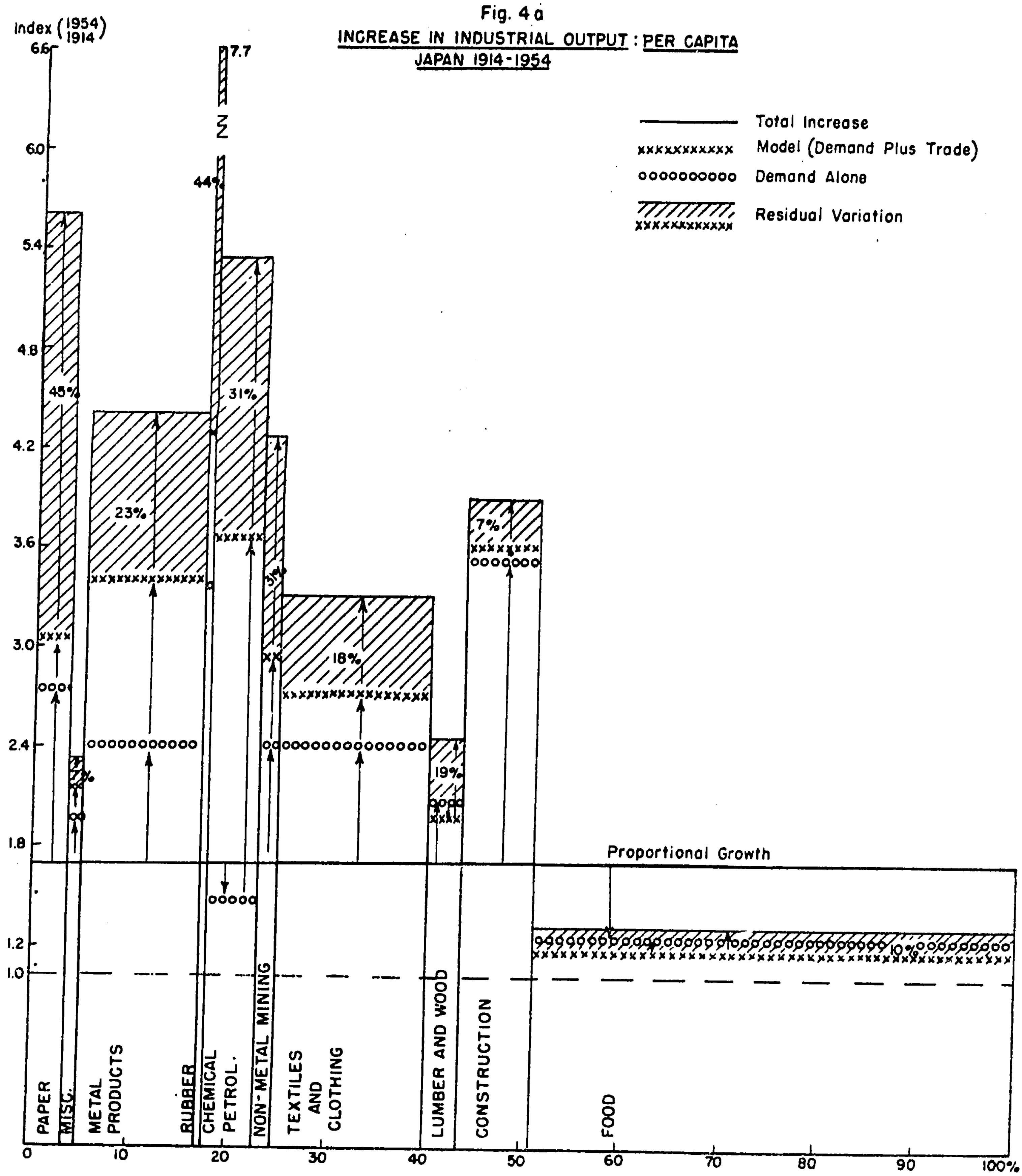

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Fig. 4 b

SIMULATED INCREASE IN INDUSTRIAL OUTPUT PER CAPITA
(FROM INCOME $200 - $400)

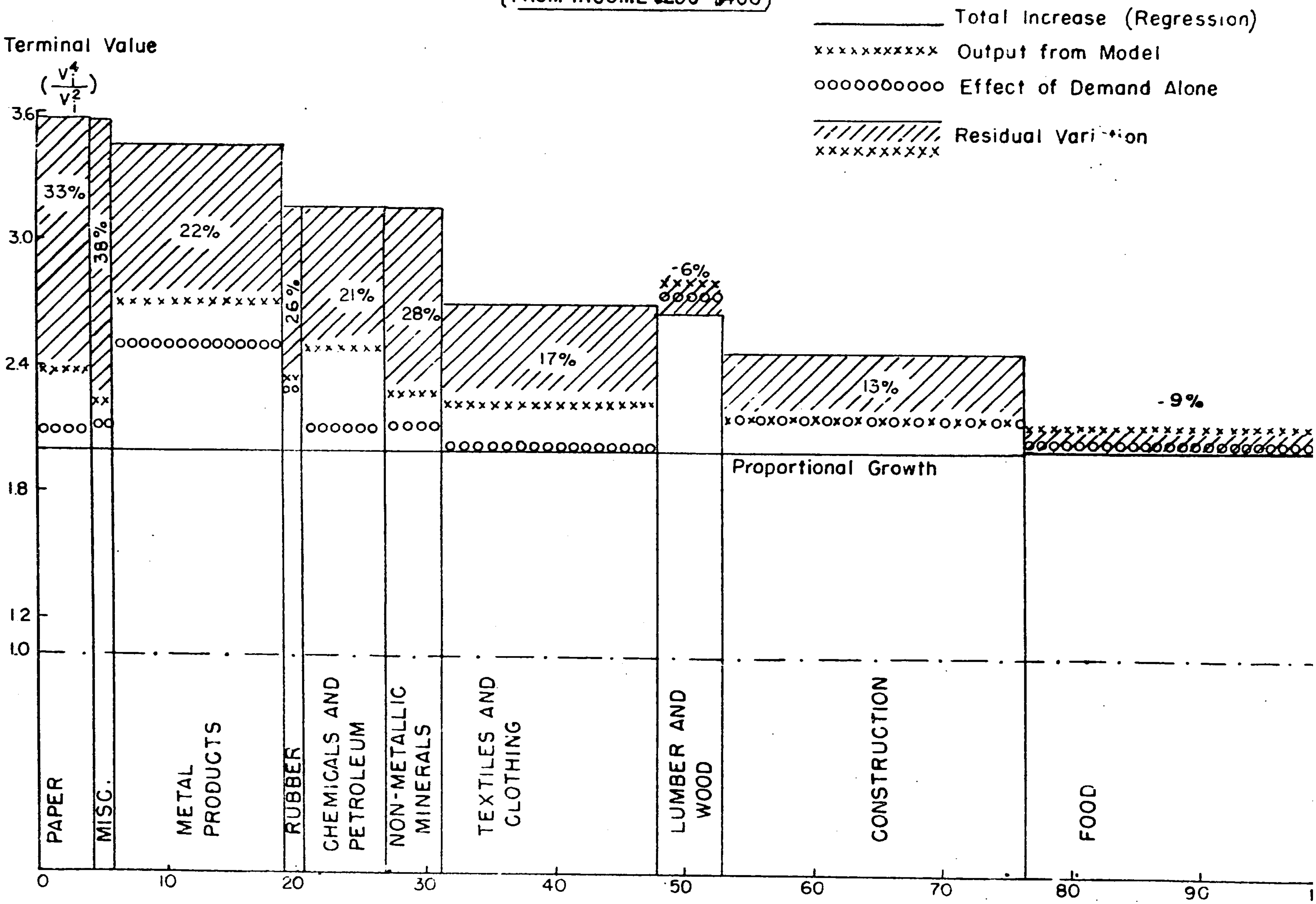

Fig. 5a

Sector 4: Food and Tobacco Products (ISIC 20 - 22)

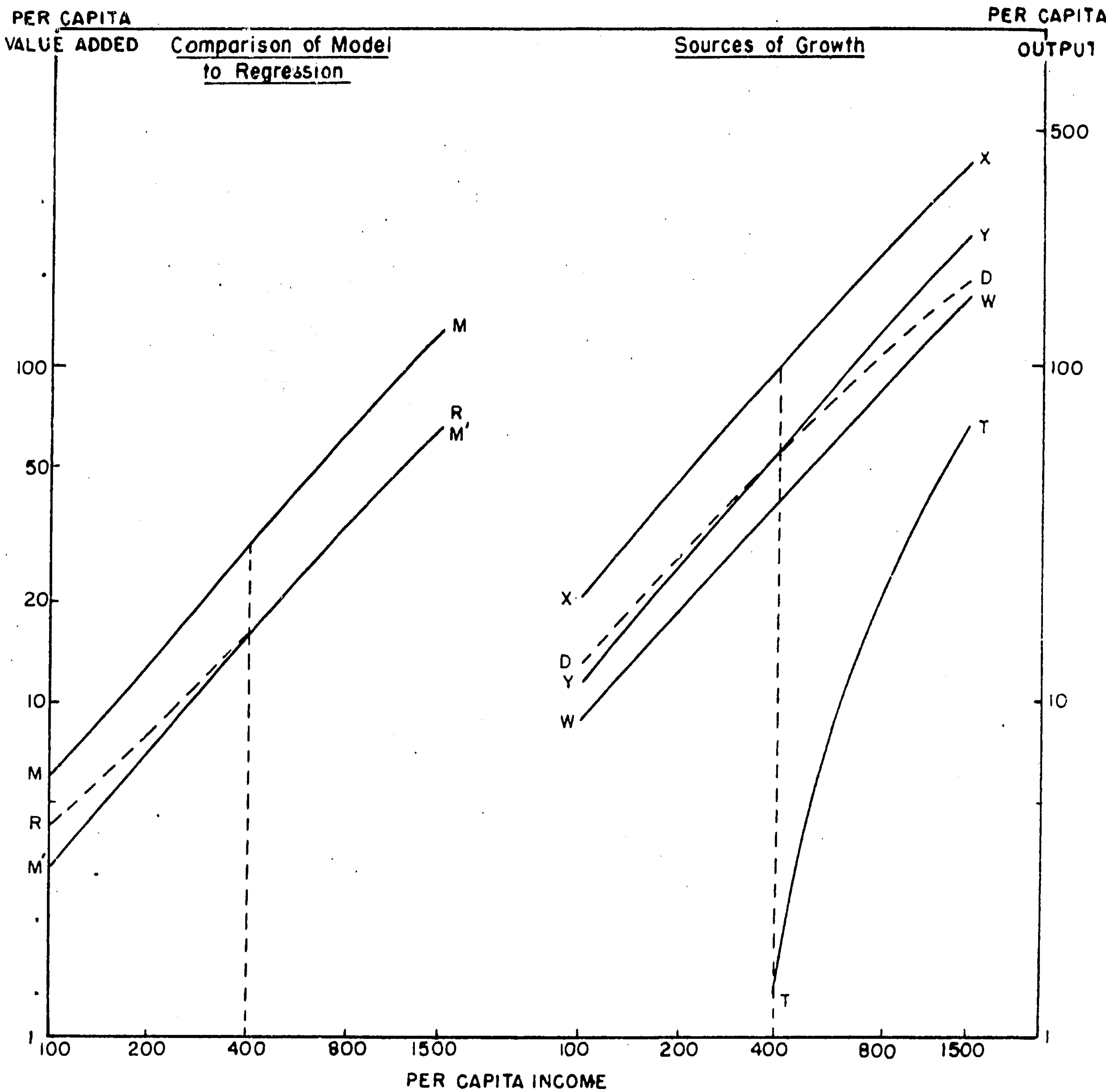

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Fig. 5b

Sector 7: Leather Products (ISIC 29)

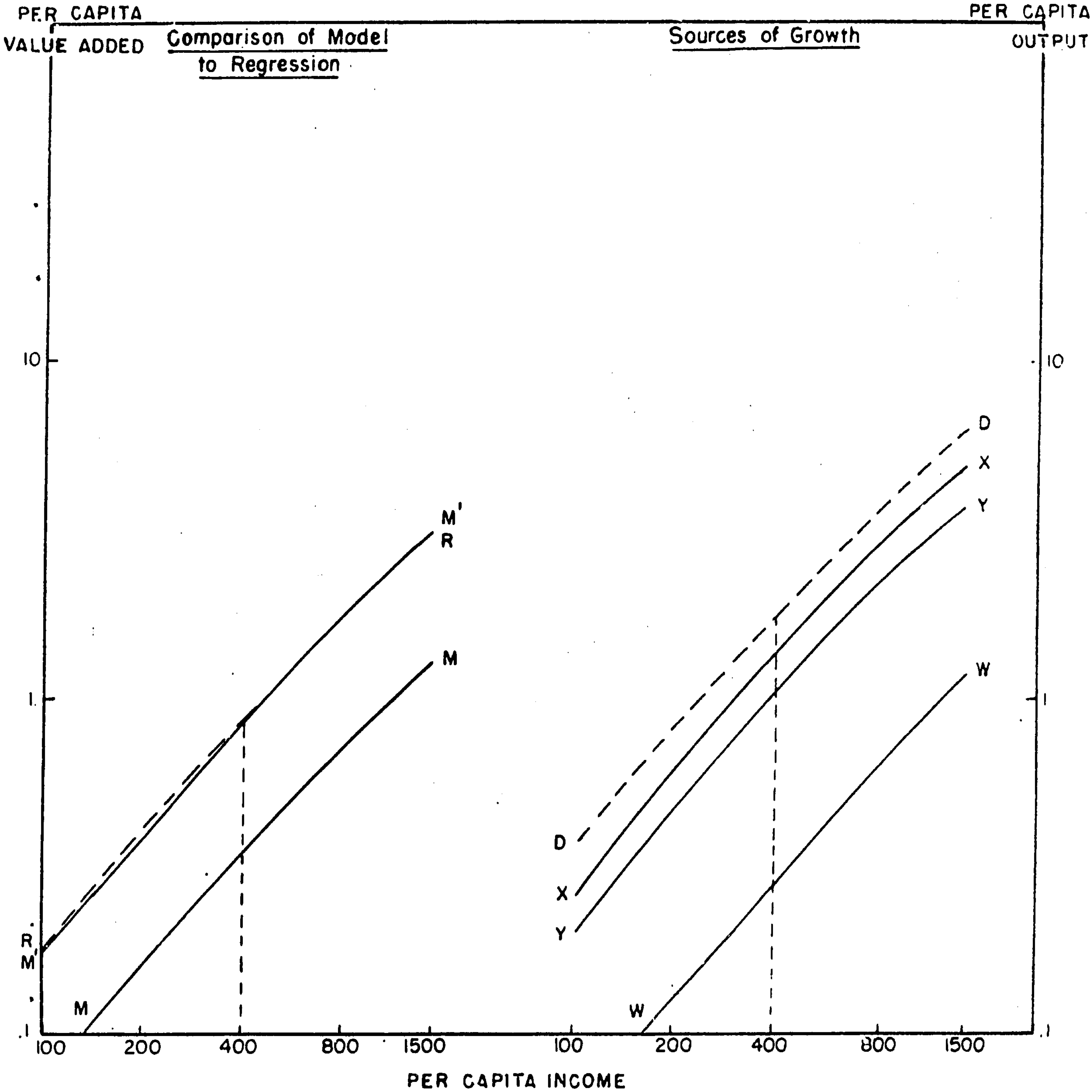

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Fig. 5c

Sectors 19 - 23: Services (ISIC 5-9)

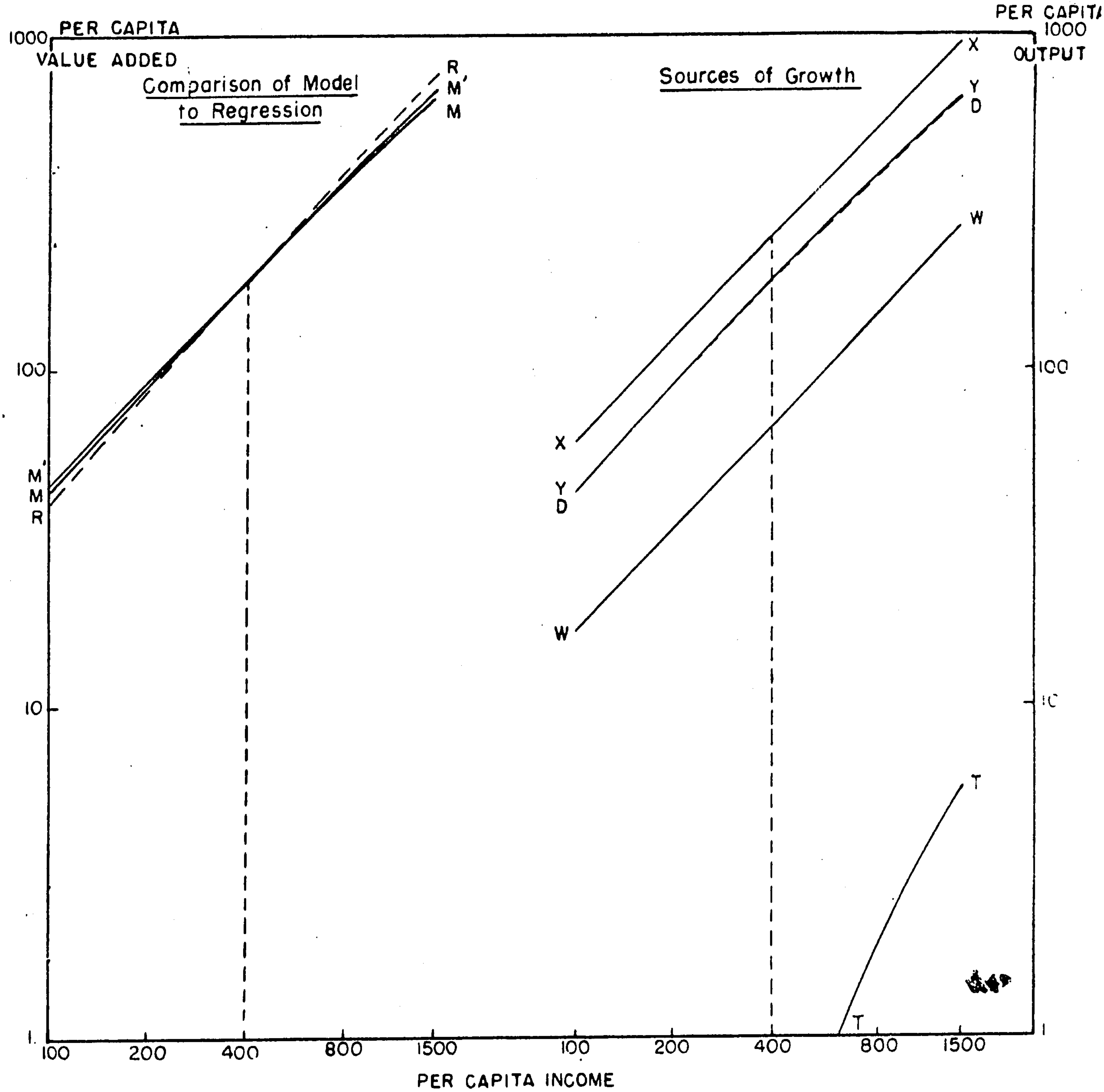

Fig. 5d

Sector 18: Construction (ISIC 40)

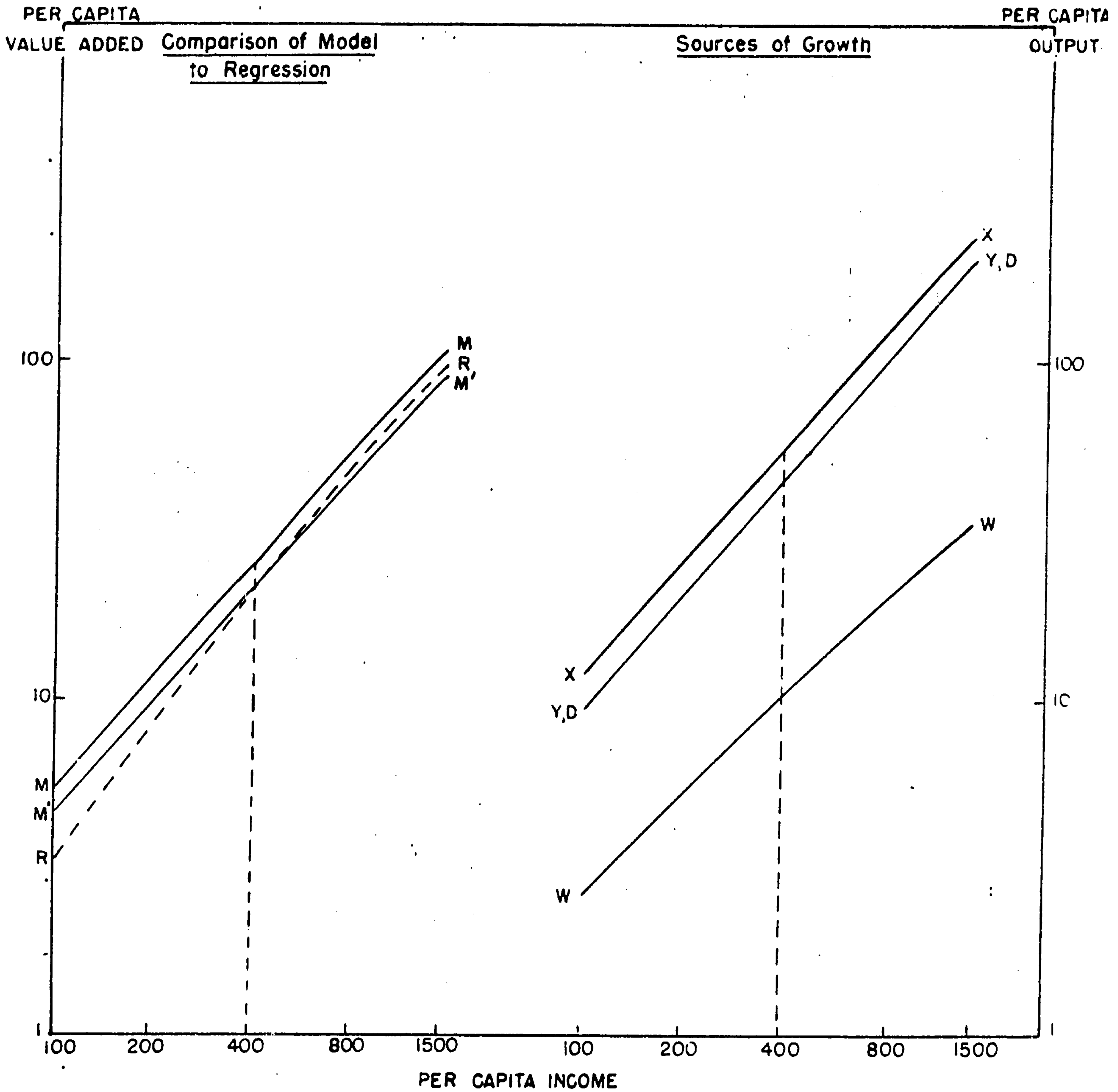

Fig. 5e

Sector 8: Lumber and Wood Products (ISIC 25,26)

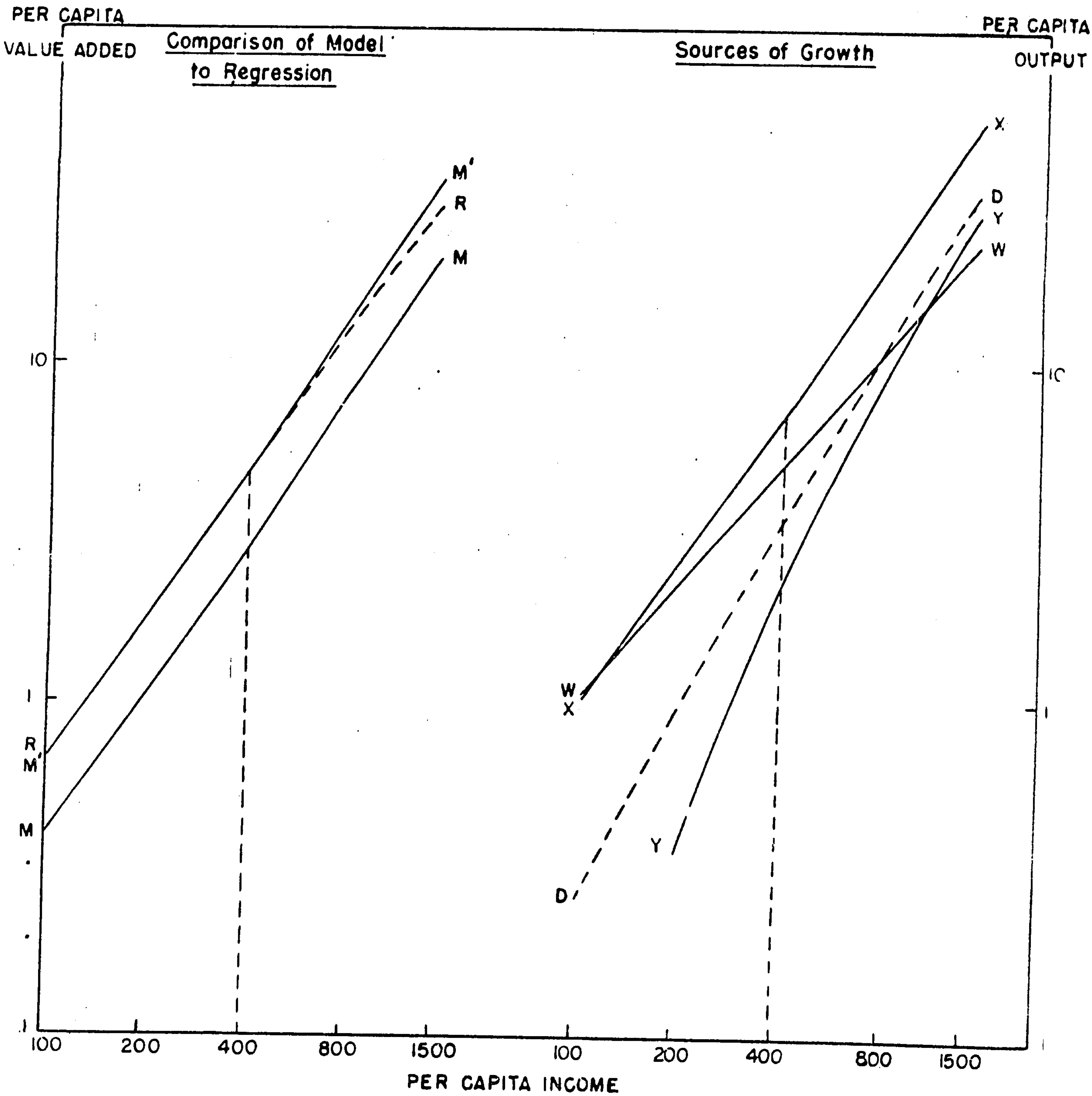

Fig. 5f

Sector 5: Clothing (ISIC 24)

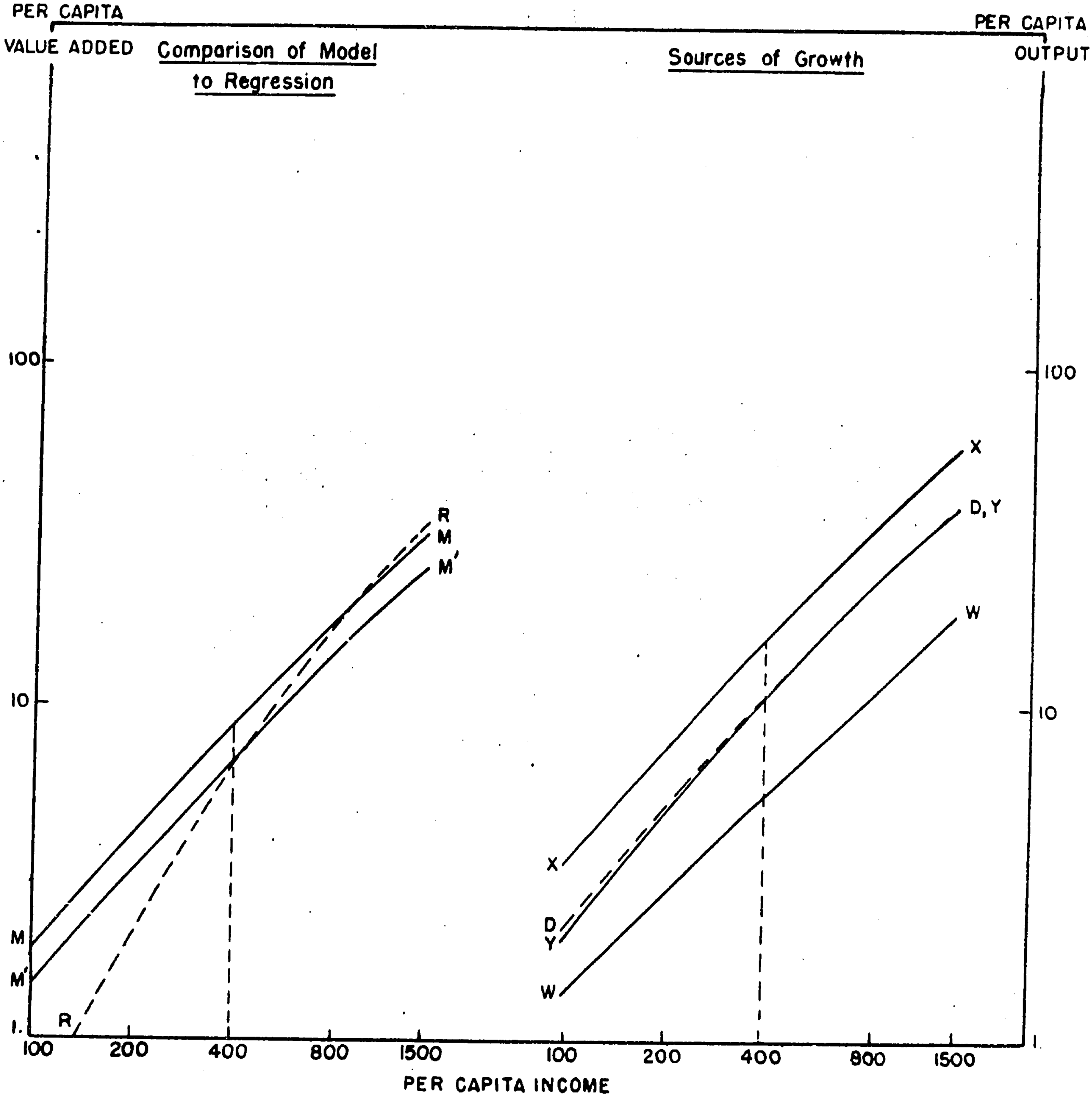

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Fig. 5g

Sectors 1-3: Primary (ISIC 0,1)

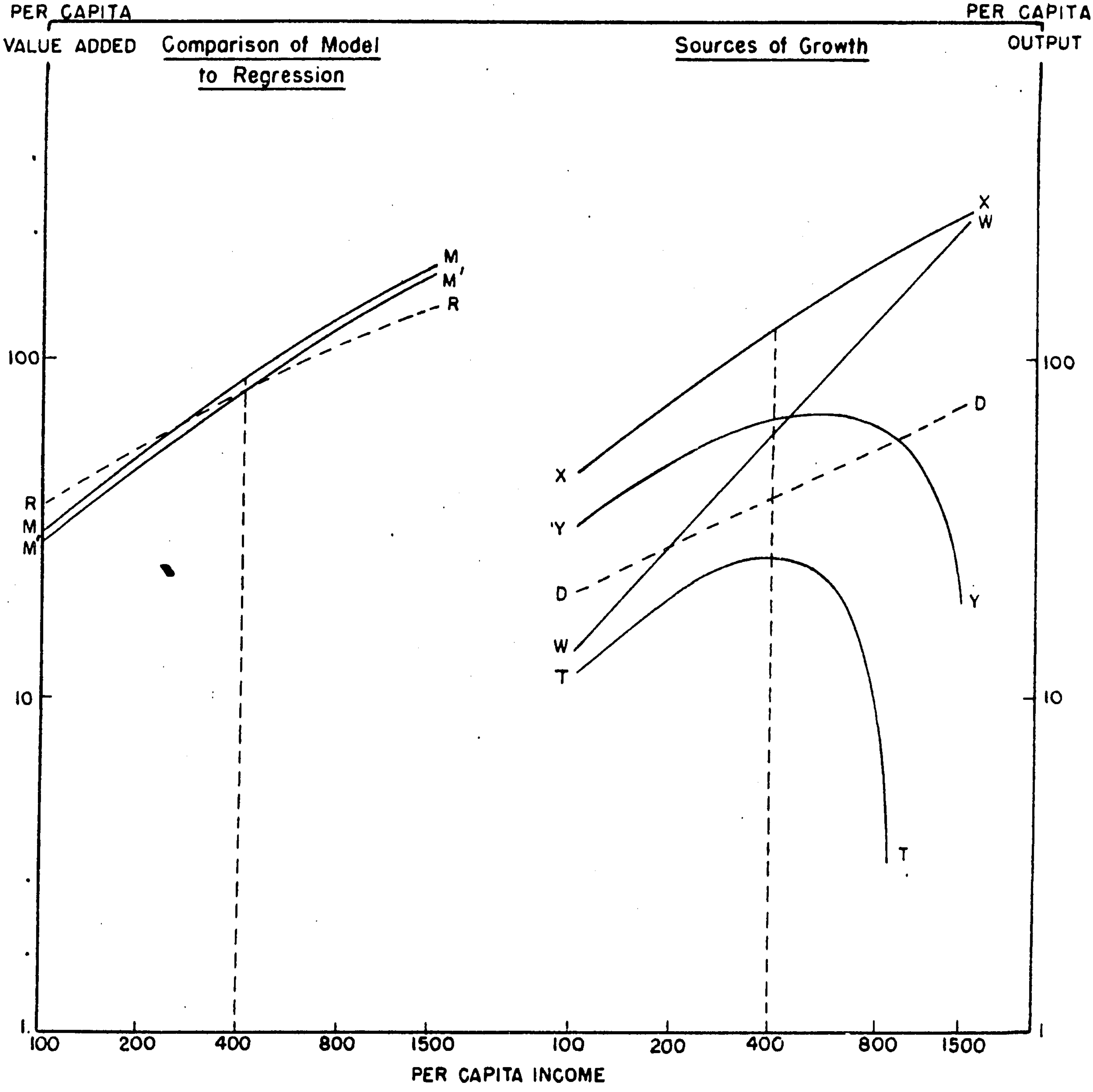

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Fig. 5h

Sector 6: Textiles (ISIC 23)

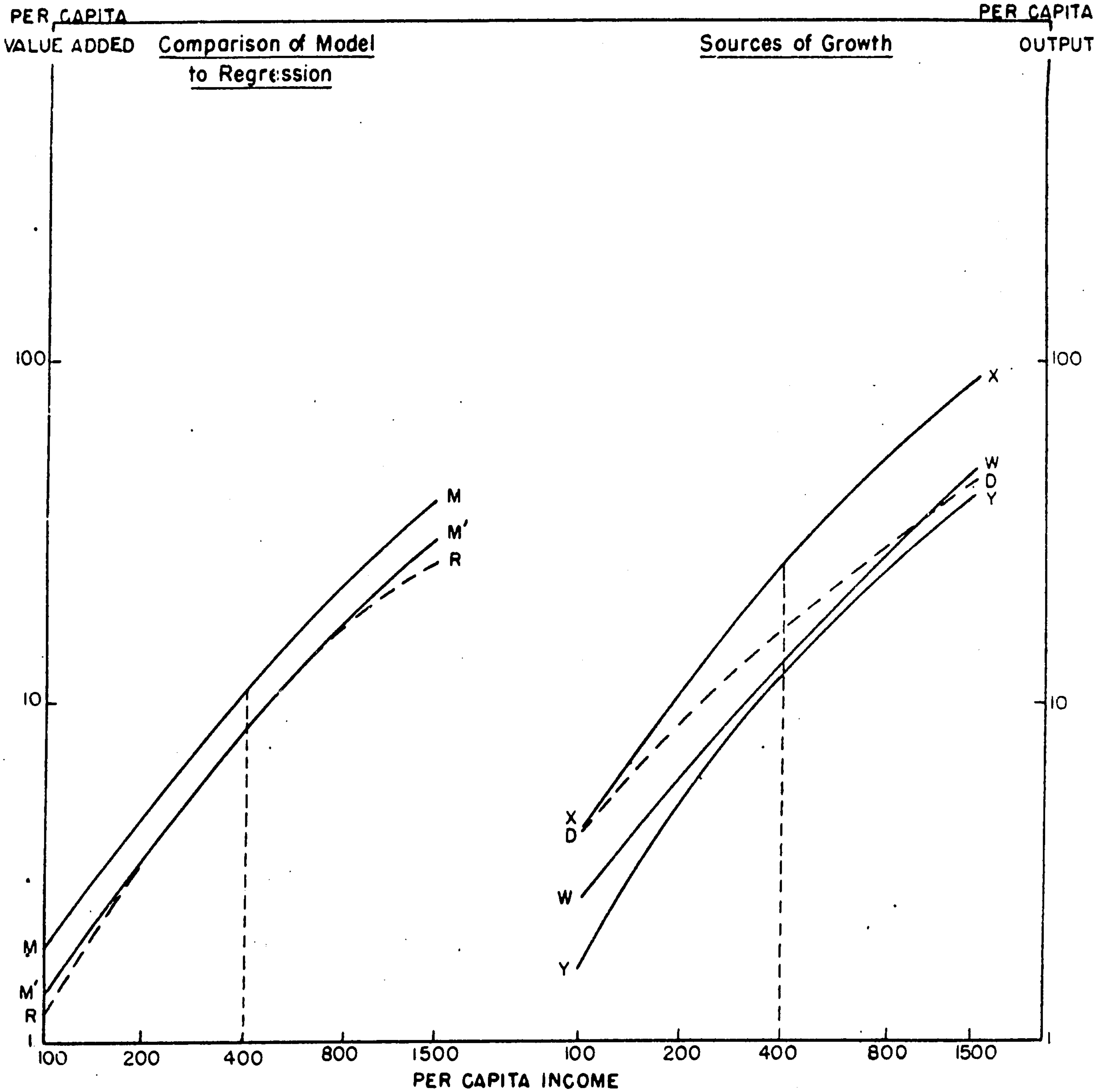
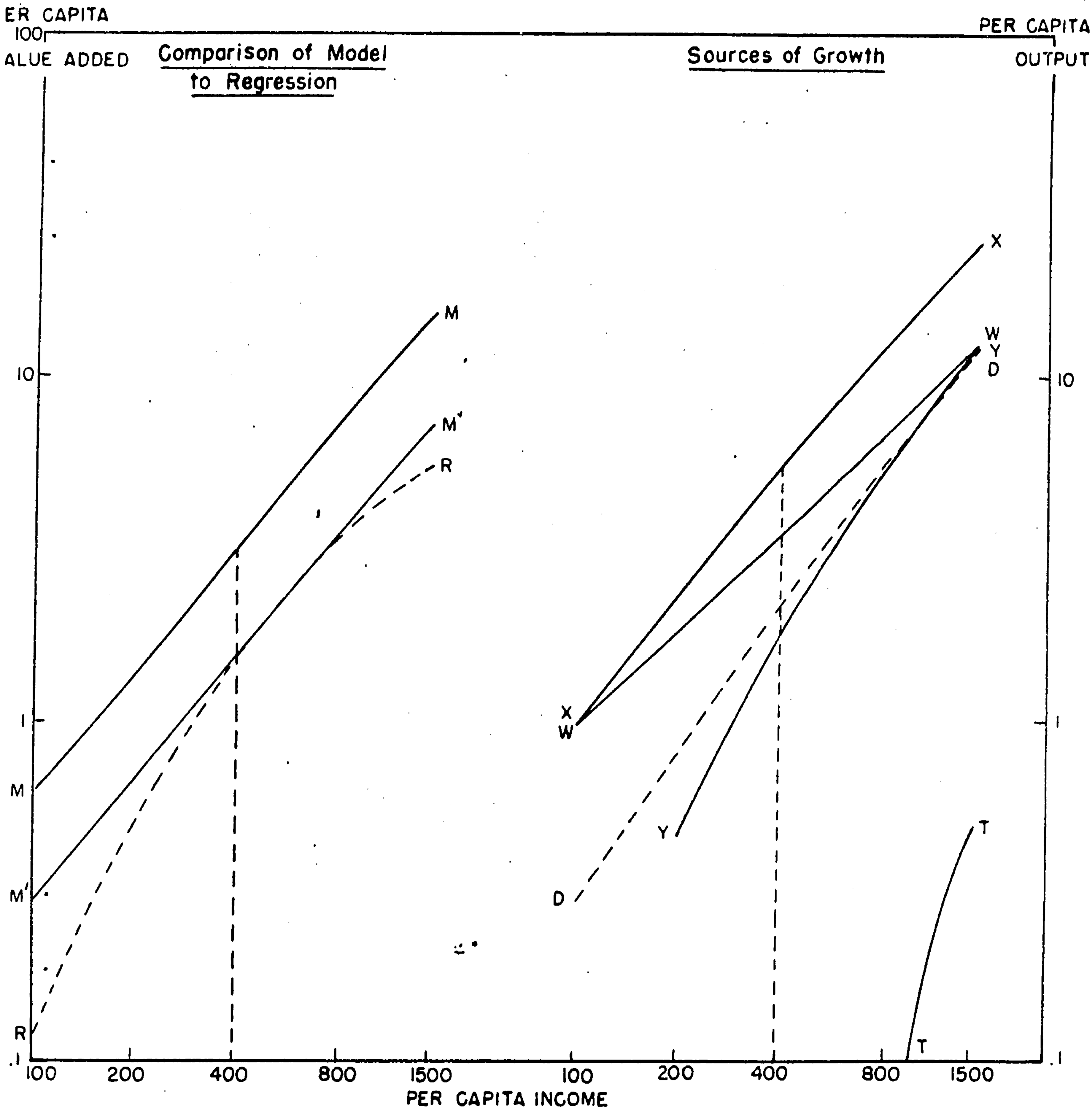


Fig. 5i

Sector 10: Rubber Products (ISIC 30)



13

Fig. 5 j

Sector 13: Non-Metallic Mineral Products (ISIC 33)

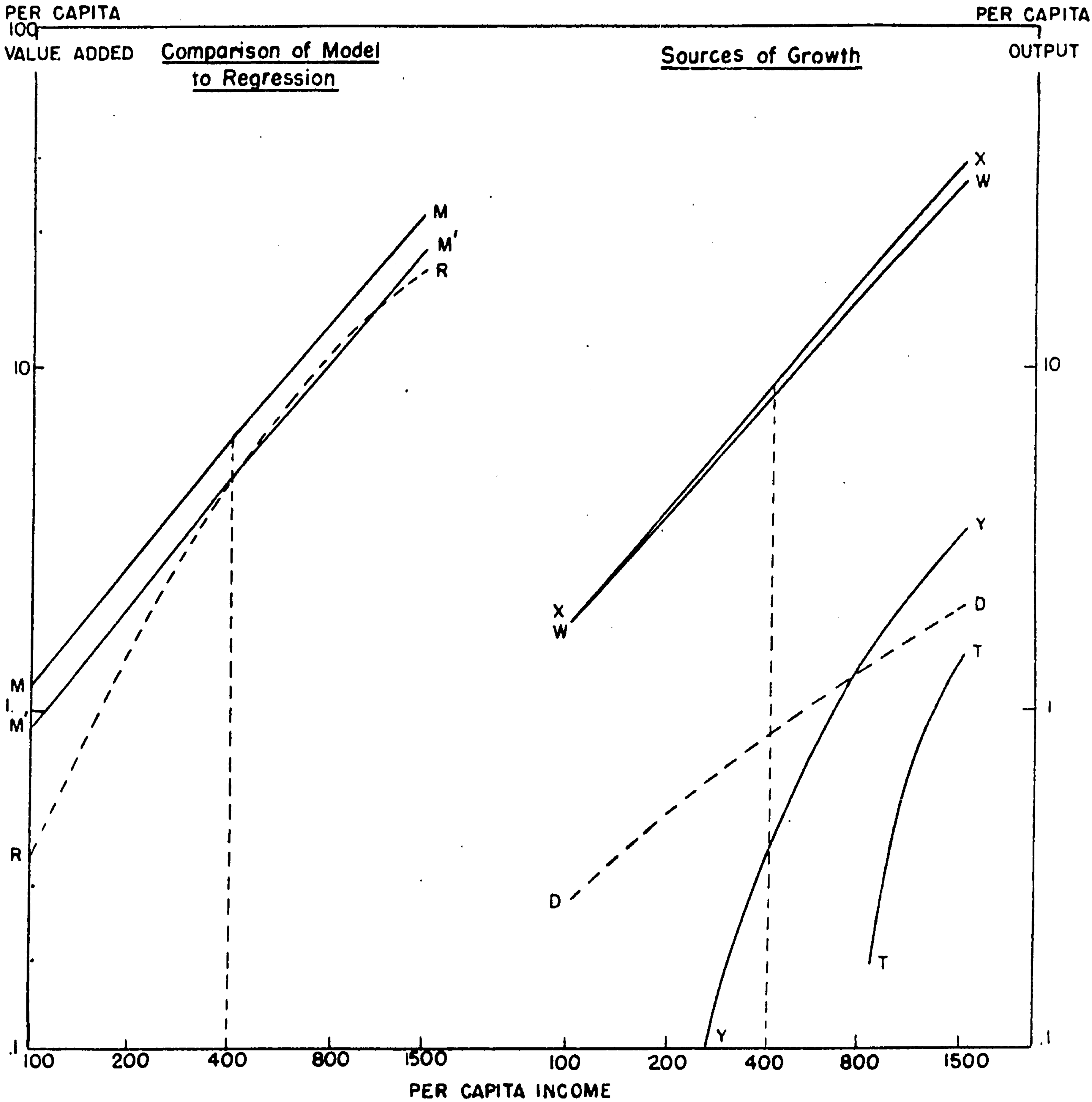
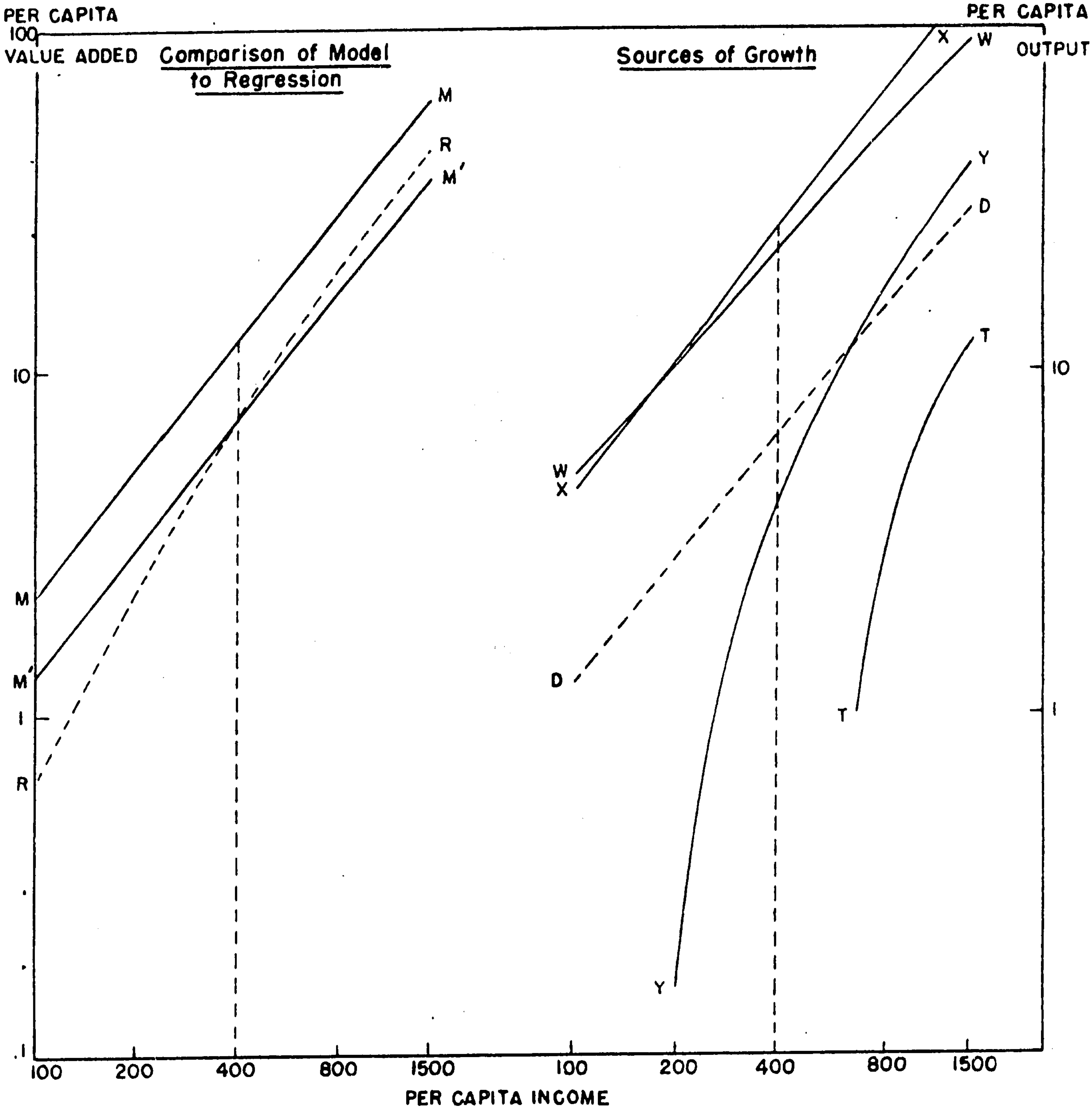


Fig. 5k

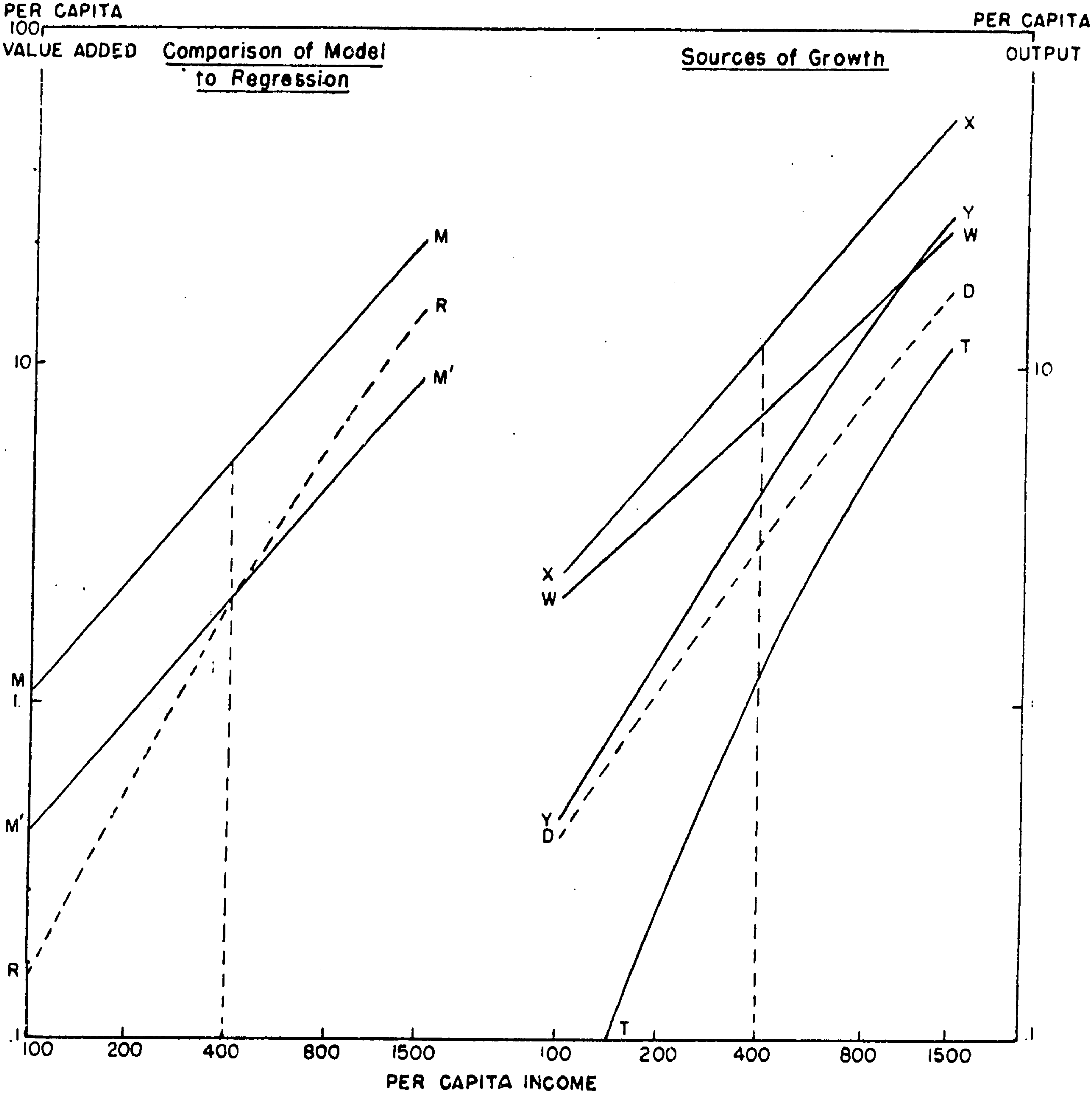
Sector 11-12 : Chemicals (ISIC 31-32)



75

Fig. 51

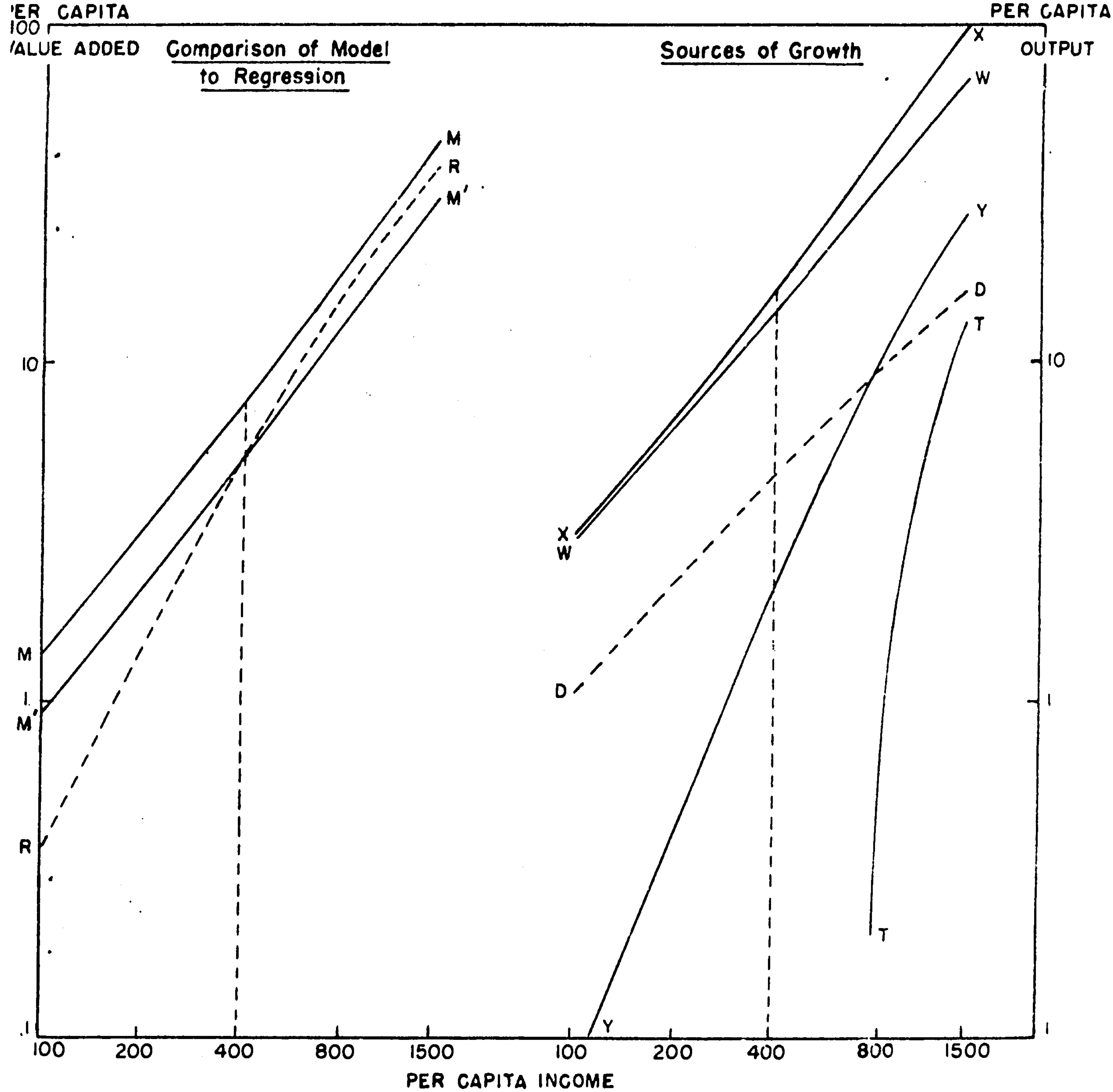
Sector 17 : Manufacturing n.e.c (ISIC 39)



76

Fig. 5m

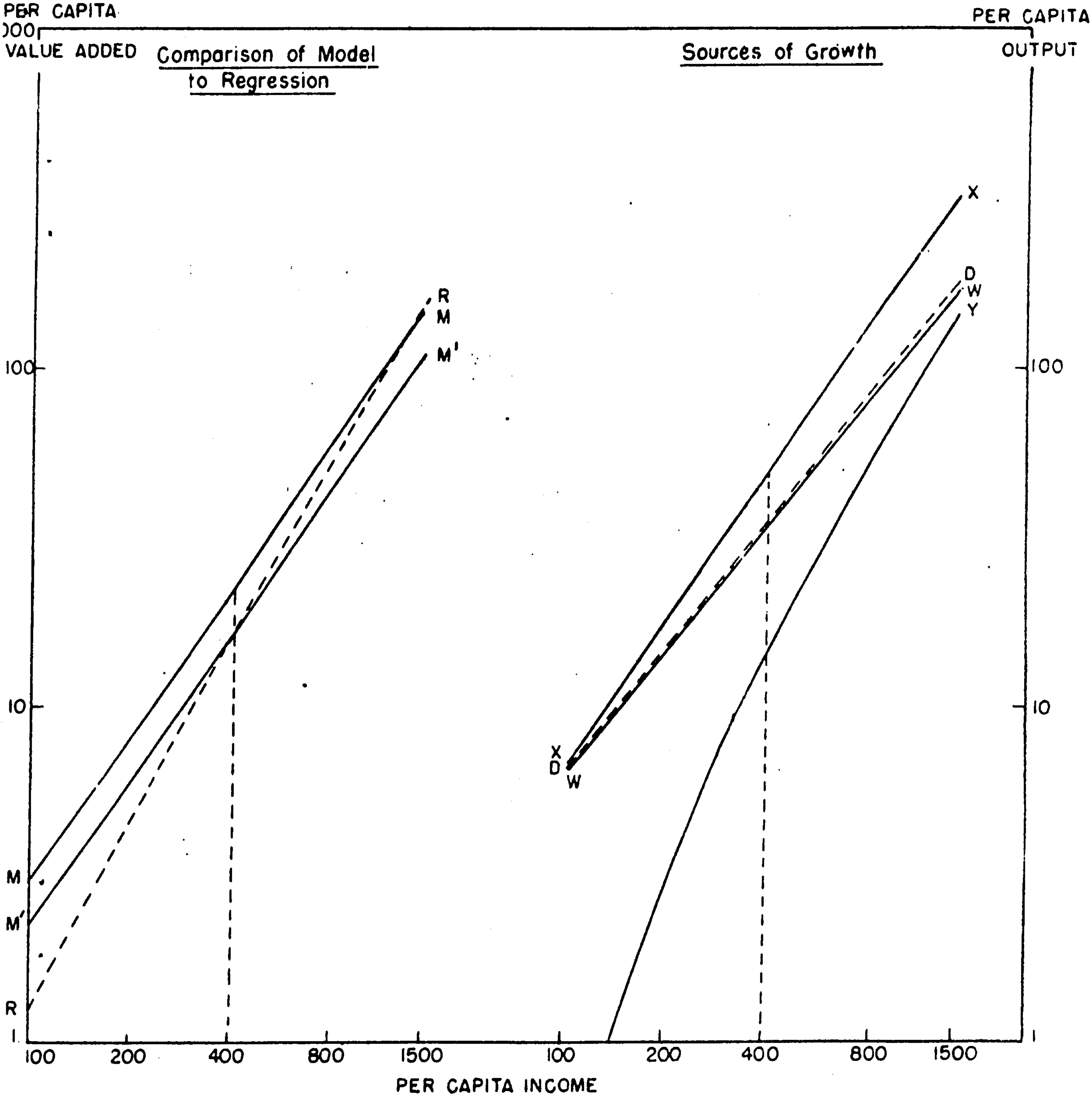
Sector 9: Paper and Printing (ISIC 27, 28)



77'

Fig. 5n

Sectors 14-16: Metal Products (ISIC 34-38)



78

Fig. 6

CAUSES OF INDUSTRIALIZATION : NORMAL CASE

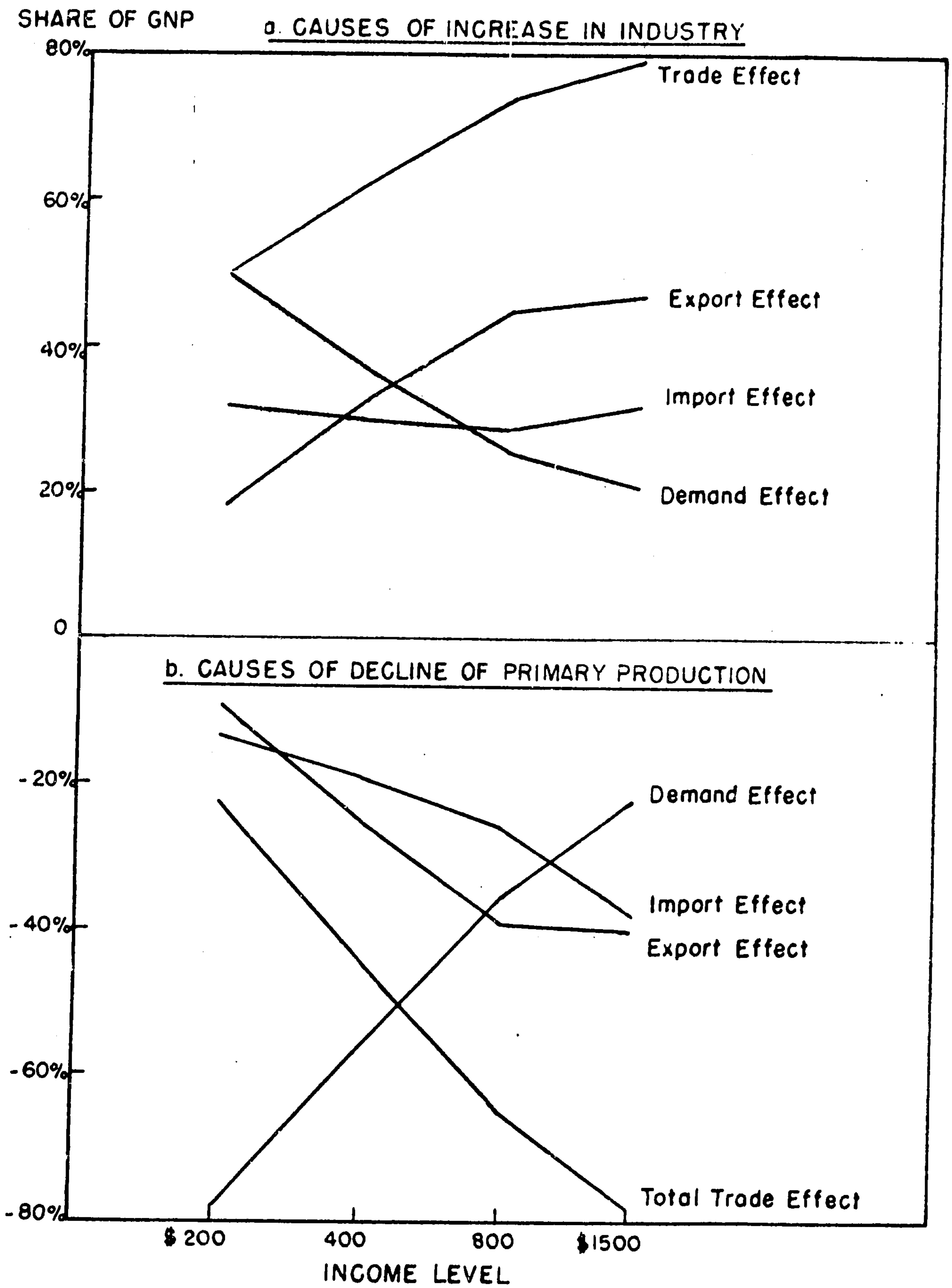
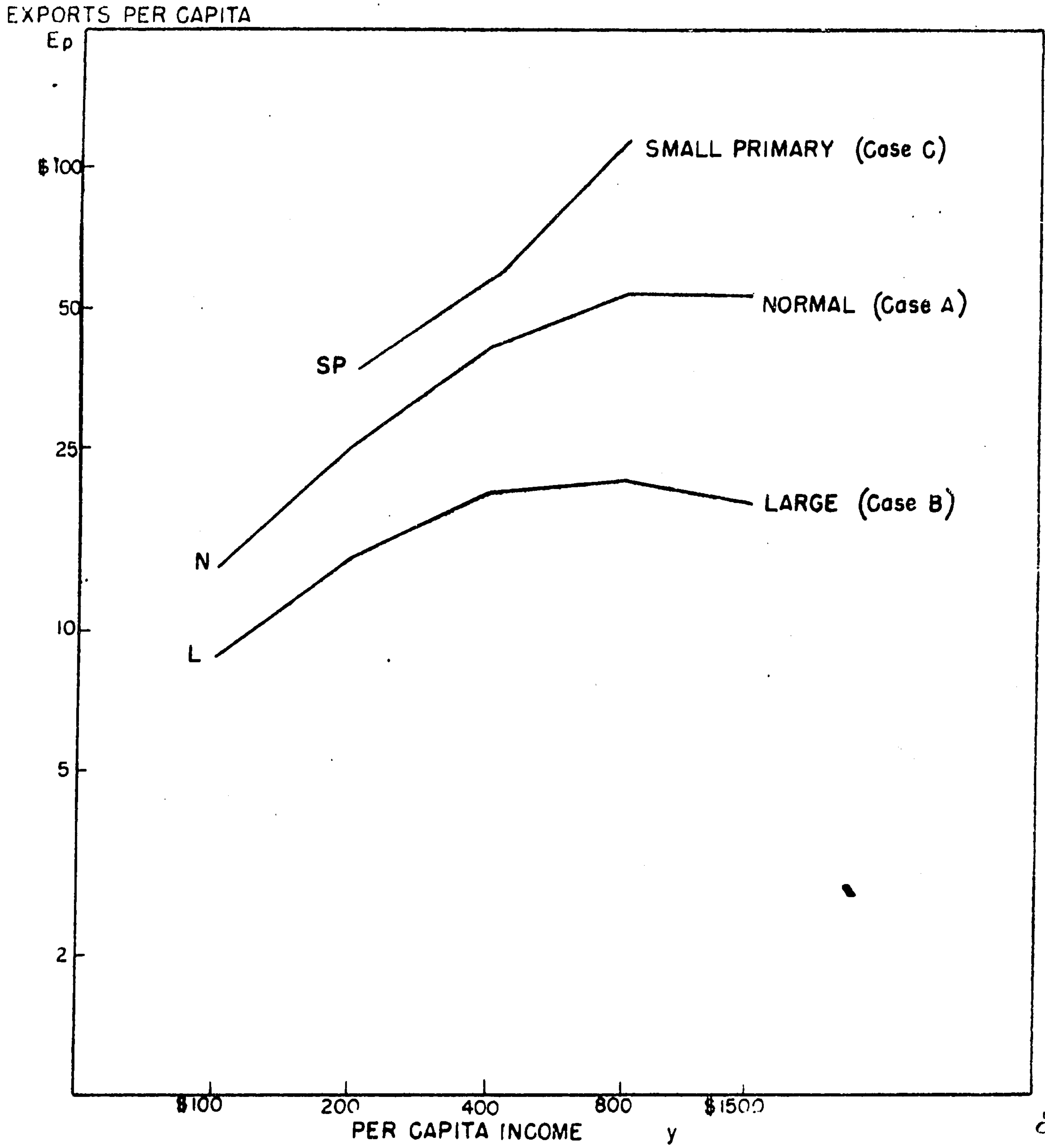


Fig. 7a

VARIATIONS IN PRIMARY EXPORTS WITH INCOME



80

Fig. 7b

VARIATIONS IN MANUFACTURED EXPORTS WITH INCOME

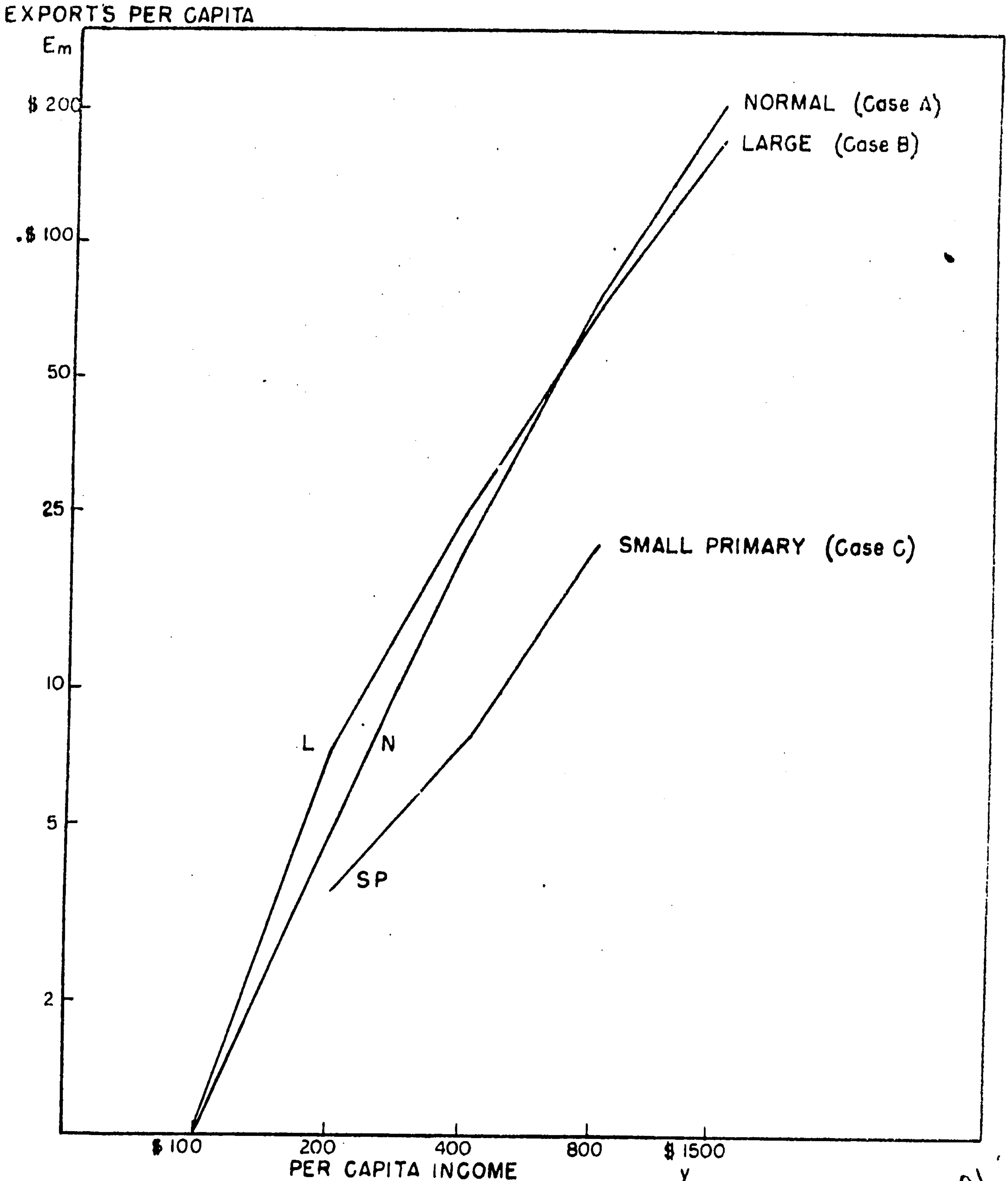
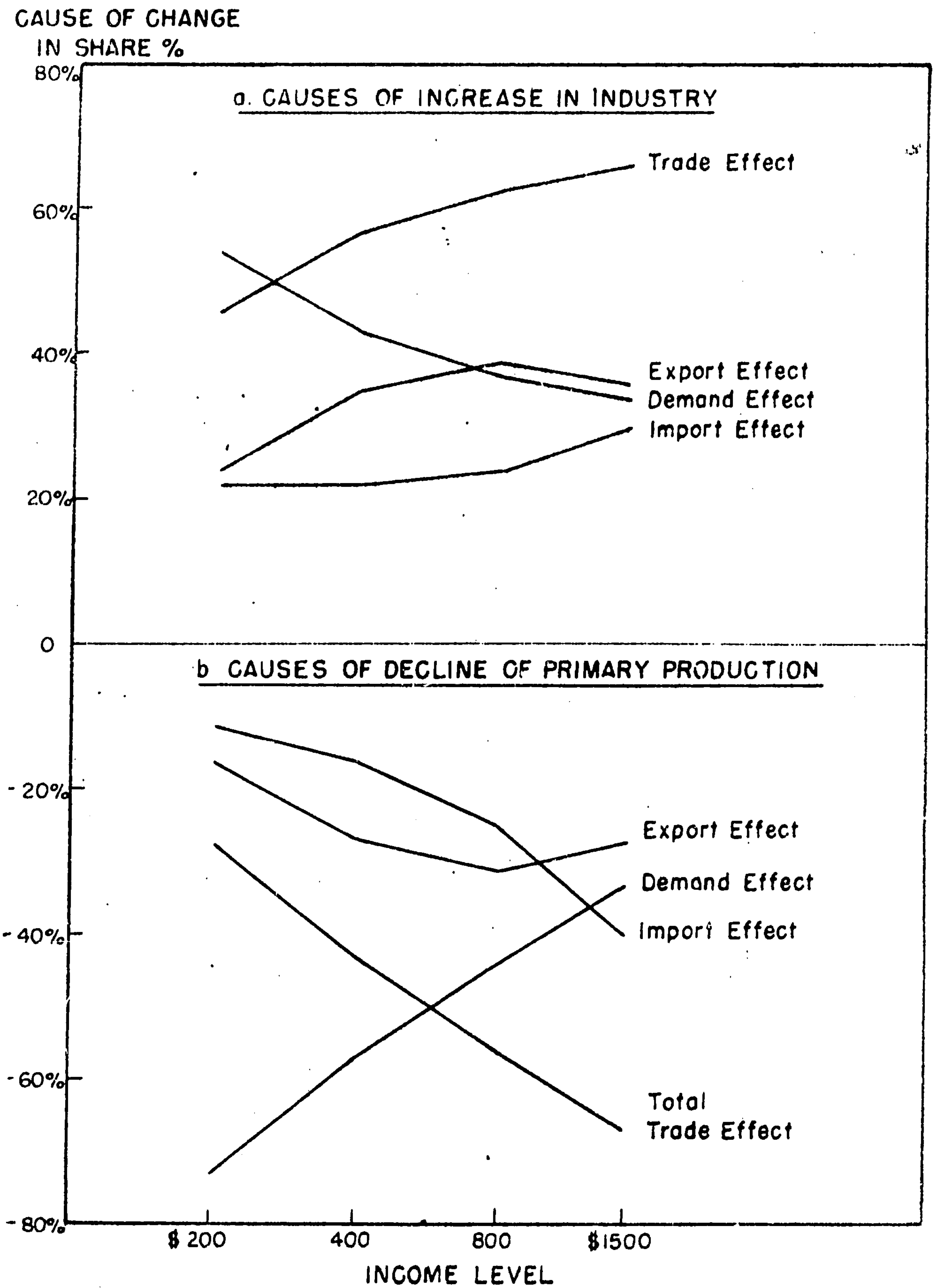


Fig. 8

CAUSES OF INDUSTRIALIZATION IN LARGE COUNTRIES



92'