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PATTERNS OF SECTORAL CHANGE: A NEW VIEW

by

Lance Taylor

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Center for International Affairs,
Harvard University,
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PATTERNS OF SECTORAL CHANGE: A NEW VIEW[1/]

1. Introduction

Investigation of the relationship between output shares of various producing sectors and the level of per capita income is an ancient occupation of economists. The first man in the field was apparently Sir William Petty, who flourished almost 300 years ago. Observing the connection between the high standard of living and non-agricultural specialization of The Netherlands in the late 17th century, he wrote[2/]

> There is much more to be gained by Manufacture than by Husbandry; and by Merchandise than by Manufacturing ... We may take notice that as Trade and Curious Arts increase; so the Trade of Husbandry will decrease ...

The chief point of Petty's observation--that the agricultural share tends to decline with economic development while the industrial and service shares rise--is by now a commonplace, demonstrated repeatedly by the phalanx of Twentieth century statistical economists who belatedly succeeded the originator of political arithmetick.[3/]

[1/] This paper is based on Chapters 2 and 3 of my Ph.D. dissertation, Aggregate Structural Change: Recent Time-Series and Cross-Section Evidence, Harvard University, 1967. The research was partly supported by the Project for Quantitative Research in Economic Development, Harvard, with funds provided under AID Research Contract No. AID/CSD. 1543. I am grateful to Hollis Chenery and Simon Kuznets for advice, but shoulder the usual burdens of error.

[2/] The quotation is from Colin Clark, The Conditions of Economic Progress, (3rd edition), Macmillan, London, 1960, p. 492. Clark gives no citation for his source.

[3/] See, as examples, Clark, ibid., H. B. Chenery, "Patterns of Industrial Growth," American Economic Review, Vol. L, No. 4, pp. 624-54, W. Hoffman, The Growth of Industrial Economies,

Beyond these demonstrations, however, not much progress has been made in relating Petty's observation to some of the other well-established empirical generalizations about economic growth. There is of course Engel's Law which one can cite in concordance with the agricultural output decline, but in an open economy this is not very telling--when there are opportunities for international trade a declining domestic demand for agricultural products is neither a necessary nor sufficient condition for a decline in agricultural production. For the most part, the Petty "Law" has entered the professional lore as a tendency only, supported almost solely by direct observation and not tied in very well with the other things we know about growth and development.

The situation on the industrial side is similar. It is agreed that the industrial share rises with income, but few save Chenery[4/] have attempted to describe this increase in quantitative terms, and even he has not explored in any great detail the complex interactions between country size, external factors, and sectoral change.[5/] In addition to

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Manchester University Press, 1958, and S. Kuznets, Modern Economic Growth, Yale University Press, New Haven, 1966.

[4/] Chenery, loc. cit.

[5/] See, however, his "Process of Industrialization" paper presented to the Rome Econometric Society Conference, 1965, with its appendix by Chenery and T. Watanabe. The model used in the present paper is a sibling of this 1965 model, with much less sectoral disaggregation but rather more elaboration of country size and trade effects.

Chenery, numerous other authors have advanced partial explanations of the observed changes in sectoral industrial shares. The footnote catalogs some of these.[6/]

This essay is devoted to tying some of the existing hypotheses about structural change into a semi-formal model of the behavior of output shares as a function of per capita income and population. This is done through the use of simple input-output analysis coupled with cross-section regressions for the "final demands" of three major sectors of the economy--industry (manufacturing and construction), primary production (agriculture and mining) and services.[7/] The model (which is described in Section 2) provides a useful means for evaluating the importance of the various final demand components in "causing" structural change, and probably has some pedagogical

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[6/] Among others, some important hypotheses about the factors underlying industrial change include: (i) The suggestions of Hoffman, op. cit., about the sequence of growth of various industries; (ii) Clark's emphasis (op. cit.) on demand side factors leading to industrial growth; (iii) A discussion by Kuznets in his "Economic Growth of Small Nations" in E. A. G. Robinson (ed.) Economic Consequences of the Size of Nations, St. Martins Press, New York, of the reasons why the size of a country should have an impact on its industrialization pattern, primarily through trade effects; (iv) The recent discussion in the economic development literature on "import substitution," and how its "running out" might be expected to slow the growth of industry. (See A. O. Hirschman, "The Political Economy of Import Substitution," (forthcoming) for an enlightening summary of this discussion.); (v) The suggestion of Balassa, "Patterns of Industrial Growth: Comment," American Economic Review, Vol. LI, No. 1, 1961, that value levels of industrial output are likely to be retarded in advanced countries due to a rise in prices of non-traded services.

[7/] See the Statistical Appendix for a more precise definition of the various production activities which go into these sectors.

value insofar as it isolates the leading demand side influences.

Using the model and the final demand regressions (from Section 3), predictions of sectoral changes are developed and analyzed in Section 4. In Section 5, predictions are tested against actual cross-section regressions for sector shares. The correspondence is qualitatively good, and this gives some reason for belief in the efficacy of simple general equilibrium models for providing insights into the complicated economic development process. Some of the implications of this statement of faith are discussed in Section 6.

2. A Simulation Model

To derive predictions of sectoral shares as a function of per capita income and population, I set up a simple simulation model based on the assumption that steady Domar-type economic growth prevails in a three-sector economy where only one sector (industry) directly produces investment goods.

The Domar assumptions are that

$$I = sY$$

$$\Delta Y = vI$$

where I is gross (= net) investment, s is the savings (= investment) rate, Y is income, and v is the marginal output-capital ratio.

Further distribution relationships state that government expenditure and consumption depend on income

$$G = G(Y)$$

$$C = C(Y)$$

and that consumption by sector depends on total consumption expenditure,

$$C_i = C_i(C)$$

$$C_p = C_p(C)$$

$$C_s = C_s(C)$$

where the subscripts stand for industrial, primary and service consumption. Similar general functions could be stated for government expenditure by sector, but lack of data ruled out their estimation so I assumed that government demands could be described by

$$G_i = a_i G$$

$$G_p = a_p G$$

$$G_s = a_s G \ ,$$

where $a_i + a_p + a_s = 1$.

If A is the economy's input-output matrix, and $L = (I - A)^{-1}$, then gross sector outputs are given by

$$\begin{bmatrix} X_i \\ X_p \\ X_s \end{bmatrix} = L \begin{bmatrix} C_i^h + I^h + G_i + E_i \\ C_p + G_p + E_p \\ C_s + G_s \end{bmatrix} - \begin{bmatrix} M_{int} \\ 0 \\ 0 \end{bmatrix}$$

where the X's are sector outputs, C_i^h and I^h are manufactured consumption goods and investment goods which can be produced domestically, M_{int} is imports of intermediate goods, and E_i and E_p are exports of industrial goods and primary products, respectively. Primary exports are treated as a residual source of foreign exchange whose level varies to give balance of trade equilibrium,

$$E_p = M_{cons} + M_{int} + M_{cap} - E_i$$

where

$$M_{cons} + C_i^h = C_m$$

$$M_{cap} + I^h = I \ .$$

The non-residual entries in the balance-of-trade equations are assumed to depend on income and population,

$$E_i = E_i(Y,N)$$

$$M_{cons} = M_{cons}(Y,N)$$

$$M_{int} = M_{int}(Y,N)$$

$$M_{cap} = M_{cap}(Y,N) \ .$$

The value added levels by sector (V_i, V_p, V_s) can be derived from gross outputs by multiplying them by the value-added ratios from the input-output matrix. These levels will be needed for comparison to the regression results of Section 5.

Solution of the model is straightforward.[8/] One starts with a level of income, and derives levels of consumption, investment and government expenditure. The distribution between domestically manufactured consumption and investment

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[8/] Perhaps the proviso should be added: "With a high speed computer." All of the model solutions were generated on the CTSS time-sharing system of the Massachusetts Institute of Technology using a computer program which carried out the computations sketched above for a 50-year period in about one half minute. I am grateful to David Kendrick and Robert Kierr for programming advice--my computation times might have been much greater but for them.

goods and imports of these goods also depends on Y, as do levels of manufactured and primary exports. Once all these final demand items are computed, gross outputs and value added by sectors follow from the input-output relationships. Next period's income comes from the investment rate and the output-capital ratio.

3. Estimation of the Model

For the most part, I estimated the functions for the simulations with national accounts data from various sources.[9/] All equations were estimated from pools of yearly cross-section data in an attempt to get away from yearly fluctuations. Largely for reasons of computational convenience, I used ordinary least squares for estimation throughout. Abstracting from questions of simultaneity (which are somewhat academic in a cross-sectional investigation where the distinction between exogenous and endogenous variables is extremely fine), the ordinary least squares estimates should be unbiased, but not efficient.[10/]

[9/] The per capita income and population figures came from Worksheets provided by the Center for Development Planning, Projections, and Policies, United Nations, to the Project for Quantitative Research in Economic Development, Harvard University. This same source also gave data on value added by sector and on domestic final demand expenditures for the period 1950-1963. Export and import data came from Yearbooks of International Trade Statistics, while consumption data was from the U.N. Yearbooks of National Account Statistics. See the Statistical Appendix for details on how I aggregated the published series to get the variables actually used in the regressions.

[10/] Nerlove in various papers has discussed efficient estimation techniques for pooled data, but his methods are not in general use as yet.

The choice of a specific functional form presented some problems. Most previous work on international comparisons (e.g. Chenery, loc. cit.) has been based on the familiar constant elasticity log-linear regression. There are, however, strong a priori grounds for suspecting that elasticities of value added and final demand shares should change as per capita income increases. One of these is the obvious point that a constant positive elasticity for the share of some component of GNP will lead ultimately to that share's exceeding unity as GNP increases. Other, more immediate grounds for non-constant elasticity can also be cited--such as probable declining demands for manufactured products at high income levels, coupled with demand shifts to services and increasing government expenditure.

For these reasons, the regression equations reported here are all of the form

$$\ln x = a + b (\ln y) + c (\ln y)^2 + d (\ln N)$$

where x is the dependent variable, y is per capita income (usually) and N is population. The quadratic term allows an easily interpreted varying elasticity with respect to per capita income.[11/] I also experimented with other curvilinear

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[11/] The exponential form of this equation is

$$x = e^a y^{(b + c \ln y)} N^d .$$

The elasticity of x with respect to y is b + 2 c ln y which is clearly increasing or decreasing as c is positive or negative.

regressions, but since the predicted values from these were very close to those from the double log quadratic specification, I present only the results using the latter.

Table 1 summarizes the regression equations needed for the model.[12/] Since the equations are only raw material for the simulations, there is no point in discussing them in any great detail. However, one digression regarding the interpretation of the results is worth making. The main point to be illustrated is simply that equation-by-equation analysis of Table 1 can easily lead to much confusion about expected cross-sectional patterns of change in value added shares--one really needs some framework of calculation (or a "model") to understand the forces working simultaneously to create change in as few as three producing sectors. This stands out sharply when we look at "causes" of change in industrial production.

Observe that lines (1) and (2) of the Table indicate that the elasticities of the consumption and investment shares with respect to per capita income are roughly constant.[12a/] Line (10) shows that the industrial goods share in total consumption also has a constant elasticity (of about .18). What should we conclude regarding the share of industry in total production? The investment demand indicates a positive

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[12/] Note that all regressions are for shares of the dependent variables in GNP or total consumption. Non-negligibl increases in R^2-values can easily be obtained by using the dependent variables on a per capita basis. I avoided this formulation in order not to give an overly optimistic picture of the goodness-of-fit one actually achieves in working with international cross-section data.

[12a/] Log linear regressions give values of -.06 and .16 for the two elasticities.

Table 1

REGRESSIONS FOR THE SIMULATION MODEL

Dependent Variable	Regression Coefficients with Respect to: ln (Y/N)	$\ln^2$(Y/N)	ln N	Intercept	R^2	S.E.	Number of Observations	Number of Countries
(1) ln (C/Y)	.04 (.04)	-.008 (.003)		- .31 (.12)	.26	.10	765	61
(2) ln (I/Y)	.23 (.13)	-.01 (.01)		-2.88 (.38)	.20	.32	765	61
(3) ln (G/Y)	- .33 (.13)	.04 (.01)		-1.58 (.39)	.14	.32	765	61
(4) ln (M_{cons}/Y)	-2.95 (.48)	.24 (.04)	-.48 (.03)	7.22 (1.44	.62	.43	135	50
(5) ln (M_{int}/Y)	.23 (.07)		-.10 (.06)	-4.76 (.45)	.11	.80	135	50
Large Countries								
(6) ln (M_{cap}/Y)	1.33 (.66)	-.13 (.06)	-.58 (.09)	-4.51 (2.07)	.63	.47	53	19
Small Countries								
(7) ln (M_{cap}/Y)	.06 (.04)		-.03 (.06)	-2.96 (.30)	.03	.35	82	31
Large Countries								
(8) ln (E_m/Y)	3.25 (.62)	-.20 (.05)	.63 (.09)	-17.85 (1.82)	.56	1.04	250	19
Small Countries								
(9) (E_m/Y)	-1.79 (1.17)	.21 (.10)	.54 (.09)	-1.02 (1.00)	.28	1.19	356	31

Table 1 Continued

Dependent Variable	Regression Coefficients with Respect to: ln (C/Y)	$\ln^2$ (C/Y)	Intercept	R^2	S.E.	Number of Observations	Number of Countries
(10) ln (C_m/C)	.44 (.46)	-.02 (.04)	-3.61 (1.31)	.41	.18	84	29
(11) ln (C_p/C)	1.06 (.45)	-.11 (.04)	-3.30 (1.27)	.43	.18	84	29
(12) ln (C_s/C)	-1.02 (.62)	.10 (.05)	1.37 (1.75)	.27	.24	84	29

elasticity, while the total consumption demand elasticity will be negative. On balance, one might expect a declining positive elasticity of industrial value added--if the negative consumption effect is strong enough. However, only more detailed calculations could really make clear the relative strength of these opposing demand effects (and even this calculation would ignore the complicating effects of intermediate demands from other sectors).

Now consider foreign trade, taking population into account in view of the well-known correlation of country size with trading propensities.[13/] Using population as an additional explanatory variable in line (4), we conclude that imports of manufactured consumption goods rise as a share of income, but that the actual level of the share depends on country size. How does this increase contribute to the growth of industrial output? Apparently we have further grounds for expecting a declining elasticity of industrial share with respect to per capita income, but a quantitative assessment of this "tendency" cannot be made off-hand in the presence of the population effect.

[13/] Recent discussions in the literature include those of Kuznets, Modern Economic Growth; N. Adams, "Import Structure and Economic Growth: A Comparison of Cross-Section and Time Series Data," Economic Development and Cultural Change, Vol. 15, No. 2, Part I, January 1967; and D. Keesing, "The Influence of A Country's Size on Its Exports and Imports of Manufactured Products," September 1966, (unpublished manuscript). The paper by Keesing contains a judicious discussion of many of the statistical problems encountered in working with cross-sections of international trade data.

Country size enters more deviously in the determination of capital goods imports and manufactured exports. Following N. Adams,[14] I split my sample into countries with populations above and below 18 million (a convenient breakpoint) to investigate differential trade effects. These show up strongly in equations (6) and (7) of Table 1, which indicate that large countries have a decreasing elasticity for the capital goods import share, while small countries have a small positive elasticity.[15] Loosely speaking, large countries show a capacity for import substitution which small countries do not possess. Just how this capacity enters into the overall determination of industrial share is again not clear, and calculations are correspondingly more difficult.

Finally, to drive the point home, let us consider lines (8) and (9) which gives regressions for the share of manufactured goods exports. Here we find that in small countries, this share shows an <u>increasing</u> elasticity with respect to income while the elasticity declines in large countries. In small countries, at least, we have an offset to a low capacity for import substitution, which in turn offsets a high propensity to import manufactured consumption

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[14] N. Adams, <u>loc. cit.</u>

[15] On the usual analysis of covariance test for homogeneity of regressions (see G. Chow, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," <u>Econometrica</u>, Vol. XXVIII, No. 3, 1960), the F-ratio on the null hypothesis that the two country group equations can be pooled is 10.36. The one percent rejection level is 3.47.

goods. It seems fairly clear that the evaluation of all these conflicting determinants of the industrial share in value added is not to be left to intuition alone. The complexity of the inputs to the simulation model in itself leads to a nice justification for the model's use!

Returning to the data needed for the simulations, we still need estimates of government marginal propensities to consume by sector and an input-output table.[16/]

National accounts data could not be used to estimate government expenditure by sector, so I had to turn to alternative data sources. The most readily available of these lies in the final demand breakdowns of input-output studies. This type of data was used by Chenery and Watanabe[17/] to allocate government demands to 23 producing sectors. I aggregated their demand coefficients to the three sector level, with the following results:

Government Demand by Sector (per cent)

Manufacturing	13.7
Primary	2.0
Services	84.3

[16/] Another parameter to be chosen is the capital-output ratio. However, this affects only the timing of the simulation model and has no direct bearing on the results reported in the next section. For the record, I chose a constant ratio of 3.5, which is close to the median ratio in Kuznets' and other studies.

[17/] Chenery and Watanabe, loc. cit.

Finally, there remains the specification of the inter-industry structure. No one to my knowledge has undertaken a complete statistical investigation of the relationship of changes in input-output coefficients to changes in income.[18/] In lieu of such a study I gathered a sample of six tables,[19/] aggregated them to three sectors, and chose a "representative" set of three-sector coefficients. This matrix and its Leontief inverse are as follows:

Three-Sector Input-Output Matrix

Sectors	1	2	3
1 - Industry	.30	.11	.12
2 - Primary Production	.14	.10	.01
3 - Services	.14	.08	.10
Value-Added Ratios	.42	.71	.77

Three-Sector Leontief Inverse Matrix

Sectors	1	2	3
1	1.51	.20	.20
2	.24	1.14	.04
3	.26	.13	1.15

[18/] See, however, H. Chenery and P. Clark, Interindustry Economics, John Wiley & Sons, Inc., N.Y., 1959; Chenery and Watanabe, loc. cit.; D. Simpson and J. Tsukui, "The Fundamental Structure of Input-Output Tables: An International Comparison," Review of Economics and Statistics, Vol. XLVII, No. 4, November 1965; and T. Watanabe, "A Test of the Constance of Input-Output Coefficients Among Countries," International Economic Review, September 1961.

[19/] The six countries and the years their tables represent are as follows: Japan, 1954; Italy, 1950; Israel, 1958; Korea, 1962; Brazil, 1959; Pakistan, 1963.

As shown in Taylor, op. cit., comparison of the "representative" Leontief inverse with the six actual inverse matrices shows no apparent systematic biases. The chief problem with using the representative matrix is that secular changes of the interindustry structure in connection with economic growth are not taken into account. This may bias the simulation results, as will be discussed more fully in Section 6.

4. Results of the Simulation

Figure 1 shows the simulation-generated sectoral shares of GNP as functions of income per capita in prototype "large" and "small" countries with constant populations of 50 and 10 million. The large country industry share lies above the small country's except at very high income levels, while the reverse is true for primary production. Only one line is shown for the share of the service sector, which is almost the same in the two countries.

Some of the qualitative differences in height and curvature of the share functions can be traced back to the factors mentioned in the discussion of the expected industrial share last section. For example, one could argue that the concave curve for the large country industrial share shows the influences of declining final demand elasticities and "completed" import substitution; these seem to be offset in the S-shaped small country curve by the rapid growth of manufactured exports at high income levels.

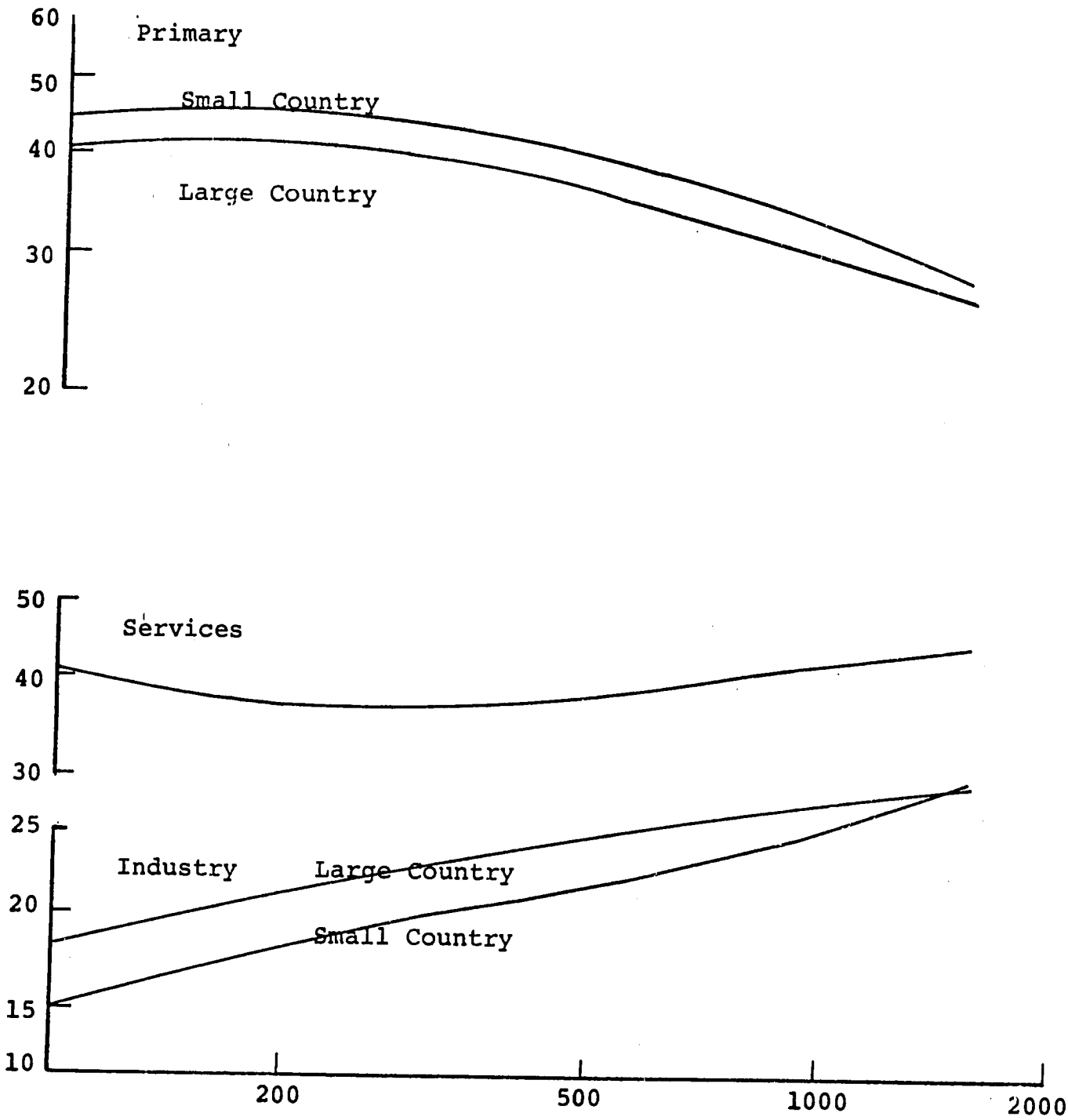

Figure 1
PREDICTED LEVELS OF SECTOR SHARES

To get more precise measurements of the relative importance of exports, import substitution, and domestic demand in creating differences between the share functions, the model was run with various limiting assumptions about how these factors behave as income increases. I carried out two experiments of this sort for each country, assuming (a) that the ratios of consumption imports to total consumption, intermediate imports to gross industrial output, and capital goods imports to investment take the values at all income levels that they take in the unconstrained model at an income of 100, and (b) that the ratio assumption of (a) holds and that, in addition, the ratio of manufactured exports to income remains constant at the income 100 level. These two assumptions can be interpreted as "no import substitution" and "no import substitution plus no export growth," respectively.

Figure 2 illustrates the results of these experiments on the industrial share in the two countries. The solid lines are the unconstrained industrial "histories" while the two lower dashed lines show the effects of assumptions (a) and (b). Taking the (b) lines as bases, one can break down the contribution of the various final demand factors to structural change as shown in Table 2.

Several points may be discerned from the graphs and the Table.

(i) Import substitution as a vehicle of industrialization is clearly much more important in the large country. This is illustrated in Table 2 by the two columns under the relevant

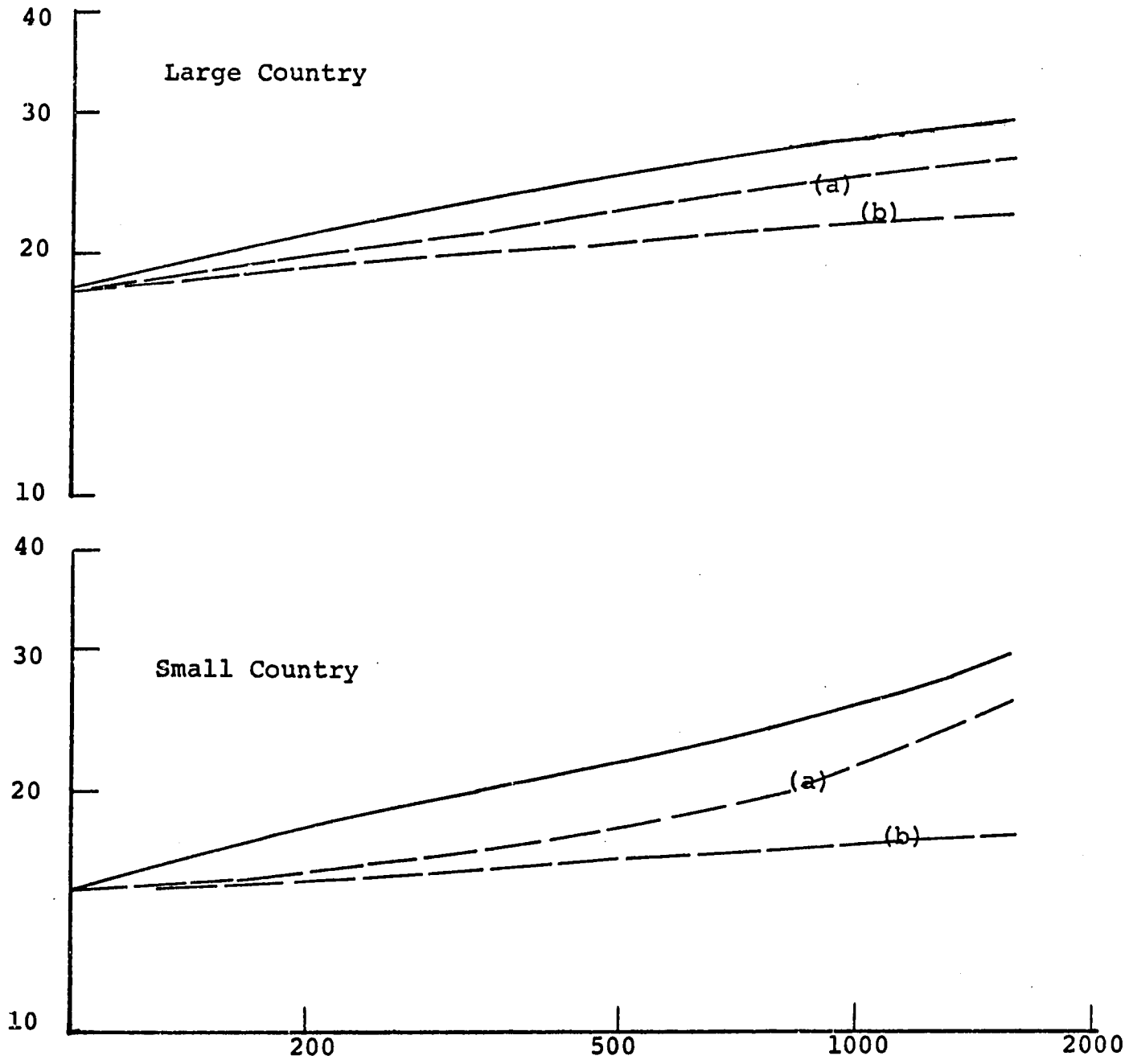

Figure 2

VARIATIONS ON THE SIMULATIONS FOR INDUSTRIAL CHARE

Table 2

CAUSES OF INDUSTRIALIZATION

	Percentage Shares of Industrial Output in GNP Due to:				
Large Country	Domestic Demand	Manufactured Exports	Import Substitution		Total
100	18.2	0	3.2	0	18.2
200	19.3	0.6	3.7	1.2	21.1
500	20.7	2.0	4.3	2.4	25.1
1000	21.7	3.3	4.6	3.0	28.0
1500	22.4	3.6	4.9	3.1	29.1
Small Country					
100	15.0	0	0		15.0
200	15.6	0.3	2.3		18.2
500	16.4	1.6	3.8		21.8
1000	17.1	4.5	4.0		25.6
1500	17.5	7.9	3.8		29.2

"Import Substitution" heading. The left-hand column shows the effects of generally lower imports in raising the large country base line (b) above that of the small country, and the right-hand column shows the effect of import substitution in raising the large country industrial growth path from its assumption (a) line up to the solid line showing the actual industrial share as a function of income. The sum of these two columns, which is the full import substitution component of large country industrialization, is considerably larger than the one column under the "Import Substitution" heading for the small country.

(ii) Manufactured exports are a very important component of industrialization in the small country, particularly at high income levels. This can be seen in Figure 3 by the rapid rise above the income 600 level of both the solid line which shows actual industrial share generated by the unconstrained model and the assumption (a) line which shows the export effect net of import substitution. By income 1500, direct and indirect effects of manufactured exports are responsible for about 27% of industrial output in the small country, as opposed to 12% in the large country.

(iii) The implications of the shape of the lines for next section's regressions of sector value added on per capita income are clearcut. Large countries should demonstrate a relationship of industrial share to per capita income which is concave on a double-logarithmic scale. The corresponding

relationship for small countries should be approximately a straight line (of constant elasticity).

Returning to Figure 1 we may observe some testable predictions about the behavior of primary and service share.

(iv) The primary share in large countries lies at a considerably lower level than the share in small countries, and the gap shows a slight tendency to narrow as income increases.

(v) Primary share in both types of countries declines at an increasing rate with income, representing the combined effect of falling domestic demands, import substitution, and the growth of manufactured exports.

(vi) The service sector shows a strong tendency to increase with increasing income, reflecting a consumer taste shift and the increasing share of service-oriented government expenditure in GNP.

5. Tests of the Simulation Hypotheses[20/]

One of the most important hypotheses suggested by the simulations is number (iii) above--that large countries and small countries should have differentially shaped functional

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[20/] The basic data for the regressions of this section is from the United Nations Worksheets, loc. cit., which provide a pool of about 700 observations on sectoral value-added ratios, per capita income and population for 54 countries during the period 1950-63.

relationships between industrial share and per capita income.[21/] To test this hypothesis, we may use the double-log parabolic regression function of the last section. As before, a significant coefficient on the $(\ln y)^2$ term indicates curvature--upward if the sign is positive, downward if the sign is negative.

The regression results are summarized in the equations (M-1) of Table 3. Clearly the regression lines of the two groups follow the pattern predicted by the simulation model. The coefficient of the $(\ln y)^2$ term in the large country regression is negative, and significantly different from zero, indicating that the "normal" industrialization path is concave on the double-log scale. The curvature term in the small country regression is very insignificant indicating a constant elasticity industrialization path.[22/] (Equation (M2-1) gives the share elasticity as .37.)

[21/] To repeat, the difference in the shapes of the two simulation paths is largely due to the different manufactured export regressions for the two countries. The concave large country export regression contributes to the general concavity of the industry expansion path, complementing the effects of completion of import substitution and a falling elasticity of domestic demand for manufactured products. The convex export regression for small countries offsets the retardation of the small country industrial share, and gives approximately a straight line expansion path. Since small countries in general tend to import larger amounts of manufactured goods per capita, the offsetting effect of exports is not complete, and the <u>level</u> of industrial output is higher in large countries.

[22/] The two groups of countries do not accept the same regression, as might be surmised from the standard errors. On

Table 3

REGRESSION EQUATIONS FOR THE MANUFACTURING SHARE

Sample	ln y	$(\ln y)^2$	ln N	Intercept	R^2	Standard Error
Pool						
(M1-P)	1.15 (.11)	-.07 (.01)		-5.95 (.31)	.71	.25
(M2-P)	.37 (.01)		.04 (.01)	-3.76 (.35)	.69	.26
(M3-P)	1.50 (.11)	-.10 (.01)	.08 (.01)	-7.03 (.33)	.73	.24
Large						
(M1-L)	1.86 (.11)	-.13 (.01)		-7.75 (.31)	.86	.20
(M2-L)	.37 (.01)		.02 (.02)	-3.63 (.11)	.75	.26
(M3-L)	2.03 (.11)	-.14 (.01)	.08 (.02)	-8.54 (.33)	.87	.19
Small						
(M1-S)	.35 (.20)	-.002 (.02)		-5.91 (.31)	.60	.26
(M2-S)	.37 (.01)		.05 (.02)	-4.17 (.59)	.62	.26
(M3-S)	.50 (.20)	-.01 (.02)	.06 (.02)	-4.17 (.59)	.62	.26

Standard errors of the coefficients are in parentheses.

Despite the general success of the regressions (in terms of satisfying the author's preconceptions), a considerable part of the cross-sectional variance remains unexplained, particularly in the small country equation.[23/] This indicates that a number of factors besides per capita income and the things it stands for are influencing the industrialization pattern. Previous investigations of industrialization and our model indicate that an important additional explanatory variable is population, interpreted as a proxy for the effects of (a) threshold size barriers to growth in certain industries, and (b) the influence of trade patterns which are closely tied to country size. The effects of using population in the regression equations is shown in equations (M-2) and (M-3) of Table 3.

As one would expect from previous studies, population has a positive effect on manufacturing share. However, increases in R^2 from adding population are rather small, and the population coefficients themselves are not large. Population thus appears as a secondary variable of significance in the group regressions and the pool. But, again, the interpretation of its significance remains difficult since both scale and trade effects lie behind the population-industrialization correlation.

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the analysis of covariance test, the F-ratio with 3 and 693 degrees of freedom is 28.8, vs. a one percent rejection level of 26.1

[23/] The poorer fit of the small country regression carries over into the pool equation, which has a significant coefficient for the $(\ln y)^2$ term forced on it by the curvature of the large country regression.

Figures 3 and 4 illustrate the information contained in the statistical analysis. The solid lines are plotted from the pool regressions with population set at 10 million for the small country graph, and 50 million for the large. The dashed lines are plotted from the two group regressions. The better fit in the large country sample is apparent, as is the curvilinear positioning of the country mean values. As can be easily verified, the regression line for the small country sample lies generally below the line for the large country, although they cross at high income levels as would the lines of Figure 1 if extended.[24/]

Turning to the other sectors, recall from Section 1 that William Petty's "Law" predicts a negative elasticity of primary production share with respect to per capita income in our cross-section regressions. From our simulation model (which follows the Petty generalization), we may also expect two more controversial characteristics of structural change in primary production. One of these--an expectation of a lower secular level for primary production in large countries than in small--follows quite simply from the role of primary exports as a trade-balancing item in the simulations. Small countries have a larger gap between manufactured imports and exports per capita (except at very high income levels). Barring

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[24/] See Table 4 for the countries corresponding to the identification model.

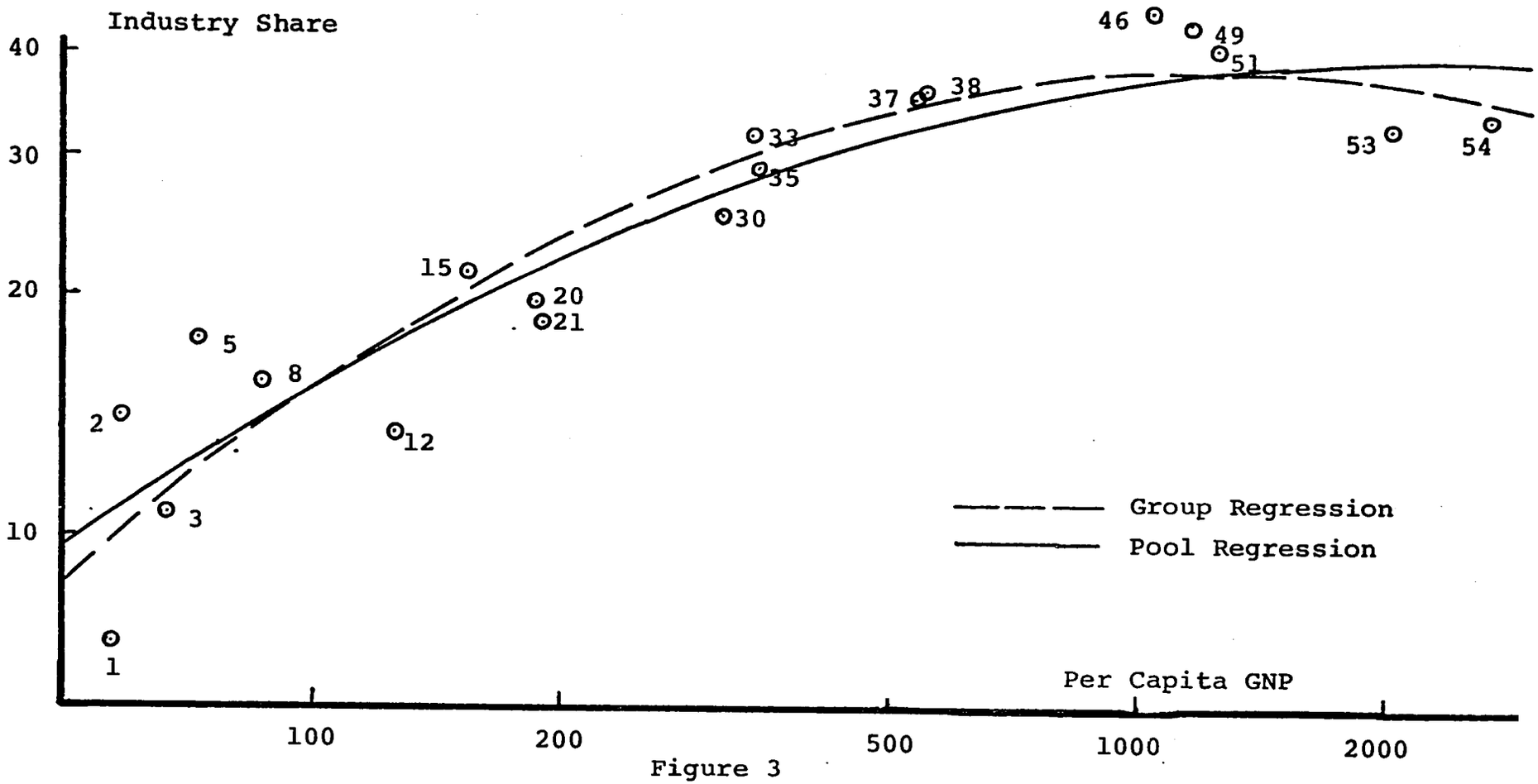

Figure 3

REGRESSIONS FOR INDUSTRY SHARE IN LARGE COUNTRIES

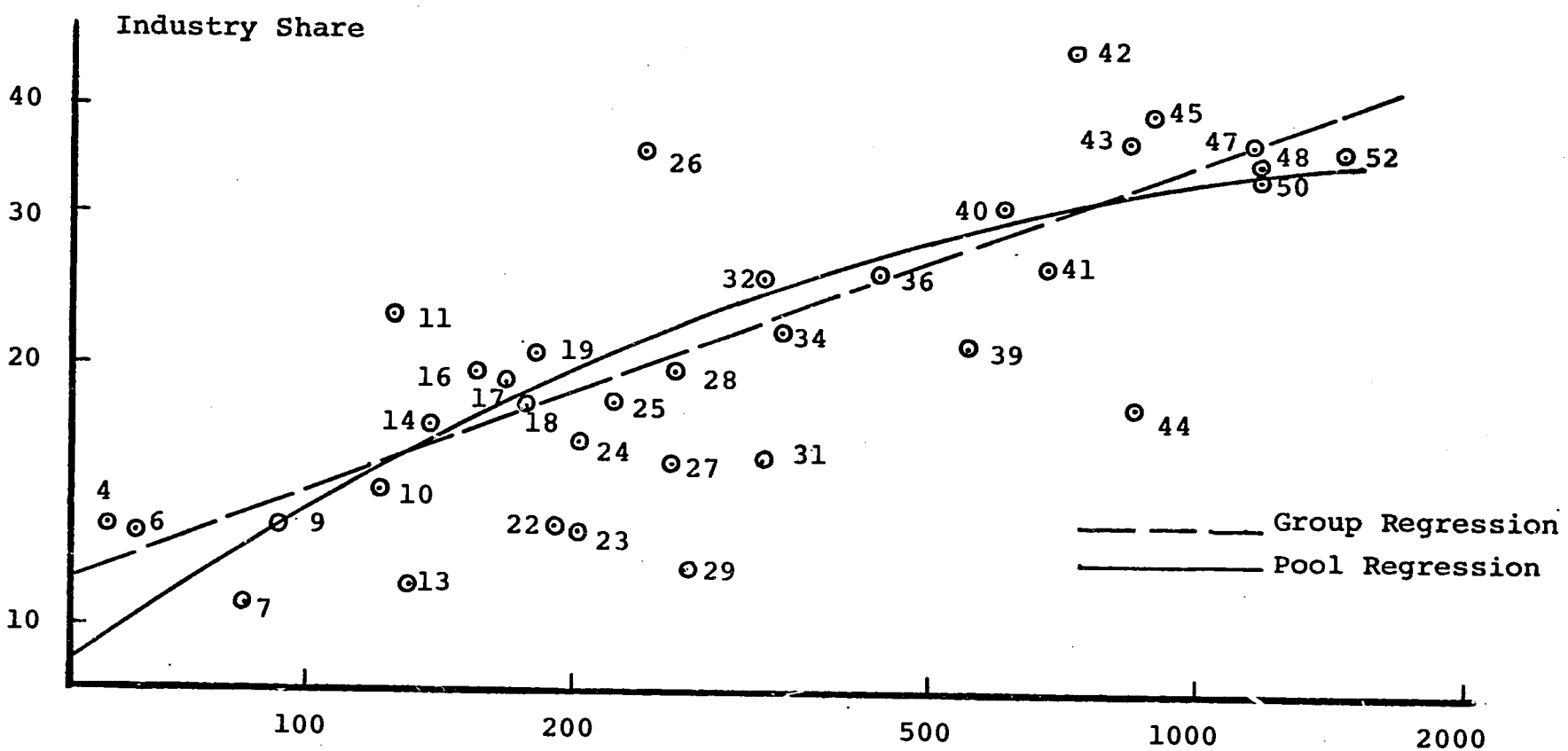

Figure 4

REGRESSIONS FOR INDUSTRY SHARE IN SMALL COUNTRIES

Table 4

IDENTIFICATION OF COUNTRIES IN THE SAMPLE

*1.	Nigeria	28.	Colombia
*2.	Burma	29.	Malaya
*3.	Pakistan	*30.	Mexico
4.	Haiti	31.	Costa Rica
*5.	India	32.	Jamaica
6.	Kenya	*33.	Japan
7.	Cambodia	34.	Greece
*8.	Thailand	*35.	Spain
9.	Congo	36.	Uruguay
10.	Bolivia	*37.	Argentina
11.	Taiwan	*38.	Italy
*12.	South Korea	39.	Chile
13.	Ceylon	40.	Israel
14.	Rhodesia	41.	Puerto Rico
*15.	Brazil	42.	Austria
16.	Paraguay	43.	Netherlands
17.	Ecuador	44.	Venezuela
18.	Tunisia	45.	Finland
19.	Peru	*46.	West Germany
*20.	Turkey	47.	Denmark
*21.	Philippines	48.	Belgium
22.	El Salvador	*49.	France
23.	Iraq	50.	Norway
24.	Honduras	*51.	United Kingdom
25.	Algeria	52.	Australia
26.	Portugal	*53.	Canada
27.	Guatemala	*54.	United States

"Large" countries are marked with an asterisk.

capital inflows, this gap must be closed by primary production for export. The other simulation prediction--that the primary share regression lines should be concave--follows from the concavity of the Engel curves estimated for primary (and total) consumption, and concavity of primary exports as a function of income.[25/]

As equations (P1) and (P2) of Table 5 indicate, all of these hypotheses are verified. The negative elasticity shows up in the curvature terms which are significant with the right sign and approximately the same magnitude, and predicted values calculated from the equations reveal a higher primary share in small countries. The large country group regression gives a somewhat steeper line than does the small, although this is of borderline significance statistically.[26/]

[25/] Primary export shares generated by the simulation model are as follows:

Income	Large Countries	Small Countries
100	8.6%	14.3%
200	6.4	12.0
500	3.4	9.5
1000	1.2	5.7
1500	0.7	0.4

Both export paths have a concave relationship to income on a double-log scale. The actual shares computed are more or less in agreement with observations. (See Taylor, op. cit., Table 3A-1.)

[26/] The F-ratio on pooling equations (2) takes the value 5.21, and the 5% rejection level with 4 and 695 degrees of freedom is 5.64. The null hypothesis of homogeneity is not rejected at the standard level, but only by a very small margin.

Table 5

REGRESSION EQUATIONS FOR THE PRIMARY AND SERVICE SHARES

Sample	ln y	$(\ln y)^2$	ln N	Intercept	R^2	Standard Error
Pool						
(P1-P)	-.48 (.01)		-.04 (.01)	1.56 (.09)	.78	.26
(P2-P)	.02 (.12)	-.04 (.01)	-.03 (.01)	.10 (.50)	.79	.26
Large						
(P1-L)	-.51 (.01)		-.04 (.02)	1.66 (.09)	.90	.21
(P2-L)	-.04 (.11)	-.04 (.01)	-.02 (.02)	.27 (.36)	.90	.21
Small						
(P1-S)	-.46 (.02)		.02 (.02)	1.34 (.09)	.67	.28
(P2-S)	.04 (.22)	-.04 (.02)	.03 (.02)	-.10 (.64)	.68	.28
Pool						
(S1-P)	.09 (.01)		-.03 (.01)	-1.28	.32	.15
(S2-P)	.16 (.07)	-.01 (.01)	-.03 (.01)	1.48	.32	.15
Large						
(S1-L)	.10 (.01)		-.05 (.01)	-1.20 (.06)	.45	.15
(S2-L)	-.01 (.08)	.01 (.01)	-.06 (.01)	-.89 (.26)	.45	.15
Small						
(S1-S)	.09 (.01)		-.04 (.01)	-1.26 (.04)	.26	.15
(S2-S)	.30 (.10)	-.02 (.01)	-.04 (.01)	-1.87 (.29)	.27	.15

Standard errors of the coefficients are in parentheses.

Analysis of the service sector, especially with ordinary econometric techniques, is a difficult task. One problem is simply lack of variance at the aggregate level--the service sector share stays approximately constant, and any existing variation is not strongly correlated with explanatory variables which work well with primary production and manufacturing. Another problem is raised by aggregation. There is evidence that the sub-sectors of manufacturing bear much the same relationship functionally to per capita income as does the aggregate.[27/] This, in fact, is one of the incentives to analyze aggregate industrial output--one gets a qualitative feel for what the individual sub-sectors may be doing on the basis of aggregate behavior supplemented by knowledge of interindustry relationships. Sidestepping the aggregation problem in the service sector is not so easy. Some components of general services--transportation, communication, and so on--act like corresponding industrial sectors.[28/]

[27/] See Chenery, loc. cit., and the United Nations, Department of Economic and Social Affairs, A Study of Industrial Growth, ST/ECA/74, New York, 1963, for analysis of industrial change at the two-digit level using log-linear regressions. Current research at the Harvard Project for Quantitative Research in Economic Development indicates that the same sort of relationships of industrial sector values added to per capita income holds as is reported here for aggregate value added--the regressions are concave on a double-log scale for large countries, and constant elasticity for small.

[28/] Kuznets in his recent studies treats transportation and communication as part of the manufacturing sector. As explained in the statistical appendix, they are included in services here for greater compatibility with the commodity trade regressions of Section 3.

Others--personal services, for example--no doubt decline with per capita income. Yet, for many complex reasons, the aggregate of all the sub-sectors stays approximately constant. Deciphering these complexities is impossible with aggregate data.

For what is is worth, then, we have from the simulation model that the service sector share should rise somewhat with per capita income, and that the relationship between share and income should be slightly convex (below its own chord).

Only the first of these predictions turns out to hold, as can be verified from equations (S1) and (S2) of Table 5. In both the large and small groups, services do rise with an elasticity of about 0.10. There is no significant curvature in the large country group, although the sign of the insignificant coefficient is positive. The small country line is concave, with borderline significance. The population coefficients in both groups and in the pool regression are negative and significant, indicating large countries should have smaller service sectors, contra the predictions of the simulations.

6. Summary and Conclusions

To summarize, we have found the following things about cross-sectional changes in sectoral shares of value added:

(i) Large countries show a strongly curvilinear expansion path (on a double-logarithmic scale) for industrial share, which explains a large part of the cross-sectional variance. The curvature of the path can be attributed to early completion of import substitution, relatively limited entry into the manufactured exports market, and gradually declining elasticities of demand for industrial products.

(ii) Small countries have a constant elasticity of industrial expansion of about .35 or so. In terms of a simulation model, this constant elasticity can be explained by the rapid growth of manufactured exports which has been observed at high income levels. In general, the small country manufacturing share lies below that of the large countries, largely because of higher import levels (especially of capital goods) throughout the income range.

(iii) Primary production is well explained by the same independent variables as used in the regressions for industry. Qualitative predictions of the simulation model regarding curvature and position of the "normal" paths for primary production changes are reflected in cross-section regressions, including the interesting result that the primary share elasticity becomes increasingly negative as per capita income increases.

(iv) The service share of GNP tends to increase with per capita income at a roughly constant elasticity. This is in line with demand shifts toward that sector.

Two final points can perhaps be made regarding the overall results of the exercise. The first of these is that the economic development process, even as simplified in a three-sector model, is tremendously complex, and that multi-sectoral general equilibrium studies probably will play an increasing role in both empirical and theoretical analysis of development because they are the only tools we have which can take account of all the developmental interactions. If there is ever to be a complete theory of development, it will have to be formulated in general equilibrium terms, taking into account many of the factors which have been included, however incompletely, in the three-sector model.[29/] The alternative to this approach is a collection of piecemeal investigations such as most of those which have characterized the investigations of structural change in the past.[30/] These

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[29/] This is perhaps as good a place as any to comment on some of the things lacking in the three-sector model. Comparing regressions to model, one sees that the worst divergence between simulations and regressions is in terms of slope—industrial share rises more steeply and primary share falls more abruptly in cross-section than in model. There are a number of things which can be suggested to "explain" the divergences (note that there must be an explanation--input-output bookkeeping guarantees an exact prediction of production given exact specification of inputs and coefficients) and two of the most important are: (i) secular changes in inter-industry integration during the course of development--in particular an increase in manufacturing coefficients in the inverse Leontief matrix due to increased intermediate demands; (ii) a systematic over-estimation of demands for primary products due to my ignoring the increasing service component of food consumption in the Engel curve estimation of Section 3. See the appendix for a discussion of this point.

[30/] Often, investigation of structural change without a fully spelled-out formal theoretical framework has led to

must ultimately become entangled in the individual strands of import substitution, government expansion, agricultural demand contraction, etc., etc. No collection of partial investigations of different factors of change, regardless of their completeness and depth, could ever weave the threads into a whole theoretical cloth. Only general equilibrium analysis can do this.

Second, if someone ever writes a general development theory, results here and elsewhere indicate that he will have to give an important role to country size and foreign trade. These linked factors have created important differences in the industrialization paths of large and small countries as summarized in the cross-sections presented here, and will no doubt continue to cause important differences in the future. As Kuznets puts it,[31/] "... small countries differ from large, both in the mechanism of economic growth and in an important aspect of the structure of national product, i.e., in the proportions within various sectors of foreign and domestic contributions and drafts." A glance back at the equilibrium growth paths of Figure 2 and the regression results in Figures 3 and 4 amply confirms this statement.

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rather extreme results. Note Hoffman's great emphasis on a certain phasing of industrial change, and Clark's stress on change in the "tertiary" sector.

[31/] Kuznets, op. cit., p. 312.

STATISTICAL APPENDIX

Here I briefly summarize the classification schemes used to define the dependent variables for the regressions of Tables 1, 3, and 5, and also describe the samples used for estimating the equations. For more details, see Taylor, op. cit.

Consumption, Investment, Government: The data here came in constant 1960 U.S. prices from worksheets provided by the Economic Projections Section, Center for Development Planning, Projections, and Policies, United Nations. (Similar, less revised data appears in the U.N. Yearbooks of National Accounts Statistics.) I ran regressions for shares of these components in total GNP for a sample of 765 observations from 61 countries over the period 1950-63.

Consumption Expenditure Components: The sample comprises 84 observations from 29 countries over the period 1961-63. The data came from the Yearbooks of National Accounts Statistics, and the aggregation from the categories there was as follows: Primary products were defined as components 1-3--food, beverages, and tobacco. Manufactured consumption goods were defined to include clothing and furniture, components 4 and 7. Services included all other components, including fuel and light, transportation and others. This aggregation is supposed to be more or less consistent with the breakdown of producing sectors used in the Section 5 regressions; however, there are

some contradictions. Probably the most important of these is in the primary sector, where the consumption values include packaging, processing and transportation of food, beverages and tobacco. The non-primary production component of this commodity bundle clearly rises with per capita income, but having no non-arbitrary means of correction at hand, I let the problem stand. Most of the non-primary component should be shifted to the services sector (see Kuznets, Modern Economic Growth, pp. 274-276, for a discussion of this point), and the Section 5 regression results should be interpreted accordingly.

Import Functions: The sample included 135 observations from 50 countries for the period 1961-63. The sources of this data were Yearbooks of International Trade Statistics, and the aggregation was as follows: Capital goods--SITC sectors 71 and 72 (machinery), 73 (exclusive of passenger cars), 68 (base metals), 661 (cement). Intermediate goods--311, 312, 313.03-09 (industrial fuels), 511, 512, 52, 53, 56 (industrial chemicals), and Division 2 (raw materials). Consumer goods--the rest of 73, 65 (textiles), and the rest of 6, and Division 8. Note that food and beverages are omitted from manufactured consumption imports since these goods have a high non-manufactured component.

Exports: Primary exports were defined as classes 0, 121, 2 (not including 266), 331, 341.1, 4, and 941 of the SITC.

Unprocessed foods and unprocessed and partially processed mine products are the chief components of primary trade thus defined. Manufactured exports were defined as the balance of exports of commodities after primary exports were removed. Thus, manufactured exports pick up all the residual errors of measurement, and their regression should be weighted accordingly. The sample used comprises 606 observations from 50 countries over the period 1950-63. The data is again from Yearbooks of International Trade Statistics, with percentages of the two export components in the total applied to a constant dollar export series in the U.N. worksheets mentioned above to get the variables actually used in the regressions.

Value Added Data: The source is again the U.N. worksheets, and the data pool includes 703 observations from 54 countries. The "industry" variable used is made up of manufacturing and construction, with construction included since its demand elasticity is similar to that of manufacturing and because the two series were not separated in many of the worksheets. Utilities and transportation were not included in industry because of the emphasis on commodity production and trade in the simulations, and again because these sectors were often not separated from other services in the worksheets. The "primary production" variable includes both agriculture and mining; the latter is included because it is a resource-based activity strongly influenced by international trade factors.